# Capital Structure under Imperfect Product Market Competition: Theory and Evidence*

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**Abstract**

We show how product market competition affects capital structure using a tractable market equilibrium model with heterogeneous, imperfectly competitive firms. The model embeds the tradeoff between bankruptcy costs and the benefits of debt in limiting private benefit extraction by managers. 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.

JEL codes: G30, G32
Keywords: imperfect competition, leverage, industry equilibrium.

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## 1 Introduction

A key stylized fact that emerges from the empirical capital structure literature is that leverage is strongly determined by a firm's industry.[1] One of the principal attributes of an industry is its competitive environment that is, in turn, shaped by distinct industry primitives such as fixed costs of production or the substitutability between products. For example, industries with higher fixed production costs discourage entry and are, therefore, expected to feature less intense competition, while industries with more substitutable products are characterized by more competition. As they affect competition through different channels, they could, in principle, lead to contrasting effects of competition on firms' capital structures. Prior empirical studies, however, typically employ *uni-dimensional* proxies for competition such as industry concentration, which is itself endogenously determined by more fundamental industry characteristics. Theoretical research also largely abstracts away from how different determinants of competition influence firms' capital structures.

Does competition have an unambiguous effect on firm leverage regardless of how it is shaped by industry primitives? If not, how do different determinants of the intensity of competition influence firms' capital structures? We address these questions by developing a tractable model of financing decisions by heterogeneous firms in industry equilibrium. We show that firms in more competitive industries with *greater* product substitutabilities have *higher* leverage, but firms in industries that are more competitive due to *lower* fixed costs of production have *lower* leverage. Leverage, therefore, varies in *contrasting* directions with the intensity of competition depending on which industry primitive drives changes in competition. We show robust empirical support for these predictions as well as the channel that drives them in our theory. Overall, our study emphasizes the importance of theoretically examining capital structure decisions in a unified equilibrium framework that accommodates different determinants of product market competition, and empirically disentangling their contrasting implications for firms' capital structures.

We develop a parsimonious model of an industry in which entrepreneurs establish firms and enter the industry by making a fixed *human capital* investment at date 0. Each firm then realizes an independent shock, which we refer to as its *quality*, that influences the demand for its product.

[1] 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*.

Specifically, consumers have constant elasticity of substitution (CES) preferences for industry products, but assign greater weights to higher quality products, thereby leading to a higher demand for the products of high quality firms. We incorporate firm quality in our model to capture an exogenous firm-specific factor realized upon the establishment and entry of the firm, and interpret it as its natural scale that is determined before its financing and production decisions. Firms next need to make *physical capital* investments for production that they finance through debt and equity. Firms' heterogeneous *productivities* are then independently realized from a known distribution. A firm's production cost has fixed and variable components. The fixed cost is proportional to firm quality with the proportionality constant being an *industry-level* parameter that is common to all firms in the industry. This comports with the notions that certain industries feature higher fixed production costs than other industries and that, even within the same industry, fixed costs could vary with firms' natural scales. The variable cost, which varies with the firm's level of production, declines with the firm's productivity. Firms then make production decisions and generate earnings from which they make debt and dividend payments. The industry is monopolistically competitive, that is, firms offer differentiated, imperfectly substitutable products for which they enjoy monopolies, but take the aggregate price index—a moment of the distribution of prices charged by all firms—as given when they make their financing and production decisions.

Following several classic studies (e.g., Jensen (1986), Stulz (1990), Hart and Moore (1995), Williams (1995), and Zwiebel (1996)), we model debt as a hard claim that reduces a firm's free cash flow—total earnings net of debt payments—thereby restricting the extraction of private benefits by the firm's management. Firms' financing decisions reflect the tradeoff between the benefits of debt against bankruptcy costs that are incurred if firms' realized productivities are below a threshold—the *bankruptcy threshold*—so that their resulting earnings are insufficient to make debt payments. There is a unique equilibrium in which the mass of firms, the aggregate price index, firms' capital structures, and their product market decisions are endogenously determined. The equilibrium is determined by four conditions: (i) the *free entry* condition; the value of an entering firm equals the initial human capital investment; (ii) the *financing* condition; firms optimally choose their capital structures rationally anticipating their subsequent product market decisions; (iii) the *bankruptcy* condition; the equity value of a firm equals zero at the bankruptcy threshold; and

(iv) the *product market clearing* condition; the aggregate revenue of firms equals the aggregate expenditure of consumers or the market size.

As firms need to make their capital investments *after* their qualities are realized, but *before* their productivities are known, firms' capital structures vary with their qualities. Given its realized quality, the optimal debt level of each firm is determined by the usual first order condition that the expected marginal benefit of debt equals the expected marginal bankruptcy cost. Because the condition depends on the probability that the firm is solvent, the expected marginal benefit of debt is determined by the mass of the distribution of firm productivities above the endogenous bankruptcy threshold. Similarly, the expected marginal 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 benefit and, therefore, the optimal leverage depend crucially on the shape of the firm productivity distribution; specifically, the relative masses of its upper and lower tails.

We analyze the equilibrium and derive our main implications for the effects of product market characteristics on firm leverage. Under a condition on the productivity distribution, which ensures that the mass of the upper tail of the distribution is sufficiently heavy relative to the lower tail, firm leverage is higher in industries with higher fixed production costs or product substitutabilities. The intuition hinges on the observation that, an increase in the fixed cost or product substitutability leads to an increase in the disproportionality between the profits generated by more productive firms in the industry relative to less productive ones (conditional on firm quality). , The condition on the firm productivity distribution, which holds for empirically observed Pareto or "power law distributions" (e.g., Gabaix (2016)), then implies that industries with higher fixed costs or product substitutabilities have *more skewed* firm earnings distributions.A more skewed earnings distribution implies that the expected marginal benefits of debt balance the expected marginal bankruptcy costs at a higher debt level. Hence, equilibrium firm debt levels are higher in industries with higher fixed production costs or higher product substitutability.

Our results, therefore, highlight that industry primitives affect capital structure through their impact on the equilibrium distribution of profits among firms with heterogeneous productivities (conditional on firm quality). The reasons that higher fixed production costs or higher product substitutability both result in an increase in the disproportionality between the profits generated by more productive relative to less productive firms are as follows. For a *given* aggregate price index, higher fixed costs 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 human capital 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 of the same quality. 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, 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 of the same quality. Hence, conditional on firm quality, firm profit increases more disproportionately with firm productivity in industries with greater product substitutability.

In standard capital structure models that abstract away from a firm's product market interactions, a firm's leverage choice is determined by its profit distribution that is specified *exogenously.* In our model, the realized distribution of firm profits is *endogenously* determined in the industry equilibrium. The trade-off between the benefits and costs of debt is influenced by the skewness of the 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 *heterogeneous* firms and, thereby, capital structures. Further, in the context of traditional capital structure models, higher fixed costs and product substitutability lower firm profitability and would, therefore, *negatively* impact firm leverage. In sharp contrast, in our market equilibrium model, fixed production costs and product substitutability are both *positively* related to firm leverage.

To forge tighter links between our theory and empirical analysis, we extend the baseline model to a general dynamic framework. As in the baseline model, a firm's quality is realized at the initial date after entrepreneurs make human capital investments. The quality remains fixed through time and can be viewed as a *persistent* determinant of the firm's profits. However, firms' productivities, physical capital investments, the market size, the fixed production cost and product substitutability parameters can all vary over time. In the unique dynamic equilibrium, firms' leverage levels vary over time, but the key implications of the baseline model are robust. A firm's optimal leverage in any period increases with the industry fixed cost and product substitutability parameters during that period with the intuition being similar to that in the baseline model. We also show that our main results also hold when we introduce firm-specific shocks to fixed production costs, thereby distinguishing between industry-specific and firm-specific fixed costs of production. The industry-driven fixed costs are positively associated with firm leverage as in our main model, while the firm-specific fixed cost is negatively related. 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.

We test the empirical implications of our theory in the standard Compustat panel of U.S. non-financial firms over the 1982-2014 period. To construct industry proxies for product substitutability and fixed production costs, we use the Compustat Segments database. Following previous literature (e.g., Nevo (2001) and Karuna (2007)), and consistent with our theory, we measure product substitutability using the industry average price-cost margin. We measure industry fixed production costs by the sensitivity of the industry average operating costs to industry average sales (e.g., Kahl et al. (2014)). For robustness, we also measure the fixed costs by the ratio of sales, general, and administrative (SG&A) expenses to assets (e.g., Chen et al. (2019)).

In our main analysis, we find strong evidence that firm leverage is higher in industries with higher product substitutability and/or higher industry fixed costs as predicted by our theory. Our results are robust to employing alternative measures of financial leverage. The estimated relationships are quantitatively significant. A firm's book leverage increases by approximately 4.2% and 0.9% relative to its sample mean in response to a one standard deviation increase in the product substitutability and the industry fixed costs, respectively. These changes respectively represent about 7.6% and

1.6% of the cross-industry standard deviation of leverage. In addition, when using an alternative measure of the fixed costs based on SG&A, we find that a one standard deviation increase in the industry fixed costs increases firm leverage by 4.3% of its cross-industry standard deviation.

We obtain these results after controlling for firm-specific fixed costs, 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), Chen et al. (2019), and Reinartz and Schmid (2016)). Hence, our results show that industry-specific and firm-specific fixed costs have *opposing* relations with financial leverage. Because they do not disentangle industry- and firm-specific fixed costs in their specifications, prior empirical studies have not uncovered their contrasting relations with firms' financial leverage that we show in our analysis. Our results caution against using industry variables as proxies for individual (firm-level) determinants of capital structure since point estimates on industry aggregates can capture product market equilibrium effects that are not present in firm-level variables. Overall, our findings suggest that industry equilibrium forces have economically and statistically significant implications for corporate capital structure.

In our main tests, we classify industries using the three-digit standard industry classification (SIC) codes. We show that our results are robust to using the four-digit SIC classification, as well as the Hoberg-Phillips (2010, 2016) classifications. To address the potential concern that the Compustat sample does not include *all* (public and private) firms in constructing industry variables, we also use the Census of Manufacturers data and show the robustness of our main results.

Finally, we provide additional evidence in support of the *channel* through which product market characteristics affect capital structure in our theory. Consistent with our model, firm leverage is, indeed, higher in industries with a greater skew in the intra-industry firm profit distribution, thereby providing empirical support for the theoretical mechanism that we highlight. Overall, our empirical analysis provides robust evidence in support of our theoretical predictions for how firm leverage is influenced by inter-industry variation in different determinants of product market competition.

## 2 Related Literature

Our study builds upon the theoretical 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 argue that a firm's choice of higher debt serves to commit the firm to undertake a more aggressive product market strategy. Williams (1995) analyzes an oligopolistic industry with ex ante identical firms. He shows that the industry can have both a profitable core of capital intensive firms with no unique optimal capital structure, and a competitive fringe of labor-intensive firms with no debt. As Showalter (1995) comments, however, the results of oligopolistic models are sensitive to the type of competition (quantity or price competition) between firms. 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 contribute to the literature by developing an industry equilibrium model with a large number of *heterogeneous* firms engaged in *imperfect* (monopolistic) product market competition in which firms have unique capital structures. 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. 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' financing choices. Hence, imperfect product market competition plays a central role in generating one of our novel implications; the effect of the product substitutability on capital structure. Further, firm heterogeneity is also an important feature of our model. As the intuition for our results clarifies, the effects of product market characteristics on capital structure stem from their impacts on the ex post profit distribution of heterogeneous firms. Our theory, therefore, points to a novel product market mechanism by which industry primitives affect capital structure.

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. Using product price and quantity data in four industries, Phillips (1995) shows both positive and negative relations bewteen industry output and debt ratios. Schargrodsky (2002) shows a positive relation between competition and debt ratios in the newspaper industry. 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. Baggs and Brander (2006) show import (export) tariff reductions tend to increase (decrease) leverage, whereas 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 porentially reconciles the conflicting evidence on the directional imoact of product market competition on capital structure by showing that distinct determinants of product market competition—fixed costs of production and product substitutability—can have diametrically opposite effects on firm leverage.

In addition, our results that industry-specific fixed costs are positively related to firm financial leverage stand in contrast to the recent literature that documents a negative relation between firm-specific fixed costs (or operating inflexibility) and financial leverage (e.g., Kahl et al. (2014), Chen et al. (2019), and Reinartz and Schmid (2016)). In our regressions, we control for the direct effect of firm-specific fixed costs, which has a negative association with financial leverage consistent with the results found in those studies. The firm-level control captures the substitutability between a firm's financial and operating leverages, which is distinct from from our theoretical prediction on the positive relation between a firm's financial leverage and the *industry-specific* operating leverage. The contrasting effects of industry- and firm-specific fixed costs 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 fixed costs so they cannot generate the opposite effects that we show in our empirical analysis.

# 3 The model

We develop a model of an industry with a continuum of heterogeneous firms. Our model is designed to be consistent with the fact that, in the data, firm leverage levels vary significantly *within industries* as well as *across industries.* There are three periods with four dates 0, 1, 2, 3.

1. At date 0, entrepreneurs establish firms and enter the industry by making a *human capital* investment.

2. The *qualities* of the firms are realized at date 1 and drawn from a known distribution. As we describe shortly, a firm's quality influences the demand for its product by consumers. Accordingly, we alternatively refer to a firm's quality as its *product quality.* After its quality is realized at date 1, each firm needs to make a *physical capital* investment for production that it finances through equity and debt.

3. At date 2, firms experience independent productivity shocks drawn from a known distribution. Firms then hire employees (including managers and workers), and make their product market decisions.

4. Firms' earnings (revenues net of production costs) are realized at date 3 from which firms make debt and dividend payments.

All agents are risk-neutral (alternatively, we work in the risk-neutral measure) with a risk-free rate that is normalized to zero purely to simplify the notation. In Appendix B, we show that our results hold in an extension of the model to a general dynamic setting with a nonzero risk-free rate.

## 3.1 Model setup

### 3.1.1 Firm creation

There is an unbounded pool of ex ante identical prospective entrepreneurs who establish firms at date 0 by making a fixed human capital investment $J$. The firm's qualities are then realized and independently drawn from a known distribution $H(.)$ with density $h(.)$ and support $[\alpha_L, \alpha_H]$, where $0 < \alpha_L < \alpha_H < \infty$. The firm quality, $\alpha$, could more generally be viewed as a parameter that influences the demand for the firm's product and, therefore, the firm's scale of operations as we describe shortly in Section 3.1.3. We refer to the parameter as "firm quality" for expositional convenience.

### 3.1.2 Firm physical capital investment and financing

At date 1, each firm of quality $\alpha$ must make a fixed physical capital investment for production. For generality, we allow for the required investment to depend on the firm's quality and denote it as $I(\alpha)$. The firm finances the capital investment through equity and debt that is due when firms' earnings are realized at the terminal date 3. After making the investment, each firm then experiences an independent productivity shock $\beta$ at date 2 that is drawn from a known distribution $G(.)$ with density $g(.)$ that has support $[\beta_L, \beta_H]$, where $0 < \beta_L < \beta_H < \infty$. For simplicity, we assume that the productivity distribution, $G(.)$, is independent of the firm quality distribution, $H(.)$.

Consider an arbitrary firm with quality $\alpha$. The firm's earnings at date 3, which we later derive in Section 3.1.3, depend on its quality and realized productivity *after* it makes the physical capital investment at date 1. If the firm's productivity is $\beta$, we denote its earnings by $\pi(\alpha, \beta)$. As we would intuitively expect, the earnings increase in the firm's quality and productivity. Since the required capital investment, $I(\alpha)$, must be made *before* the firm's productivity is realized, the firm's financing decision depends only on its quality, $\alpha$.

Accordingly, let the face value of debt chosen by the firm be $D(\alpha)$, which is the amount that a firm must pay back its debtholders if it is able to do so at date 3, that is, there is limited liability for shareholders. We adopt the perspective of studies such as Grossman and Hart (1982), Jensen (1986), Stulz (1990), Hart (1993), Hart and Moore (1995), Williams (1995) and Zwiebel (1996) where debt is a hard claim that reduces a firm's *free cash flow*—total earnings net of debt payments—and, thereby, restricts the extraction of private benefits by the firm's management. Specifically, we assume that the firm's management extracts a proportion $\kappa$ of its free cash flow as private benefits. Alternatively, only a proportion $1 - \kappa$ of the free cash flow is pledgeable to shareholders (see Chapters 3-5 of Tirole (2006)).[2] When the firm is solvent, therefore, the payoff to shareholders is

$$\pi_E(\alpha, \beta, D(\alpha)) = (1 - \kappa)(\pi(\alpha, \beta) - D(\alpha)). \tag{1}$$

[2] Our main results also hold if we assume an alternate benefit of debt, such as debt tax shields, that induces firms to choose nonzero leverage.

Since shareholders are protected by limited liability, the firm is insolvent if its realized productivity $\beta$ is below the *bankruptcy threshold*, $\beta_B(\alpha, D(\alpha))$, that solves

$$\pi_E(\alpha, \beta_B(\alpha, D(\alpha)), D(\alpha))) = (1-\kappa)(\pi(\alpha, \beta_B(\alpha, D(\alpha))) - D(\alpha)) = 0. \tag{2}$$

In the above, we explicitly indicate the dependence of the bankruptcy threshold on the firm quality, $\alpha$, and the debt level, $D(\alpha)$, for clarity.

If the realized productivity is $\beta \geq \beta_B(\alpha, D(\alpha))$, the firm is solvent and its equity payoff is given by (1). If $\beta < \beta_B(\alpha, D(\alpha))$, the firm is insolvent, and control of the firm transfers to debtholders. The firm continues to operate as an all-equity firm with debtholders effectively becoming the firm's new shareholders. Bankruptcy has deadweight costs so that the firm's free cash flow after bankruptcy is $(1-\theta)\pi(\alpha, \beta)$, where $0 < \theta < 1$ is the proportional bankruptcy cost. As the firm continues to operate as an all-equity firm in insolvency, the management continues to extract a proportion $\kappa$ of the free cash flow. Hence, the bankruptcy payoff to debtholders is

$$\pi_D(\alpha, \beta) = (1-\kappa)(1-\theta)\pi(\alpha, \beta), \text{ for } \beta < \beta_B(\alpha, D(\alpha)). \tag{3}$$

The market value of debt at date 1, which is the amount the firm is able to raise through debt financing, rationally anticipates the likelihood of bankruptcy and is given by

$$\begin{aligned} \text{Debt Value} &= \overbrace{\int_{\beta_B(\alpha, D(\alpha))}^{\beta_H} D(\alpha) g(\beta) d\beta}^{\text{solvency region}} + \overbrace{\int_{\beta_L}^{\beta_B(\alpha, D(\alpha))} \pi_D(\alpha, \beta) g(\beta) d\beta}^{\text{bankruptcy region}} \\ &= D(\alpha)\left[1 - G(\beta_B(\alpha, D(\alpha)))\right] + \int_{\beta_L}^{\beta_B(\alpha, D(\alpha))} (1-\kappa)(1-\theta)\pi(\alpha, \beta) g(\beta) d\beta. \end{aligned} \tag{4}$$

As indicated above, the first term on the R.H.S. of (4) represents the value of payouts to debtholders in the "solvency" region where the firm's realized productivity $\beta$ is greater than or equal to the bankruptcy threshold, $\beta_B(\alpha, D(\alpha))$. The second term represents the value of payouts to debtholders in the "bankruptcy" region where $\beta < \beta_B(\alpha, D(\alpha))$.

When the firm makes its financing decision at date 1, it takes into account the possibility that it may go bankrupt if its realized productivity after making the required capital investment, $I(\alpha)$, is below the bankruptcy threshold, that is, $\beta < \beta_B(\alpha, D(\alpha))$. The payoff to the firm's entrepreneur, who is the original owner of the firm, equals the total proceeds from debt and equity financing less the investment $I(\alpha)$. Under rational expectations, the total proceeds from debt and equity financing equal the market values of debt and equity, respectively. Hence, each firm's capital structure decision maximizes its *total value*, that is, the sum of the values of its debt and equity. The firm's capital structure is determined by the face value of debt or the *debt level* that it chooses. The optimal debt level chosen by the firm at date 1 trades off the benefits of debt in limiting the extraction of private benefits by management against the bankruptcy cost incurred by the firm when its ex post realized productivity is below the bankruptcy threshold. The firm's optimal debt level, therefore, solves the following optimization problem:

$$\sup_{D(\alpha)} \overbrace{\int_{\beta_L}^{\beta_H} \pi_E(\alpha, \beta, D(\alpha)) g(\beta) d\beta}^{\text{equity value}} + \overbrace{+ D(\alpha)\left[1 - G(\beta_B(\alpha, D(\alpha)))\right] + \int_{\beta_L}^{\beta_B(\alpha, D(\alpha))} (1-\kappa)(1-\theta)\pi(\alpha,\beta) g(\beta) d\beta}^{\text{debt value}} - I(\alpha), \tag{5}$$

where the equity payoff is

$$\pi_E(\alpha, \beta, D(\alpha)) = \mathbf{1}_{\beta \geq \beta_B(\alpha, D(\alpha))} (1-\kappa)(\pi(\alpha,\beta) - D(\alpha)). \tag{6}$$

In the above, the indicator function equals one in the solvency region (if $\beta \geq \beta_B(\alpha, D(\alpha))$) or zero in the bankruptcy region (if $\beta < \beta_B(\alpha, D(\alpha))$). Plugging (6) into (5), we can rewrite the optimal capital structure choice problem as

$$\sup_{D(\alpha)} \int_{\beta_B(\alpha, D(\alpha))}^{\beta_H} (1-\kappa)\pi(\alpha,\beta) g(\beta) d\beta + \overbrace{+ \kappa D(\alpha)\left[1 - G(\beta_B(\alpha, D(\alpha)))\right]}^{\text{agency benefit of debt}} + \overbrace{\int_{\beta_L}^{\beta_B(\alpha, D(\alpha))} (1-\kappa)(1-\theta)\pi(\alpha,\beta) g(\beta) d\beta}^{\text{bankruptcy cost of debt}} - I(\alpha). \tag{7}$$

In the objective function above, we indicate the two key terms that represent the benefit of debt in limiting the firm's free cash flow and, thereby, private benefit extraction by management as well as the cost of debt associated with bankruptcy.

#### 3.1.3 Firm production

As mentioned above, firm productivities are realized at date 2 after firms make their physical capital investments. Given their realized productivities, firms make their product market decisions. which require a description of the product market in which firms compete. As in Dixit and Stiglitz (1977), firms compete *monopolistically* in the sense that each firm produces a differentiated good $\omega$ for which it enjoys a monopoly and sets its price. However, firms take the aggregate price index—a weighted average of prices charged by all firms—as *given* when they make their pricing decisions.

The representative consumer's preferences for the consumption of goods produced by firms in the industry are described by the utility function

$$U = \left[ \int_{\Omega} \alpha(\omega)^{1-\rho} q(\omega)^{\rho} d\omega \right]^{\frac{1}{\rho}}, \tag{8}$$

where $\Omega$ is the set of goods available in the industry, and $0 < \rho < 1$ with $\sigma \equiv \frac{1}{1-\rho} > 1$ being the *elasticity of substitution* or *product substitutability* between any two goods in the market. As (8) indicates, the representative consumer assigns *different weights* to the consumption of the *same* number of units of *different* products. This motivates our interpretation of the firm quality, $\alpha(\omega)$, as synonymous with the quality of the product $\omega$ since the consumer derives greater utility from consuming the same number of units of higher quality products. We, therefore, use the terms "firm quality" and "product quality" interchangeably.

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 and $p(\omega)$ be the price of the product $\omega$. Following Dixit and Stiglitz (1977), we maximize the representative consumer's utility given by (8) subject to the budget constraint, $\int_{\Omega} p(\omega)q(\omega)d\omega = R$, which results in the following demand of the representative consumer for the product $\omega$

$$q(\omega) = U\alpha(\omega) \left[ \frac{P}{p(\omega)} \right]^{\sigma}. \tag{9}$$

The firm anticipates the demand for its product specified above when choosing the price of its product. In the above, $P$ is the *aggregate price index* that is given by

$$P = \frac{R}{U} = \Big[\int_{\Omega} \alpha(\omega) p(\omega)^{1-\sigma} d\omega\Big]^{\frac{1}{1-\sigma}}. \tag{10}$$

As mentioned earlier, firms compete monopolistically in the sense that each firm produces a differentiated good $\omega$ 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. As implied by (9), a firm's quality determines its *scale* in that a firm with higher quality sells more units of its product and earns greater revenue for the same price. The production cost of a firm with quality $\alpha$ and productivity $\beta$ has a *fixed* component that does not depend on its output and a *variable* component that increases with its output. The production cost is given by

$$c(\alpha, \beta) = \overbrace{f\alpha}^{\text{fixed cost}} + \overbrace{\frac{q}{\beta}}^{\text{variable cost}}, \tag{11}$$

where $f > 0$ is an *industry-level* parameter that determines the firm's fixed cost of production. The parameter, $f$, could vary across industries, thereby capturing the significant *inter-industry* variation in fixed production costs in the data. By (11), the firm's fixed cost of production increases with firm quality $\alpha$, which comports with the notion that a firm's fixed costs increase with its scale. This is also in line with the data where firms, even within an industry, have different fixed production costs. The production cost, (11), also indicates that the firm's realized productivity $\beta$ determines its marginal cost of production: $mc(\beta) = 1/\beta$.

It follows immediately from (6) and (3) that, regardless of the firm's capital structure, and whether its productivity is above or below the bankruptcy threshold, it is optimal for the firm to choose its product price to maximize its total earnings. Indeed, this choice of product price maximizes total firm value as well as shareholder value. Hence, the firm solves the optimization problem,

$$p(\alpha, \beta) = \arg\max_{p}\ pq(\alpha, p) - f\alpha - q(\alpha, p)/\beta. \tag{12}$$

In the above, $q(\alpha, p)$ is the demand for the firm's product when it chooses a price $p$, which is given by the demand function (9) that is derived from the consumer choice problem. Solving (12) subject to (9), we obtain

$$p(\alpha,\beta)=\frac{\sigma}{(\sigma-1)\beta}. \tag{13}$$

As the optimal product price depends only on the firm's productivity, we hereafter denote it as $p(\beta)$. Because $\sigma > 1$, the product price is greater than the firm's marginal production cost, $1/\beta$, so the firm charges a proportional markup,

$$\frac{p(\beta)-mc(\beta)}{mc(\beta)}=p(\beta)\beta-1=\frac{1}{\sigma-1}. \tag{14}$$

As indicated by (14), 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 (10) and (13), the aggregate price index is then given by

$$P=\left[M\int_{\alpha_L}^{\alpha_H}\left[\int_{\beta_L}^{\beta_H}\alpha\left(\frac{\sigma}{(\sigma-1)\beta}\right)^{1-\sigma}g(\beta)d\beta\right]h(\alpha)d\alpha\right]^{\frac{1}{1-\sigma}}. \tag{15}$$

In the above, $M$ is the mass of firms. We replace the product variety, $\omega$, with the ordered pair, $(\alpha,\beta)$, representing firm quality and productivity, as each firm and, therefore, each product is determined by the firm quality, $\alpha$, and productivity, $\beta$. We note here that, even though an individual firm's optimal product price is unaffected by its capital structure, the mass of firms and the aggregate price index, which are determined endogenously in equilibrium, *are* affected by firms' capital structure choices, as will become clear in Section 4.

By (9), (10), and (13), the firm's revenue and operating profit are

$$r(\alpha,\beta) = R\alpha\left(P\frac{(\sigma-1)}{\sigma}\beta\right)^{\sigma-1}, \tag{16}$$

$$\pi(\alpha,\beta) = \frac{R\alpha\left(P\frac{(\sigma-1)}{\sigma}\beta\right)^{\sigma-1}}{\sigma}-f\alpha. \tag{17}$$

As mentioned earlier in Section 3.1.2, firm revenue and profit are increasing in firm quality and productivity.[3] Further, keeping firm quality fixed, firm revenue and profit increase *more dispropor-*

[3]We assume that $\frac{R\left(P\frac{(\sigma-1)}{\sigma}\beta\right)^{\sigma-1}}{\sigma}>f$ for all $\beta$, so that an operating firm has nonnegative profit.

*tionately* 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 relative to less productivity firms of the same quality. 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, which charge lower prices, are able to garner even greater rents. Hence, conditional on firm quality, firm revenue and profit increase more disproportionately with firm productivity in industries with less product differentiation.

To avoid complicating the analysis without altering our main implications, we assume that parameter values are such that

$$\int_{\beta_L}^{\beta_H} (1-\kappa)\pi\left(\alpha,\beta\right) g(\beta)d\beta \geq I(\alpha),\ \forall\ \alpha \in [\alpha_L, \alpha_H]. \tag{18}$$

As is clear from each firm's objective function on the R.H.S. of (5), a firm's market value at date 1 (that is, after it makes the human capital investment and its quality is realized) equals the sum of the market values of equity and debt less the physical capital investment. The above condition implies that the market value of every firm is nonnegative even if it chooses all-equity financing. Because each firm chooses its capital structure to maximize its market value by (5), the condition guarantees that the market values of all firms are nonnegative at date 1. Alternatively, the physical capital investments have positive NPV for all firms.

### 3.2 Equilibrium conditions

An equilibrium of the economy is characterized by (i) a mass $M^*$ of firms (and hence $M^*$ differentiated products); (ii) an aggregate price index $P^*$; (iii) the optimal capital structure choices of firms that are determined by their optimal debt levels $\{D^*(\alpha); \alpha \in [\alpha_L, \alpha_H]\}$; and (iv) the bankruptcy thresholds $\{\beta_B^*(\alpha) = \beta_B^*(\alpha, D^*(\alpha))\}$ of the firms. 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 conditions that determine the equilibrium. We use the superscript * to denote equilibrium variables.

1. Each firm's debt level choice ($D^*(\alpha)$) solves (7), where the profit, $\pi^*(\alpha, \beta)$, of a firm with quality $\alpha$ and productivity $\beta$ is given by (17) with the aggregate price index equal to $P^*$. Here, $P^*$ is given by (15) with the mass of firms equal to $M^*$, i.e.,

$$P^* = \left[ M^* \int_{\alpha_L}^{\alpha_H} \left[ \int_{\beta_L}^{\beta_H} \alpha \left( \frac{\sigma}{(\sigma - 1)\beta} \right)^{1-\sigma} g(\beta) d\beta \right] h(\alpha) d\alpha \right]^{\frac{1}{1-\sigma}}. \tag{19}$$

2. The *bankruptcy* (B) condition specifies that the equity payoff of each firm must be zero at the bankruptcy threshold $\beta_B^*(\alpha)$, i.e.,

$$B : \pi_E^*(\alpha, \beta_B^*(\alpha)) = (1 - \kappa)(\pi^*(\alpha, \beta_B^*(\alpha)) - D^*(\alpha)) = 0, \ \forall \ \alpha \in [\alpha_L, \alpha_H]. \tag{20}$$

3. The *free entry* (FE) condition specifies that the *ex ante* expectation of a firm's market value post-entry must equal the human capital investment $J$ made at date 0, i.e.,

$$\begin{aligned} FE : J = ( & \int_{\alpha_L}^{\alpha_H} \left( -I(\alpha) + \left[ \int_{\beta_B^*(\alpha)}^{\beta_H} (1 - \kappa)\pi^*(\alpha, \beta) g(\beta) d\beta \right] \right) h(\alpha) d\alpha \\ & + \int_{\alpha_L}^{\alpha_H} \kappa D^*(\alpha) \left[1 - G(\beta_B^*(\alpha))\right] h(\alpha) d\alpha \\ & + \int_{\alpha_L}^{\alpha_H} \int_{\beta_L}^{\beta_B^*(\alpha)} (1 - \kappa)(1 - \theta) \left[\pi^*(\alpha, \beta) g(\beta) d\beta\right] h(\alpha) d\alpha \end{aligned} \tag{21}$$

Note that we integrate over firm quality levels on the R.H.S. above as it is the *ex ante* expectation of firm value at date 0. The motivation for the free entry condition is that, if a firm's expected post-entry market value strictly exceeds the human capital investment $J$, more firms will be created at date 0, thereby decreasing the expected market value until it equals $J$. If firms' expected post-entry market value is strictly less than $J$, then no firms will be created at date 0. In equilibrium, therefore, the expected market value post-entry must equal $J$.

4. The *product market clearing* (PMC) condition requires that the aggregate revenue of firms

operating in the market must equal the total consumer expenditure (i.e., market size), $R$, i.e.,

$$PMC: \; R = M^* \int_{\alpha_L}^{\alpha_H} \left[ \int_{\beta_L}^{\beta_H} r^*(\alpha,\beta) g(\beta) d\beta \right] h(\alpha) d\alpha, \tag{22}$$

where the revenue of a firm with quality $\alpha$ and productivity $\beta$, $r^*(\alpha,\beta)$, is given by (16) with the aggregate price index equal to $P^*$. By (19), the equilibrium mass, $M^*$, of firms and the aggregate price index, $P^*$, are related as follows.

$$M^* = \left( P^* \frac{(\sigma-1)}{\sigma} \right)^{1-\sigma} \left[ \int_{\alpha_L}^{\alpha_H} \int_{\beta_L}^{\beta_H} \alpha \beta^{\sigma-1} g(\beta) h(\alpha) d\beta d\alpha \right]^{-1}. \tag{23}$$

# 4 The equilibrium

We now characterize the equilibrium and derive the main testable implications of the theory.

## 4.1 Optimal debt levels

Consistent with monopolistic competition, firms take the aggregate price index, $P^*$, as given when they choose their capital structures at date 1. Consider a firm of quality $\alpha$. The firm's optimal choice of debt level solves (7), where the firm's profit function is $\pi^*(\alpha,\beta)$ given by (17) with the aggregate price index set to $P^*$. Hence, the optimal debt level of the firm solves the following problem:

$$\begin{aligned} D^*(\alpha) = \arg\sup_D \int_{\beta_B(\alpha,D)}^{\beta_H} (1-\kappa)\pi^*(\alpha,\beta) g(\beta) d\beta + \\ + \kappa D \left[1 - G(\beta_B(\alpha,D))\right] + \int_{\beta_L}^{\beta_B(\alpha,D)} (1-\kappa)(1-\theta)\pi^*(\alpha,\beta) g(\beta) d\beta, \end{aligned} \tag{24}$$

where the bankruptcy threshold, $\beta_B(\alpha,D)$, solves

$$\pi^*(\alpha, \beta_B(\alpha,D)) = D. \tag{25}$$

If $D^*(\alpha) > 0$ (in Proposition 1 below, we show that this must hold), the first order necessary condition of the optimization problem is as follows.

$$\overbrace{\kappa[1-G(\beta_B(\alpha,D^*(\alpha)))]}^{\text{expected marginal benefit of debt}} = \overbrace{[\kappa D^*(\alpha)+(1-\kappa)\theta\pi^*(\alpha,\beta_B(\alpha,D^*(\alpha)))]g(\beta_B(\alpha,D^*(\alpha)))\beta_B^{'}(\alpha,D^*(\alpha))}^{\text{expected marginal cost of debt}}. \tag{26}$$

As shown by (26), the expected marginal benefit of debt is determined by the proportional private benefit parameter, $\kappa$, multiplied by the mass $1-G(\beta_B(\alpha,D^*(\alpha)))$ of the productivity distribution to the right of the bankruptcy threshold because this is the region where the firm is solvent and enjoys the full benefits of debt. The expected marginal cost of debt depends on the density $g(\beta_B(\alpha,D^*(\alpha)))$ of the productivity distribution at the bankruptcy threshold, and the marginal change in the bankruptcy threshold $\beta_B^{'}(\alpha,D^*(\alpha))$. 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 levels and, therefore, the optimal capital structures of all firms.

**Proposition 1 (Optimal Debt Levels)**

1. *The optimal debt levels of firms scale with firm quality, that is,*

$$D^*(\alpha) = \left(\frac{\alpha}{\alpha_L}\right) D^*(\alpha_L). \tag{27}$$

*Moreover, in equilibrium, firms' bankruptcy thresholds do not depend on their qualities, that is,*

$$\beta_B^*(\alpha,D^*(\alpha)) = \beta_B^*(\alpha_L,D^*(\alpha_L)) = \beta_B^* \tag{28}$$

2. *The optimal debt level chosen by a firm of quality $\alpha$ is strictly positive and satisfies*

$$D^*(\alpha) = \frac{\kappa(\sigma-1)f\alpha}{(\kappa+(1-\kappa)\theta)\Lambda(\beta_B^*)-\kappa(\sigma-1)}, \tag{29}$$

*where*

$$\Lambda(\beta) = \frac{\beta g(\beta)}{1-G(\beta)}. \tag{30}$$

A firm's profit as well as the bankruptcy payoff to the firm's debtholders if the firm is insolvent are *both* proportional to its quality by (17) and (3). Hence, as Part 1 of the proposition shows, the optimal debt levels chosen by firms are also proportional to their qualities. As the optimal debt level, $D^*(\alpha)$, is proportional to a firm's quality, it then follows immediately from (20) that a firm's equilibrium bankruptcy threshold is, in fact, independent of its quality. Intuitively, firms of higher quality (or scale) choose proportionally more debt than firms of lower quality (or scale) so that the productivity threshold below which they are insolvent is the same. By (29) and (30), the optimal debt level of each firm depends on the shape of the firm productivity distribution as captured by the function, $\Lambda(\beta)$. As we show in Section 4.3 below, the properties of $\Lambda(\beta)$ play a central role in how product market characteristics affect firms' capital structures.

## 4.2 Product market equilibrium

We now complete our analysis of the full equilibrium of the model. We derive the equilibrium of the product market, and, thereby, characterize the equilibrium aggregate price index, $P^*$. This, in turn, determines the equilibrium mass of firms, $M^*$, by (23); the equilibrium bankruptcy threshold, $\beta_B^*$; and the equilibrium firm capital structures by (29). By Proposition 1, the equilibrium debt levels of firms scale with firm quality and the bankruptcy threshold does not vary with firm quality.

By the scaling property, $\pi^*(\alpha,\beta) = \frac{\alpha}{\alpha_L}\pi^*(\alpha_L,\beta)$ (see (17)) and $D^*(\alpha) = \frac{\alpha}{\alpha_L}D^*(\alpha_L)$ by (27), and the invariance of the bankruptcy threshold with respect to firm quality, we can replace the continuum of bankruptcy conditions for firms of different qualities by a *single* bankruptcy condition for firms of the lowest quality, $\alpha_L$.

$$B : \pi_E^*(\alpha_L, \beta_B^*) = (1-\kappa)(\pi^*(\alpha_L, \beta_B^*) - D^*(\alpha_L))) = 0. \tag{31}$$

We can similarly exploit the scaling properties of firm profits and debt levels, as well as the invariance of the bankruptcy threshold, to re-express the free entry condition, (21), as follows.

$$FE : J = \int_{\alpha_L}^{\alpha_H} \left( -I(\alpha) + \frac{\alpha}{\alpha_L} \left[ \int_{\beta_B^*}^{\beta_H} (1-\kappa)\pi^*(\alpha_L, \beta) g(\beta) d\beta \right] \right) h(\alpha) d\alpha$$

$$+\kappa D^*(\alpha_L)\int_{\alpha_L}^{\alpha_H}\frac{\alpha}{\alpha_L}\left[1-G(\beta_B^*)\right]h(\alpha)d\alpha+(1-\kappa)(1-\theta)\int_{\alpha_L}^{\alpha_H}\frac{\alpha}{\alpha_L}\left[\int_{\beta_L}^{\beta_B^*}\pi^*(\alpha_L,\beta)g(\beta)d\beta\right]h(\alpha)d\alpha. \tag{32}$$

It is convenient to further re-express the bankruptcy (B) and free entry (FE) conditions. We define the *average* firm revenue and profit of firms with the lowest quality $\alpha_L$ *prior to the realization of their productivities* at date 2 as follows.

$$\overline{r}^*(\alpha_L) \equiv \int_{\beta_L}^{\beta_H} r^*(\alpha_L,\beta)g(\beta)d\beta, \tag{33}$$

$$\overline{\pi}^*(\alpha_L) \equiv \int_{\beta_L}^{\beta_H} \pi^*(\alpha_L,\beta)g(\beta)d\beta = \frac{\overline{r}^*(\alpha_L)}{\sigma} - f\alpha_L, \tag{34}$$

where (34) follows from (16), (17) and (33). By the law of large numbers, $\overline{r}^*(\alpha_L)$ and $\overline{\pi}^*(\alpha_L)$ are, respectively, equal to the expected revenue and profit of firms with the lowest quality. The functional form of the revenue function, $r^*(\alpha_L,\beta)$, in (16) allows us to express the average revenue as $\overline{r}^*(\alpha_L)=r^*(\alpha_L,\bar{\beta})$, where

$$\overline{\beta}^{\sigma-1} \equiv \int_{\beta_L}^{\beta_H} \beta^{\sigma-1}g(\beta)d\beta. \tag{35}$$

As the following proposition shows, the bankruptcy (B) and free entry (FE) conditions, (31) and (32), can be viewed as two different functional relations linking the average profit level of the lowest quality firms, $\overline{\pi}^*(\alpha_L)$, with the bankruptcy threshold, $\beta_B^*$.

**Proposition 2 (B and FE conditions)**

*The bankruptcy (B) and free entry (FE) conditions, (31) and (32), can be expressed as follows.*

$$B:\overline{\pi}^*(\alpha_L) = \left[\left(\frac{\overline{\beta}}{\beta_B^*}\right)^{\sigma-1}-1\right]f\alpha_L+\left(\frac{\overline{\beta}}{\beta_B^*}\right)^{\sigma-1}D^*(\alpha_L), \tag{36}$$

$$\begin{aligned} FE: J+\int_{\alpha_L}^{\alpha_H} I(\alpha)h(\alpha)d\alpha &= (1-\kappa)\frac{\overline{\alpha}}{\alpha_L}\overline{\pi}^*(\alpha_L)+\kappa D^*(\alpha_L)\frac{\overline{\alpha}}{\alpha_L}\left[1-G(\beta_B^*)\right)] \\ &\quad -(1-\kappa)\theta\frac{\overline{\alpha}}{\alpha_L}\int_{\beta_L}^{\beta_B^*}\left[\left(\frac{\beta}{\overline{\overline{\beta}}}\right)^{\sigma-1}\overline{\pi}^*(\alpha_L)-\left(1-\left(\frac{\beta}{\overline{\overline{\beta}}}\right)^{\sigma-1}\right)f\alpha_L\right]g(\beta)d\beta, \end{aligned} \tag{37}$$

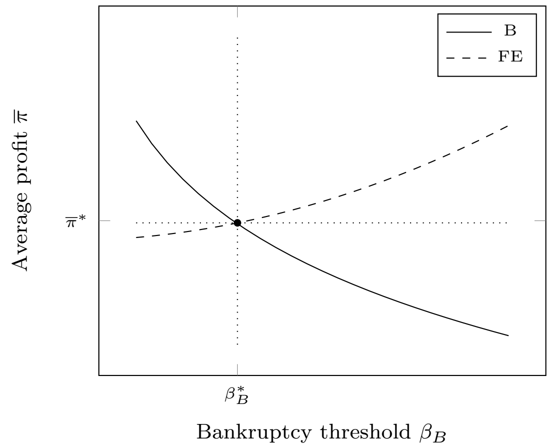


Figure 1: Determination of the equilibrium bankruptcy threshold, $\beta_B^*(D)$, and average profit, $\overline{\pi}^*(\alpha_L)$, for a given debt level $D$

*where* $\overline{\alpha} = \int_{\alpha_L}^{\alpha_H} \alpha h(\alpha) d\alpha$ *is the average firm quality.*

As shown in Figure 1, it follows from (36) and (37) that, in the space of ordered pairs, $(\beta_B^*, \overline{\pi}^*(\alpha_L))$, 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.

## 4.3 Product market characteristics and capital structure

The equilibrium debt level, $D^*(\alpha)$, given by (29) depends on the product market characteristics; the product substitutability $\sigma$ and the fixed production cost parameter, $f$. Further, by (20) and (21), the endogenous bankruptcy threshold, $\beta_B^*$, is itself influenced by the product market characteristics. Consequently, product market characteristics both *directly* affect the debt level and indirectly influence it via the endogenous bankruptcy threshold. Given the equilibrium debt level, $D^*(\alpha)$, of a firm with quality $\alpha$, the *book leverage* of the firm is the ratio of the debt level to the book value of the firm, which equals the physical capital investment $I(\alpha)$. The following proposition shows how the optimal debt levels and book leverages of firms vary with product market characteristics.

**Proposition 3 (Product market characteristics and leverage)**

*Suppose that* $D^*(\alpha_L) < \overline{\pi}^*(\alpha_L)$ *and* $\Lambda'(\beta) \leq 0$ *over the support,* $[\beta_L, \beta_H]$*, of the productivity distribution. The optimal debt levels and book leverage ratios of firms all increase with the fixed* *cost of production $f$ and the product substitutability $\sigma$.*

To understand the intuition for the proposition, we first observe that an increase in the fixed production cost or product substitutability leads to an increase in the degree of disproportionality between the profits generated by more productive firms relative to less productive firms *for each level* of firm quality. 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, (21), then implies that the endogenously determined aggregate price index must be higher to ensure that the average ex post profit of firms equals the total physical and human capital 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 (17), a higher aggregate price index has a greater positive effect on the profits of more productive firms relative to less productive ones of the same quality. 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 (9)). 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 (17) and (21) that, at each level of firm quality, 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. More productive firms can, therefore, capture disproportionately higher market shares and rents by charging lower prices than less productive firms of the same quality. Hence, the firm profit-productivity relation is *more disproportionate* in industries with greater product substitutability.

As discussed above, conditional on firm quality, an increase in the fixed production costs or product substitutability increases the disproportionality between the profits generated by more productive relative to less productive firms . Firms' leverage choices reflect the trade-off between the advantages of debt, which accrue when firms have positive free cash flows so that debt is effective in constraining the extraction of private benefits by managers, and the disadvantages of debt due to bankruptcy costs. Consequently, the ex ante debt level choice depends on the skew of the firm profit distribution that, in turn, depends on the relative masses of the tails of the firm productivity distribution above and below the bankruptcy threshold. The debt capacity and, therefore, the optimal debt level increase if the upper tail of the firm productivity distribution is sufficiently pronounced relative to the lower tail. The condition, $D^*(\alpha_L) < \overline{\pi}^*(\alpha_L)$, which is equivalent to $D^*(\alpha) < \overline{\pi}^*(\alpha)$ by the scaling property of profit and debt levels, simply expresses that the optimal debt level is less than the average profit of firms. This, in turn, implies that the bankruptcy threshold, $\beta_B^*$ is less than the average productivity of firms, $\overline{\beta}$. defined by (35). [4] This condition along with the condition on the productivity distribution, $\Lambda'(\beta) \leq 0$, implies that the mass of the tail of the firm productivity distribution above the bankruptcy threshold, indeed, sufficiently outweighs that of the lower tail.

The condition on the productivity distribution, which is a sufficient but not necessary condition for the results, holds if firm productivity has a Pareto or power law distribution, that is,

$$G(\beta) = 1 - k\beta^{-x}, \tag{38}$$

where $k$ and $x$ are positive constants. 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 5 for details on the construction of industry variables). The evidence in Figure 3 is consistent with considerable empirical evidence that firm size follows a Pareto distribution (Gabaix and Landier (2008), Gabaix (2016)). In our model, it follows from (16) and (17) 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 on the productivity

[4] By the law of large numbers, the average profit, $\overline{\pi}^*(\alpha)$, is the ex ante expectation of the earnings/value of a firm of quality $\alpha$ at the terminal date 3. Hence, the condition says that the debt level should be less than expected firm value. By the positive NPV condition (18), the condition automatically holds if $D^*(\alpha) < I(\alpha)$, that is, the face value of debt is less than the required physical capital investment.

distribution holds in the data.[5]

An interesting and novel implication of Proposition 3 is that the effects of product market competition on capital structure 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.

It is instructive to contrast the predictions of our market equilibrium model with those of traditional tradeoff models. In the traditional model, each firm's profit distribution is *exogenously specified*. The firm's leverage choice trades off the benefits of debt against bankruptcy costs. An increase in the fixed cost of production or product substitutability negatively impacts profitability so that the traditional model would predict *negative* relations between firm leverage and *both* product market characteristics. In contrast, in our model, each firm's profit distribution is endogenously derived in equilibrium of the product market. Consequently, as discussed above, the mechanism through which product market characteristics influence firm leverage is more complex. An increase in either the fixed cost or the product substitutability leads to a transfer of wealth from less profitable to more profitable firms. The increased skewness of the firm profit distribution then induces firms to increase leverage, thereby leading to *positive* relations between firm leverage and the product market characteristics.

## 4.4 Dynamic Model

In the data, firms' leverage ratios change over time, and product market characteristics may also be time-varying. To forge tighter links between our theory and empirical analysis in Section 5, we incorporate these possibilities by extending our baseline model to a general dynamic setting

[5]More generally, the condition holds if $G(\beta) = 1 - f(\beta)\beta^{-x}$, where the function $f(.)$ is strictly positive and such that $\frac{\beta f^{'}(\beta)}{f(\beta)}$ is non-decreasing over the support, $[\beta_L, \beta_H]$ of the distribution.

in Appendix B. We briefly describe the model here and provide the details in Appendix B.

We consider an infinite horizon, discrete time setting with dates $0, 1, 2, .....$ The risk-free rate is a constant $r > 0$. As in the baseline model, entrepreneurs establish firms by making a human capital investment at date 0 after which the qualities of the firms are realized and drawn from a known distribution, $H$, with density $h$ and support $[\alpha_L, \alpha_H]$. A firm's quality remains constant through time and can be viewed as a *persistent* characteristic of the firm that determines its natural scale. At the beginning of each period, $[t, t+1]; t \geq 0$, each firm of quality $\alpha$ needs to make a physical capital investment $I_t(\alpha)$ for production that it finances through equity and debt. The capital investment, $I_t(\alpha)$, could vary stochastically over time so that firms of the same quality could have different required capital investments. As in the baseline model, after making the capital investment, each firm experiences an independent productivity shock $\beta$ that is drawn from a known distribution $G_t(.)$ with density $g_t(.)$ that has support $[\beta_L, \beta_H]$. The productivity distribution, $G_t(.)$ is independent of the product quality distribution, $H(.)$. The time subscripts on the firm productivity distributions indicate that they can vary over time. All agents know the laws of these processes. Firms compete monopolistically in each period as in the baseline model. The market size, the fixed cost of production parameter, $f_t$, and the product substitutability, $\sigma_t$, may all vary stochastically over time.

We derive the unique equilibrium of the model. By arguments very similar to those in Section 4.3, we show that, if $\Lambda_t'(\beta) \leq 0$, where $\Lambda_t(\beta) = \frac{\beta g_t(\beta)}{1-G_t(\beta)}$, then a firm's debt level and, therefore, its book leverage in period $t$ increases with the fixed costs of production and the product substitutability in the period. Hence, the implications of the baseline model extend to the general dynamic model. Our analysis, therefore, leads to the following two testable hypotheses.

**Hypothesis 1**. *A firm's book leverage increases with the industry-specific fixed cost of production.*

**Hypothesis 2**. *A firm's book leverage increases with the product substitutability of the industry.*

# 5 Empirical analysis

As discussed above, our model predicts that firm leverage ratios increase with the industry fixed costs and product substitutability We first present empirical evidence on the variation in firm leverage with the industry-level product market characteristics. We then provide evidence in support of the theoretical channel through which product market characteristics influence firm leverage by showing that firm leverage ratios increase with the skewness of the intra-industry firm profit distribution.

## 5.1 Data and descriptive statistics

Our firm-level sample consists of U.S. companies covered by the Compustat database over the period 1982–2014. To identify a firm's primary industry sector, we use a firm's historical SIC code (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 SIC code from Compustat.

We exclude all regulated utilities (SIC 4900-4999) and financial firms (SIC 6000-6999) as their capital structures are regulated, and our theory is not designed to explain the financial decisions of firms in these industries. For the same reasons, 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, 2016) industry classification. To capture industry characteristics reasonably, we retain observations in industries that have more than five firms each year.[6] After an additional sample restriction arising from the construction of our product market variables, described in detail below, the final baseline sample consists of 72,994 firm-years for 8,236 distinct firms in 229 three-digit SIC code industries. Appendix D provides detailed definitions of our empirical variables.

#### 5.1.1 Product market variables

As the Compustat Fundamentals Annual database assigns a firm's consolidated operating statistics (such as sales and operating costs) to its primary industry only, we construct the industry variables using Compustat's Segment database that reports a firm's operating variables at the segment level. We start with all operating/business segments from the database and retain segments with positive sales and operating costs. We compute operating 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 industry-level product market variables using both single- and multi-segment firms' sales and operating costs. As mentioned above, we later consider alternate industry classifications (four-digit SIC and the Hoberg-Phillips (2010, 2016) classification).

Following prior studies in the industrial organization and finance literatures (e.g., Nevo (2001), Karuna (2007), Subramanian (2013), Jung and Subramanian (2017)), we measure the degree of product substitutability in an industry by the *industry average price-cost margin.* 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 (see (14)). Hence, our measure of the industry product substitutability is also consistent with our model. 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. Our model predicts a *positive* relationship between leverage ratios and the product substitutability

[6] Our results are robust to retaining industry observations that have at least two firms each year.

measure.

To construct our proxy for industry fixed costs, we follow the literature that estimates firm-level operating leverage using the sensitivity of a firm's operating costs to sales. This approach is necessary because firms do not disclose the breakdown of total costs into variable and fixed costs. Instead, *greater* operating leverage—that is, *higher* fixed costs—corresponds to a *lower* sensitivity of total operating costs to sales shocks. Following Kahl et al. (2014), we 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. We employ the following regression:

$$\mu_{i,\kappa}^{X} = b_i^t \times \mu_{i,\kappa}^{S} + \varepsilon_{i,\kappa}, \quad \kappa \in [t-3, t]\,. \tag{39}$$

In the above,

$$\mu_{i,\kappa}^{X} = (X_{i,\kappa} - E[X_{i,\kappa}])/X_{i,\kappa-1} \text{ and } \mu_{i,\kappa}^{S} = (S_{i,\kappa} - E[S_{i,\kappa}])/S_{i,\kappa-1}$$

represent innovations in the growth rate of operating costs and sales for firm $i$ in period $\kappa$, respectively. The innovations are computed relative to the ex-ante expectations of operating costs and sales, extrapolated from the previous two-year geometric growth rate as follows: $E[X_{i,\kappa}] = X_{i,\kappa-1}\left(\frac{X_{i,\kappa-1}}{X_{i,\kappa-3}}\right)^{1/2}$ and $E[S_{i,\kappa}] = S_{i,\kappa-1}\left(\frac{S_{i,\kappa-1}}{S_{i,\kappa-3}}\right)^{1/2}$.

We use the coefficient on innovations in the sales growth rate, $b_i^t$, to construct our proxy for *firm-level operating leverage*. Intuitively, $b_i^t$ 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. To estimate $b_i^t$ for each firm $i$ in period $t$, we run the firm-level regressions in (39) using the previous four 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 take the negative of the estimated $b_i^t$ as our measure of firm-level operating leverage for ease of interpretation since higher fixed costs reduce the sensitivity of operating costs to sales. We use an analogous approach to construct a measure of *industry-level operating leverage* meant to capture the component of fixed operating costs that is common to all firms in an industry. To obtain our industry fixed cost measure, we run the regression in (39) 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 $b_{j,t}$.[7]

For robustness, we also carry out our analysis with another proxy for operating leverage proposed in Chen et al. (2019) based on the *ratio of sales, general, and administrative (SG&A) expenses to asset*s. The advantage of this measure relative to our main proxy, which relies on estimating the sensitivity of operating costs to sales shocks, is that it imposes fewer data restrictions and is hence available for a larger sample. However, SG&A is a very coarse proxy for operating leverage and may capture other firm characteristics such as intangible capital (e.g., Eisfeldt and Papanikolaou (2014)). Therefore, we use the measures based on the sensitivities of operating costs as our main measures of operating leverage, and employ the SG&A-based measure in additional robustness tests.

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.

#### 5.1.2 Financial leverage measures

In our regression analyses, the dependent variable is a firm's financial leverage ratio. We employ *four alternative* measures of financial leverage in our analysis. (i) Our main measure of financial 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 in our model better than market leverage since it does not depend on ex-post market values of firms. (ii) Our second measure is a firm's long-term book leverage, measured as the ratio of long-term debt to total book assets. (iii) Our third measure adds the capitalized value of operating leases to total debt to capture the fact that operating leases are a large source of external finance for some firms (Eisfeldt and Rampini (2009)). (iv) Our fourth measure of financial leverage is a firm's market leverage, measured as total debt divided by the

[7] We 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 72,994 to 59,185 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.

market value of total assets.

### 5.1.3 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 descriptive statistics indicate that the average and the median markup in our sample are about 1.7% and 3.5%. The average industry-level operating leverage implies 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.

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. The correlation between the industry-level and firm-level operating leverages is positive but low, which implies that these measures tend to capture different types of fixed costs. The correlation matrix does not show very high correlations among the main independent variables, thereby mitigating the possibility of multicollinearity.

## 5.2 Baseline analysis

To explore our testable predictions, we run firm-level panel regressions that include our measures of product substitutability and industry fixed cost as regressors.

$$\begin{aligned} y_{ijt} &= \beta_t + \alpha_1 \text{Product substitutability}_{jt-1} + \alpha_2 \text{Industry fixed cost}_{jt-1} \\ &\quad + \alpha_3 \text{Firm fixed cost}_{it-1} + \alpha_4 X_{it-1} + \alpha_i + \varepsilon_{ijt}. \end{aligned} \tag{40}$$

In the above regression model, the subscripts $i$, $j$, and $t$ represent the firm, industry, and year, respectively. 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 also include the *firm-level fixed cost* measure as another control variable to allow for a direct effect of firm-level fixed costs on financial leverage (Kahl et al. (2014), Chen et al. (2019), and Reinartz and Schmid (2016)). 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 implies a *negative* relation between financial leverage and the *firm-level* fixed cost. This needs to be distinguished from our theoretical prediction of a *positive* relation between a firm's financial leverage and the *industry-level* fixed cost. We include year effects, $\beta_t$, to control for average variation in capital structure over time. Further, we include firm fixed effects, $\alpha_i$, in all our specifications to control for unobserved time-invariant heterogeneity across firms. The inclusion of firm fixed effects also makes the baseline specification consistent with our general dynamic model presented in Appendix B that incorporates persistent (time-invariant) characteristics for firms in addition to productivity shocks that vary over time. 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.[8] Consistent with the predictions of our model, the estimated coefficients of our measures of product substitutability and industry fixed cost are significantly positive in both specifications. The estimates are also economically meaningful. For example, based on the estimates obtained after controlling for firm fixed effects in column (2), a one-standard deviation increase in product substitutability corresponds to a 4.16% increase in the book leverage ratio relative to to the sample average leverage ratio. Along similar lines, a one standard deviation increase in industry fixed cost measure is related to a 0.88% increase in book leverage relative to the sample average leverage ratio. These changes correspond, respectively, to

[8] We present the results from the baseline specification with industry fixed effects in this table for robustness, to show that our findings are not driven by the inclusion of firm fixed effects. In subsequent empirical results, we focus on the firm fixed effects specification as such a specification is more consistent with our model.

about 7.6% and 1.6% increases relative to the cross-industry standard deviation of leverage.[9] 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, a firm's financial leverage increases with the industry product substitutability and industry fixed cost, even though they are expected to infuence product market competition among firms in the industry in *opposite* directions. These results suggest that different proxies for "industry competition" might be positively or negatively related to a firm's capital structure, depending on which underlying industry primitive these proxies tend to capture.

In contrast with the positive relation between book leverage and the *industry-level* fixed cost, the relation between book leverage and the *firm-level* fixed cost is negative. This finding is consistent with recent empirical studies (Kahl et al. (2014), Chen et al. (2019), and Reinartz and Schmid (2016)) and with the extension of our model in Appendix C. The coefficient on the firm fixed cost is significant at the 1% confidence level, with economic significance comparable to that of the industry fixed cost.[10]

## 5.3 Robustness tests

We now examine the robustness of our main empirical results to alternate choices of our dependent and independent variables.

### 5.3.1 Single-segment firms

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 char-

[9] Our theory shows that *inter-industry* variations in the product substitutability and industry fixed cost contribute to *inter-industry* variation in leverage. The variation in firm leverage is also influenced by variations in a host of other firm-specific variables. Accordingly, we compare the variation in leverage generated by variation in each of the product market variables of interest—the product substitutability and the industry fixed cost—relative to the standard deviation of leverage across the industry-years (0.127), rather than the standard deviation of leverage across the firm-years (0.206).

[10] A one-standard deviation increase in firm-level fixed cost is related to an 1.41% decrease in book leverage relative to the sample average leverage ratio.

acteristics 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 (40) using the sample of *single-segment firms* alone. 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 fixed cost. We conclude that our baseline results are unlikely to be distorted by systematic differences between multi-segment and single-segment firms.

#### 5.3.2 Alternate measures of financial leverage

In Table 3, we explore the robustness of our empirical results to alternate measures of financial 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. The table reports the results of re-estimating regression (40) 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 on product substitutability and industry fixed cost remain positive and statistically significant in all these regressions. We note though that, in the case of market leverage, the statistical significance of the firm-level fixed cost is only at the 10% confidence level. The finding of the weaker association of firm-level fixed cost with financial leverage is similar to the results in Kahl et al. (2014).

#### 5.3.3 Alternate industry variables

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 (e.g., Karuna (2007) and 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). The Census data reports a detailed breakdown of the components of variable costs such as materials, production workers' wages, total pay and energy. We construct our alternate measure of product substitutability using these variables costs only, in contrast to our baseline analysis in which we use the total operating costs (i.e., the difference between sales and operating profits). Using variable costs only would be more closely tied to the model as it relates the product substitutability to the difference between price and marginal costs (instead of total costs).

A drawback of the Census data, however, 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, and, therefore, fixed operating costs. Thus, in these robustness tests, we can use the Census data to construct alternate measures of the product substitutability and market size, but not the measures of fixed costs. For fixed costs—both firm and industry-level—we continue to use the variables constructed from the Compustat Segment database. Columns (1) and (2) of Table 3 show the regression results we obtain using the Census data. We measure variable costs by the sum of material costs and production workers' wages in Column (1), and by the sum of material costs, total pay, and energy in Column (2). In both columns, the positive coefficient estimates on product substitutability and industry fixed cost remain significant, whereas the negative estimates of firm-level fixed cost become insignificant. Hence, our main results are robust to the alternate measure of product substitutability as well as the inclusion of private firms.

Next, we investigate the robustness of our results to an alternate measure of fixed costs. As discussed in Section 5.1.1, the empirical measurement of fixed costs is not straightforward since firms do not report the breakdown of total operating costs into fixed and variable components. Our baseline measure follows the long tradition of estimating fixed costs as an elasticity of earnings to changes in sales using a time-series regression approach that goes back to Mankelder and Rhee (1984). While sound on conceptual grounds, this approach imposes substantial data restrictions as it relies on a within-firm estimation that requires that the data are available for at least six years for each firm. In addition, the baseline measure is by construction persistent as it is based on estimated regression coefficients, which tends to result in conservative point estimates in firm fixed effects regressions. An alternate proxy, recently proposed in Chen et al. (2019), does not rely on an estimation approach and uses the ratio of sales, general, and administrative (SG&A) expenses to assets as a measure of fixed costs. Columns (3) and (4) of Table 3 show results from using two alternate proxies for fixed costs: SG&A to assets in Column (3) and SG&A less R&D to assets, which is based on the view that R&D needs to be regarded as investment rather than operating expenses, in Column (4). In both columns, industry fixed costs remains positive and significant, while the estimates of firm-level fixed costs are insignificant. The point estimate on this alternate measure of industry fixed costs is more quantitatively significant that that on our baseline measure, and implies that a one standard deviation increase in the industry fixed costs measure in Column (3) increases book leverage by 4.3% of the cross-industry standard deviation of leverage.

#### 5.3.4 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 (5) of Table 4, are similar to the baseline results in Table 2.

Next, to address concerns that the SIC industry classification may be imprecise, we replace the three-digit SIC grouping with a text-based fixed industry classification (FIC) as in Hoberg and Phillips (2010, 2016), 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 fixed cost using firms' sales and operating costs from the Compustat's Fundamentals Annual data, rather than the Segment database. As shown in Column (6) of Table 4, the results are robust to using the Hoberg-Phillips industry classification.

## 5.4 Evidence for theoretical channel: Intra-industry firm profit distribution and leverage

Our baseline results establish robust evidence consistent with the predictions of the model on how the main industry characteristics that we focus on—the industry fixed cost and the product substitutability—affect firm leverage. As discussed in Sections **??**, 4.4 and Appendix B, our baseline and general dynamic models imply that industry characteristics affect firm leverage through their effect on the intra-industry firm profit distribution. In this subsection, we provide empirical evidence for the channel through which our theory predicts that industry characteristics influence firm leverage, thereby establishing tighter links between our theoretical and empirical analyses.

We re-run regression (40), replacing the two industry characteristics examined in the baseline (product substitutability and industry fixed cost), with a proxy for intra-industry profit skewness. Our model implies that firm-level leverage should be higher in industries with a greater skew in the firm profit distribution, which we measure, for each industry and year, as skewness of firm-level operating profits in each industry in Compustat Segment data. It should be noted that in the baseline and general models, the predicted relationship between product market characteristics and leverage arises from the skewness of the distribution of firms' productivity distribution. However, firm profits are also affected by the firm/product quality that varies across firms. Therefore, to isolate the component of the firms' earnings distribution that is driven by variation in firm productivities, we employ the distribution of *residualized p*rofits. Specifically, we *de-mean* operating profits at the firm level and then compute the within-industry skewness of the distribution of demeaned data.

Table 5 presents the results. As in Table 2, the first two columns of the table show regression results with industry and firm fixed effects, respectively. The estimated coefficient on industry profit skewness is significantly positive across both specifications. In the next two columns, we re-run the same regressions on a sample of single-segment firms only. The estimated coefficients are similar, and if anything even larger, than those in the first two columns that use both single- and multi-segment firms.

The regressions in Columns (1)-(4) control for our baseline measure of firm-level operating leverage, based on the sensitivities of operating costs to sales, to allow for a direct effect of fixed costs on financial leverage as in Table 2. In Panel B, we replace the baseline firm-level fixed cost measure with the one based on the ratio of SG&A less R&D to assets. Results in Columns (5)-(8) show that the positive relationship between industry profit skewness and book leverage ratios holds regardless of which approach we use to proxy for the firm-level fixed cost and that they are not impacted by sample-size restrictions associated with our baseline measure of the fixed cost.

Overall, we find strong support in the data that the skewness of the intra-industry firm profit distribution is an important determinant of firms' leverage choices, which is consistent with the central mechanism in our model that firms' leverage choices reflect intra-industry productivity heterogeneity and its effect on product market equilibrium. The impact of intra-industry firm profit skewness on firm leverage choices is an additional novel and unique contribution of our model to the literature on corporate financial leverage.

## 6 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 structures based on the trade-off between the benefits of debt in restricting private benefit extraction by firm insiders 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, 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. The industry fixed cost and the product subsitutability influence firm leverage by affecting the skewness of the intra-industry firm profit distribution.

We show strong empirical support for the testable hypotheses from the model in an empirical analysis of U.S. nonfinancial firms. Our empirical findings that leverage increases with *both* fixed costs and product substitutability reconcile potentially conflicting evidence on how leverage varies with the intensity of product market competition by highlighting that leverage can vary in contrasting directions depending on which underlying industry parameter the proposed empirical proxy for competition is capturing. The *positive* relation between a firm's debt ratio and the *industry-level* fixed costs, 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* fixed costs, which stems from the substitutability between firm-level financial and operating leverages. We also show that firm leverage ratios increase with the skewness of the firm size distribution as predicted by the theory, thereby providing empirical support for the theoretical channel through which product market characteristics influence capital structure. 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.

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# Appendix A: Proofs

**Proof of Proposition 1**

1. Consider a firm of quality $\alpha$. By (7) and equilibrium condition 1 in Section 3.2, the firm's equilibrium capital structure choice solves the following problem:

$$D^*(\alpha) = \arg\sup_D \int_{\beta_B(\alpha,D)}^{\beta_H} (1-\kappa)\pi^*(\alpha,\beta)g(\beta)d\beta + \kappa D\left[1 - G(\beta_B(\alpha,D))\right] \qquad \text{(A1)}$$
$$+ \int_{\beta_L}^{\beta_B(\alpha,D)} (1-\kappa)(1-\theta)\pi^*(\alpha,\beta)g(\beta)d\beta.$$

In the above, $\pi^*(\alpha,\beta)$ is given by (17) with the aggregate price index equal to the equilibrium aggregate price, $P^*$. The bankruptcy threshold, $\beta_B(\alpha,D)$, solves

$$\pi^*(\alpha, \beta_B(\alpha,D)) = D. \qquad \text{(A2)}$$

By (17), $\pi^*(\alpha,\beta) = \frac{\alpha}{\alpha_L}\pi^*(\alpha_L,\beta)$. We can then rewrite (A1) and (A2) as follows.

$$D^*(\alpha) = \arg\sup_D \frac{\alpha}{\alpha_L}\int_{\beta_B(\alpha,D)}^{\beta_H} (1-\kappa)\pi^*(\alpha_L,\beta)g(\beta)d\beta + \kappa D\left[1 - G(\beta_B(\alpha,D))\right] \qquad \text{(A3)}$$
$$+ \frac{\alpha}{\alpha_L}\int_{\beta_L}^{\beta_B(\alpha,D)} (1-\kappa)(1-\theta)\pi^*(\alpha_L,\beta)g(\beta)d\beta,$$

$$\frac{\alpha}{\alpha_L}\pi^*(\alpha_L, \beta_B(\alpha,D)) = D. \qquad \text{(A4)}$$

Defining $D^{'} = \frac{\alpha_L}{\alpha}D$, we can rewrite the above as

$$\frac{\alpha}{\alpha_L}\pi^*(\alpha_L, \beta_B(\alpha,D)) = \frac{\alpha}{\alpha_L}D^{'} \qquad \text{(A5)}$$

or

$$\pi^*(\alpha_L, \beta_B(\alpha,D)) = D^{'} \qquad \text{(A6)}$$

Comparing (A2) with (A6), we see that the productivity levels that solve (A6) and (A2) coincide. Indeed,by definition, the productivity level that solves the bankrupcy condition for $(\alpha_L, D^{'})$, (A6), is $\beta_B(\alpha_L, D^{'})$. Hence,

$$\beta_B(\alpha, D) = \beta_B(\alpha_L, D^{'}). \qquad \text{(A7)}$$

The above is an immediate consequence of the linear homogeneity of the profit function in firm quality. Plugging the above into the R.H.S. of (A3), we see that

$$D^*(\alpha) = \arg\sup_{D^{'}} \frac{\alpha}{\alpha_L}\int_{\beta_B(\alpha_L,D^{'})}^{\beta_H} (1-\kappa)\pi^*(\alpha_L,\beta)g(\beta)d\beta + \kappa\frac{\alpha}{\alpha_L}D^{'}\left[1 - G(\beta_B(\alpha_L,D^{'}))\right] \qquad \text{(A8)}$$
$$+ \frac{\alpha}{\alpha_L}\int_{\beta_L}^{\beta_B(\alpha_L,D^{'})} (1-\kappa)(1-\theta)\pi^*(\alpha_L,\beta)g(\beta)d\beta$$
$$= \frac{\alpha}{\alpha_L}[\arg\sup_{D^{'}} \int_{\beta_B(\alpha_L,D^{'})}^{\beta_H} (1-\kappa)\pi^*(\alpha_L,\beta)g(\beta)d\beta + \kappa D^{'}\left[1 - G(\beta_B(\alpha_L,D^{'}))\right]$$

$$+\int_{\beta_L}^{\beta_B(\alpha_L,D^{'})}(1-\kappa)(1-\theta)\pi^*(\alpha_L,\beta)g(\beta)d\beta]$$
$$=\frac{\alpha}{\alpha_L}D^*(\alpha_L),$$

where the last expression on the R.H.S. above follows from (A1) with $\alpha = \alpha_L$. Hence, we have established that $D^*(\alpha) = \frac{\alpha}{\alpha_L}D^*(\alpha_L)$.

2. Define the function

$$\Gamma(D) = \int_{\beta_B(\alpha,D)}^{\beta_H}(1-\kappa)\pi^*(\alpha,\beta)g(\beta)d\beta+ \kappa D\left[1-G(\beta_B(\alpha,D))\right]+\int_{\beta_L}^{\beta_B(\alpha,D)}(1-\kappa)(1-\theta)\pi^*(\alpha,\beta)g(\beta)d\beta, \quad \text{(A9)}$$

where $\beta_B(\alpha, D)$, solves

$$\pi^*(\alpha,\beta_B(\alpha,D)) = D. \quad \text{(A10)}$$

We note that

$$\Gamma(0) = \int_{\beta_L}^{\beta_H}(1-\kappa)\pi^*(\alpha,\beta)g(\beta)d\beta > 0.$$

Since $\lim_{D\to\infty}\beta_B(\alpha, D) = \beta_H$,we see that

$$\lim_{D\to\infty}\Gamma(D) = \int_{\beta_L}^{\beta_H}(1-\kappa)(1-\theta)\pi^*(\alpha,\beta g(\beta)d\beta < \Gamma(0).$$

Hence, $\Gamma(D)$ has a global maximum, which is the optimal debt level, $D^*(\alpha)$, chosen by a firm of quality $\alpha$.

If $D^*(\alpha) > 0$, then it must satisfy the first order condition,

$$\kappa[1-G(\beta_B(\alpha,D^*(\alpha)))]-[\kappa D^*(\alpha)+(1-\kappa)\theta\pi^*(\alpha,\beta_B(\alpha,D^*(\alpha)))]g(\beta_B(\alpha,D^*(\alpha)))\beta_B^{'}(\alpha,D^*(\alpha)) = 0. \quad \text{(A11)}$$

Since $\pi^*(\alpha_L, \beta_B(\alpha, D^*(\alpha)) = D^*(\alpha)$, we can rewrite the above as

$$\kappa[1-G(\beta_B(\alpha,D^*(\alpha)))]-(\kappa+(1-\kappa)\theta)D^*(\alpha)g(\beta_B(\alpha,D^*(\alpha)))\beta_B^{'}(\alpha,D^*(\alpha)) = 0.$$

By the bankruptcy condition, $\pi^*(\alpha, \beta_B(\alpha, D^*(\alpha)) = D^*(\alpha)$, we must have

$$\beta_B'(\alpha,D^*(\alpha)) = \frac{1}{\pi^*_\beta(\alpha,\beta_B(\alpha,D^*(\alpha))}. \quad \text{(A12)}$$

By (17), the marginal firm profit with respect to productivity is

$$\pi^*_\beta(\alpha,\beta)\,(\equiv\partial\pi^*/\partial\beta) = \frac{(\sigma-1)R\alpha\left(P^*\frac{(\sigma-1)}{\sigma}\beta\right)^{\sigma-1}}{\beta\sigma} = \frac{(\sigma-1)}{\beta}(\pi^*(\alpha,\beta)+f\alpha_L). \quad \text{(A13)}$$

We can then rewrite the first order condition (A11) as

$$\kappa(\sigma-1)(D^*(\alpha)+f\alpha)-(\kappa+(1-\kappa)\theta)D^*(\alpha)\Lambda(\beta_B(\alpha,D^*(\alpha))) = 0, \quad \text{(A14)}$$

where

$$\Lambda(\beta) \equiv \frac{\beta g(\beta)}{1-G(\beta)}. \tag{A15}$$

By Part 1 of the proposition, $\beta_B(\alpha, D^*(\alpha)) = \beta_B^*$. As a result, if $D^*(\alpha) > 0$, it must solve

$$D^*(\alpha) = \frac{\kappa(\sigma-1)f\alpha}{(\kappa+(1-\kappa)\theta)\Lambda(\beta_B^*) - \kappa(\sigma-1)}. \tag{A16}$$

It remains to show that there is, indeed, an interior optimal debt level, that is, all-equity financing is suboptimal. This follows immediately from the fact that the L.H.S. of (A14) equals $\kappa(\sigma-1)f\alpha > 0$ for $D^*(\alpha) = 0$. Hence, the objective function $\Gamma(D)$ defined in (A9) is strictly increasing for $D > 0$ sufficiently small so that $D = 0$ cannot be a global maximum of $\Gamma(D)$. Q.E.D.

**Proof of Proposition 2**

We can rewrite the bankruptcy condition as

$$\begin{aligned}
\pi^*(\alpha_L, \beta_B^*) &= D^*(\alpha_L) \\
\Rightarrow \frac{r^*(\alpha_L, \beta_B^*)}{\sigma} &= f\alpha_L + D^*(\alpha_L) \\
\Rightarrow \frac{\overline{r}^*(\alpha_L)}{\sigma}\left(\frac{\beta_B^*}{\overline{\overline{\beta}}}\right)^{\sigma-1} &= f\alpha_L + D^*(\alpha_L) \\
\Rightarrow (\overline{\pi}^*(\alpha_L) + f\alpha_L)\left(\frac{\beta_B^*}{\overline{\overline{\beta}}}\right)^{\sigma-1} &= f\alpha_L + D^*(\alpha_L),
\end{aligned} \tag{A17}$$

where the second line follows from (16) and (17), and the third and fourth lines follow from the fact, derived further by (33), (34), and (35), that

$$r^*(\alpha_L, \beta) = \overline{r}^*(\alpha_L)\left(\frac{\beta}{\overline{\overline{\beta}}}\right)^{\sigma-1} = \sigma[\overline{\pi}^*(\alpha_L) + f\alpha_L]\left(\frac{\beta}{\overline{\overline{\beta}}}\right)^{\sigma-1}. \tag{A18}$$

The last equation in (A17) leads to (36).

The sum of the second and fourth expressions on the R.H.S. of the free entry condition (32) can be re-expressed as

$$(1-\kappa)\int_{\alpha_L}^{\alpha_H}\frac{\alpha}{\alpha_L}\left[\int_{\beta_L}^{\beta_H}\pi^*(\alpha_L,\beta)g(\beta)d\beta\right]h(\alpha)d\alpha - (1-\kappa)\theta\int_{\alpha_L}^{\alpha_H}\frac{\alpha}{\alpha_L}\left[\int_{\beta_L}^{\beta_B^*}\pi^*(\alpha_L,\beta)g(\beta)d\beta\right]h(\alpha)d\alpha.$$

We can then rewrite the free entry condition as

$$\begin{aligned}
J + \int_{\alpha_L}^{\alpha_H} I(\alpha)h(\alpha)d\alpha &= (1-\kappa)\frac{\overline{\alpha}}{\alpha_L}\int_{\beta_L}^{\beta_H}\pi^*(\alpha_L,\beta)g(\beta)d\beta \\
&+ \kappa D^*(\alpha_L)\frac{\overline{\alpha}}{\alpha_L}[1-G(\beta_B^*)] - (1-\kappa)\theta\frac{\overline{\alpha}}{\alpha_L}\int_{\beta_L}^{\beta_B^*}\pi^*(\alpha_L,\beta)g(\beta)d\beta \\
&= (1-\kappa)\frac{\overline{\alpha}}{\alpha_L}\overline{\pi}^*(\alpha_L) + \kappa D^*(\alpha_L)\frac{\overline{\alpha}}{\alpha_L}[1-G(\beta_B^*)] - (1-\kappa)\theta\frac{\overline{\alpha}}{\alpha_L}\int_{\beta_L}^{\beta_B^*}\pi^*(\alpha_L,\beta)g(\beta)d\beta,
\end{aligned} \tag{A19}$$

where $\overline{\pi}^*(\alpha_L)$ is given by (34) and $\overline{\alpha} = \int_{\alpha_L}^{\alpha_H} \alpha h(\alpha)d\alpha$ is the average firm quality.

By (16) and (17), we now re-express the integrand $\pi^*(\alpha_L, \beta)$ in (A19) as a function of the profit at the bankruptcy threshold,

$$\pi^*(\alpha_L,\beta) = \frac{r^*(\alpha_L,\beta_B^*)}{\sigma}\left(\frac{\beta}{\beta_B^*}\right)^{\sigma-1} - f\alpha_L = [\pi^*(\alpha_L,\beta_B^*) + f\alpha_L]\left(\frac{\beta}{\beta_B^*}\right)^{\sigma-1} - f\alpha_L, \quad \text{(A20)}$$

which, by the bankruptcy condition, the first line in (A17), leads to

$$\pi^*(\alpha_L,\beta) = [D^*(\alpha_L) + f\alpha_L]\left(\frac{\beta}{\beta_B^*}\right)^{\sigma-1} - f\alpha_L. \quad \text{(A21)}$$

Using the above and the last line in (A17), we can then show that (A19) leads to (37). Q.E.D.

**<u>Proof of Proposition 3</u>**

Step 1:
Denote the function on the L.H.S. of (A14) by $\psi(D^*(\alpha_L), f, \sigma)$. By the implicit function theorem,

$$\frac{\partial D^*(\alpha_L)}{\partial f} = -\frac{\partial\psi/\partial f}{\partial\psi/\partial D}|_{D=D^*(\alpha_L)}. \quad \text{(A22)}$$

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

$$\frac{\partial\psi(D^*(\alpha_L))}{\partial f} = \kappa(\sigma-1)\alpha_L - (\kappa + (1-\kappa)\theta)D^*(\alpha_L)\Lambda'(\beta_B^*)\frac{\partial\beta_B^*}{\partial f}, \quad \text{(A23)}$$

where $\beta_B^* = \beta_B(D^*(\alpha_L))$. Since $\Lambda'(\beta) \leq 0$, we see that $\frac{\partial\psi(D^*(\alpha_L))}{\partial f} > 0$ if $\frac{\partial\beta_B^*}{\partial f} > 0$.

Similarly,

$$\frac{\partial D^*(\alpha_L)}{\partial\sigma} = -\frac{\partial\psi/\partial\sigma}{\partial\psi/\partial D}|_{D=D^*(\alpha_L)}. \quad \text{(A24)}$$

It again suffices to show that $\frac{\partial\psi(D^*(\alpha_L))}{\partial\sigma} > 0$. From (A14), we have

$$\frac{\partial\psi(D^*(\alpha_L))}{\partial\sigma} = \kappa(D^*(\alpha_L) + f\alpha_L) - (\kappa + (1-\kappa)\theta)D^*(\alpha_L)\Lambda'(\beta_B^*)\frac{\partial\beta_B^*}{\partial\sigma}. \quad \text{(A25)}$$

Again, since $\Lambda'(\beta) \leq 0$, we see that $\frac{\partial\psi(D^*(\alpha_L))}{\partial\sigma} > 0$ if $\frac{\partial\beta_B^*}{\partial\sigma} > 0$.
Step 2:

To complete the proof, we now show that $\frac{\partial\beta_B^*}{\partial f} > 0$ and $\frac{\partial\beta_B^*}{\partial\sigma} > 0$. Given the debt level $D^*(\alpha_L)$, the endogenous bankruptcy threshold and average firm profit of the lowest quality firms are uniquely determined by the the bankruptcy (B) and free entry (FE) conditions with $D = D^*(\alpha_L)$ that we reproduce below for convenience.

$$\begin{aligned} B : \overline{\pi}^*(\alpha_L) &= \left[\left(\frac{\overline{\beta}}{\beta_B^*}\right)^{\sigma-1} - 1\right] f\alpha_L + \left(\frac{\overline{\beta}}{\beta_B^*}\right)^{\sigma-1} D^*(\alpha_L), \quad \text{(A26)} \\ FE : J + \int_{\alpha_L}^{\alpha_H} I(\alpha)h(\alpha)d\alpha &= (1-\kappa)\frac{\overline{\alpha}}{\alpha_L}\overline{\pi}^*(\alpha_L) + \kappa D^*(\alpha_L)\frac{\overline{\alpha}}{\alpha_L}[1 - G(\beta_B^*))] \\ &\quad -(1-\kappa)\theta\frac{\overline{\alpha}}{\alpha_L}\int_{\beta_L}^{\beta_B^*}\left[\left(\frac{\beta}{\overline{\beta}}\right)^{\sigma-1}\overline{\pi}^*(\alpha_L) - \left(1 - \left(\frac{\beta}{\overline{\beta}}\right)^{\sigma-1}\right) f\alpha_L\right] g(\beta)d\beta. \end{aligned}$$

(A27)

Since $\pi^*(\alpha_L, \beta_B^*) = D^*(\alpha_L)$ by definition of the bankruptcy threshold, the condition, $D^*(\alpha_L) < \overline{\pi}^*(\alpha_L)$ implies that $\pi^*(\alpha_L, \beta_B^*) < \overline{\pi}^*(\alpha_L)$. By the definition of the average firm profit and the average productivity, (34) and (35), it then immediately follows that $\beta_B^* < \overline{\beta}$.

For each possible value of the bankruptcy threshold, we then see that the average firm profit that solves the bankruptcy condition, (A26), increases with an increase in either $f$ or $\sigma$. Hence, the B curve shifts to the right in response to an increase in $f$ or $\sigma$.

Now consider the FE curve. The behavior of the FE curve with an increase in $f$ or $\sigma$ is determined by the expression

$$\int_{\beta_L}^{\beta_B^*} \left[ \left(\frac{\beta}{\overline{\beta}}\right)^{\sigma-1} \overline{\pi}^*\left(\alpha_L\right) - \left(1 - \left(\frac{\beta}{\overline{\beta}}\right)^{\sigma-1}\right) f\alpha_L \right] g(\beta)d\beta. \tag{A28}$$

By the definition of $\overline{\beta}$ in (35), $\int_{\beta_L}^{\beta_H} \left(1 - \left(\frac{\beta}{\overline{\beta}}\right)^{\sigma-1}\right) g(\beta)d\beta = 0$. Because $\left(\frac{\beta}{\overline{\beta}}\right)^{\sigma-1}$ increases with $\beta$, it follows that $\int_{\beta_L}^{\beta_B(D)} \left(1 - \left(\frac{\beta}{\overline{\beta}}\right)^{\sigma-1}\right) g(\beta)d\beta > 0$. Hence, an increase in $f$ decreases this expression (A28). It then follows from (A27) that, for each possible value of the bankruptcy threshold, the average firm profit that solves the FE condition decreases.

Consider now an increase in $\sigma$. By the definition of $\overline{\beta}$ in (35), $\int_{\beta_L}^{\beta_H} \left(\frac{\beta}{\overline{\beta}}\right)^{\sigma-1} g(\beta)d\beta = 1$. Hence, $\int_{\beta_L}^{\beta_B^*} \left(\frac{\beta}{\overline{\beta}}\right)^{\sigma-1} g(\beta)d\beta < 1$. Further, because $\left(\frac{\beta}{\overline{\beta}}\right)^{\sigma-1}$ increases with $\sigma$ for $\beta > \overline{\beta}$, and decreases with $\sigma$ for $\beta < \overline{\beta}$, it follows that $\int_{\beta_L}^{\beta_B^*} \left(\frac{\beta}{\overline{\beta}}\right)^{\sigma-1} g(\beta)d\beta$ decreases with $\sigma$. Similarly, since $\int_{\beta_L}^{\beta_H} \left(1 - \left(\frac{\beta}{\overline{\beta}}\right)^{\sigma-1}\right) g(\beta)d\beta = 0$, $\int_{\beta_L}^{\beta_B^*} \left(1 - \left(\frac{\beta}{\overline{\beta}}\right)^{\sigma-1}\right) g(\beta)d\beta > 0$ and increases with $\sigma$. It then follows from (A27) that, for each possible value of the bankruptcy threshold, the average firm profit that solves the FE condition decreases with $\sigma$. Hence, the FE curve shifts to the right as $f$ or $\sigma$ increases. Hence, $\frac{\partial \beta_B^*}{\partial f} > 0$ and $\frac{\partial \beta_B^*}{\partial \sigma} > 0$,which completes the proof. Q.E.D.

# Appendix B: General Dynamic Model

We consider an infinite horizon, discrete time setting with dates $0, 1, 2, \ldots$.. The risk-free rate varies stochastically over time with the rate in period $t$ being $\gamma_t > 0$. As in the baseline model, entrepreneurs establish firms at date 0 by making a human capital investment, $J$. The *qualities* of the firms are then realized and independently drawn from a distribution $H(.)$ with density $h(.)$ and support $[\alpha_L, \alpha_H]$. A firm's quality remains constant through time and can be viewed as a *persistent* characteristic of the firm. The mass of firms that enter the industry at date zero, which is determined by a free entry condition that we specify later, is constant through time, that is, firms are infinitely lived. We can extend the model to incorporate firm entry and exit, as well as stochastically varying firm quality, but the extensions complicate the analysis and exposition without altering our main implications.

At the beginning of each period, $[t, t+1]; t \geq 0$, each firm of quality $\alpha$ needs to make a physical capital investment $I_t(\alpha)$ for production that it finances through equity and debt. The capital investment, $I_t(\alpha)$, could vary stochastically over time. Specifically, $I_t(\alpha)$ is a random variable that is independently drawn from a distribution, $\mathcal{I}_t(.|\alpha)$, that has compact support. Hence, firms of the same quality could have different required capital investments. As in the baseline model of Section

3, after making the capital investment, each firm experiences an independent productivity shock $\beta$ that is drawn from a distribution $G_t(.)$ with density $g_t(.)$ that has support $[\beta_L, \beta_H]$. For simplicity, the productivity distribution, $G_t(.)$ is independent of the product quality distribution, $H(.)$, and the capital investment distributions, $\{\mathcal{I}_t(.|\alpha)\}$. The time subscripts on the the firm productivity distribution indicates that it can also vary over time. We assume that all agents know the laws of these processes. These processes and all processes defined in the following discussion have compact support.

### B.1 Firm investment and financing

Each firm must finance the required capital investment at the beginning of period $t$ before its productivity for the period is realized. Hence, as in the baseline model, each firm's capital structure in any period depends only on its quality. Accordingly, suppose that a firm with quality $\alpha$ issues debt with face value $D_t(\alpha)$ in period $t$ that is due at the end of the period. If the firm's productivity in period $t$ is $\beta(t)$, the firm's profit is $\pi(t, \alpha, \beta(t))$ that we derive endogenously later. The profit function, $\pi(t, \alpha, \beta(t))$, increases with $\alpha$ and $\beta(t)$. The firm's management extracts a proportion, $\kappa_t$ of the firm's free cash flow—earnings net of debt payments—as private benefits, where we allow for the process $\kappa$ to be stochastic with $\kappa_t \in [0, 1]$ being its realization at the beginning of period $t$. Hence, the payout to the firm's shareholders at the end of period $t$ is $(1 - \kappa_t)(\pi(t, \alpha, \beta(t)) - D_t(\alpha))$. Note that the parameter, $\kappa_t$, is realized before the firm chooses its capital structure, which is also true for other stochastically varying parameters described below (with the exception of firm productivities). For simplicity, we assume that the firm is insolvent when its earnings are insufficient to make the required debt payment. Hence, the firm is insolvent if its productivity shock $\beta$ is below the *bankruptcy threshold*, $\beta_B(t, \alpha, D_t(\alpha))$, that solves

$$\pi_E(t, \alpha, \beta_B(t, \alpha, D_t(\alpha))) = (1 - \kappa_t)(\pi(t, \alpha, \beta_B(t, \alpha, D_t(\alpha))) - D_t(\alpha)) = 0. \tag{A29}$$

If the realized productivity is below the bankruptcy threshold, control transfers to debtholders for the period, and their bankruptcy payoff is

$$\pi_D(t, \alpha, \beta(t)) = (1 - \kappa_t)(1 - \theta_t)\pi(t, \alpha, \beta(t)), \text{ for } \beta(t) < \beta_B(t, \alpha, D_t(\alpha)), \tag{A30}$$

where $0 < \theta_t < 1$ is the proportional bankruptcy cost in period $t$. The bankruptcy cost process, $\theta$, can also vary stochastically over time.

Note that a firm is insolvent only for the current period if its realized productivity is below the bankruptcy threshold. At the beginning of the next period, each firm draws a new productivity shock and could be solvent again. Generalizing (7), each firm's optimal choices of debt levels, $\{D_t^*(\alpha)\}$ in every period solves the following problem:

$$\begin{aligned}
\sup_{D_t(\alpha)} -I_t(\alpha) + \int_{\beta_B(t,\alpha,D_t(\alpha))}^{\beta_H} (1 - \kappa_t)\pi(t, \alpha, \beta)g_t(\beta)d\beta + \kappa_t D_t(\alpha)\left[1 - G_t(\beta_B(t, \alpha, D_t(\alpha)))\right] \\
+ \int_{\beta_L}^{\beta_B(t,\alpha,D_t(\alpha))} (1 - \kappa_t)(1 - \theta_t)\pi(t, \alpha, \beta)g_t(\beta)d\beta \\
+\mathbb{E}_t[\sum_{s=t+1}^{\infty} e^{-\gamma_s(s-t)} \left[-I_s(\alpha) + \int_{\beta_B(s,\alpha,D_s^*(\alpha))}^{\beta_H} (1 - \kappa_s)\pi(s, \alpha, \beta)g_s(\beta)d\beta + \kappa_s D_s^*(\alpha)\left[1 - G_s(\beta_B(s, \alpha, D_s^*(\alpha)))\right]\right]
\end{aligned} \tag{A31}$$

$$+\mathbb{E}_t[\sum_{s=t+1}^{\infty} e^{-r(s)(s-t)} \int_{\beta_L}^{\beta_B(s,\alpha,D_t^*(\alpha))} (1-\kappa_s)(1-\theta_s)\pi(s,\alpha,\beta)g_t(\beta)d\beta$$

In the above, $\mathbb{E}_t$ denotes the conditional expectation at date $t$ with respect to the joint probability law of all the processes defined above. Note that, because the product market parameters vary stochastically, the optimal debt levels, $\{D_t^*(\alpha)\}$, can also vary stochastically. At the beginning of each period $t$,each firm chooses it capital structure for the period rationally anticipating its capital structures in future periods depending on the realized values of the product market parameters. From (A31), we note that each firm's optimal debt levels solve the following "period by period" optimization program:

$$\sup_{D_t(\alpha)} \int_{\beta_B(t,\alpha,D_t(\alpha))}^{\beta_H} (1-\kappa_t)\pi(t,\alpha,\beta)g_t(\beta)d\beta + \kappa_t D_t(\alpha)\left[1-G_t(\beta_B(t,\alpha,D_t(\alpha)))\right] + \int_{\beta_L}^{\beta_B(t,\alpha,D_t(\alpha))} (1-\kappa_t)(1-\theta_t)\pi(t,\alpha,\beta)g_t(\beta)d\beta \tag{A32}$$

with

$$\pi(t,\alpha,\beta_B(t,\alpha,D_t(\alpha))) = D_t(\alpha) \tag{A33}$$

## B.2 Firm production

The representative consumer's preferences for the goods produced by firms in the industry in any period, $[t,t+1]$, (alternately referred to as period $t$) are described by the utility function

$$U_t = \left[\int_{\Omega_t} \alpha(\omega)^{1-\rho_t} q_t(\omega)^{\rho_t} d\omega\right]^{\frac{1}{\rho_t}}. \tag{A34}$$

where $0 < \rho_t < 1$ with $\sigma_t \equiv \frac{1}{1-\rho_t} > 1$ being the product substitutability between any two goods in the market, $\Omega_t$ is the set of available goods in the industry in period $t$, and $\alpha(\omega)$ is the quality of the product $\omega$. The market size and product substitutability can both vary stochastically over time. Let $R_t$ be the industry (or market) *size* in period $t$ and $p_t(\omega)$ be the price of the product $\omega$. Maximizing the representative consumer's utility given by (A34) subject to the budget constraint, $\int_{\Omega_t} p_t(\omega)q_t(\omega)d\omega = R_t$, we obtain the demand of the representative consumer for the product $\omega$ by

$$q_t(\omega) = U_t\alpha(\omega)\left[\frac{P_t}{p_t(\omega)}\right]^{\sigma_t}, \tag{A35}$$

where the aggregate price index, $P_t$ , and industry size, $R_t$, are given by

$$P_t = \Big[\int_{\Omega_t} \alpha(\omega)p_t(\omega)^{1-\sigma_t}d\omega\Big]^{\frac{1}{1-\sigma_t}}, \tag{A36}$$

$$R_t = P_tU_t. \tag{A37}$$

The production cost of a firm with quality $\alpha$ and productivity $\beta(t)$ in period $t$ is

$$c_t(\alpha,\beta(t)) = \overbrace{f_t\alpha}^{\text{fixed cost}} + \overbrace{\frac{q_t}{\beta(t)}}^{\text{variable cost}}, \tag{A38}$$

where $f_t > 0$ is the industry-level parameter that determines the firm's fixed cost of production over the period. The industry-level fixed cost also varies stochastically over time. As in the baseline model, firms compete monopolistically in each period. We can solve the firm's profit maximization problem to show that it optimally chooses the product price, $p_t = p(t, \beta(t)) = \frac{\sigma_t}{(\sigma_t - 1)\beta(t)}$. The firm's revenue and operating profit, which depend on the firm's quality, $\alpha$, and the firm's productivity, $\beta(t)$, are

$$r(t, \alpha, \beta(t)) = R_t \alpha \left( P_t \frac{(\sigma_t - 1)}{\sigma_t} \beta(t) \right)^{\sigma_t - 1}, \tag{A39}$$

$$\pi(t, \alpha, \beta(t)) = \frac{R_t \alpha \left( P_t \frac{(\sigma_t - 1)}{\sigma_t} \beta(t) \right)^{\sigma_t - 1}}{\sigma_t} - f_t \alpha. \tag{A40}$$

We see from (A39) and (A40) that the firm's revenue and profit are both proportional to its quality or scale, $\alpha$. If $M$ is the mass of firms in the industry, which is determined at date 0, then market clearing in period $t$ implies that we must have

$$R_t = R_t M \int \int \boldsymbol{\alpha} \left( \boldsymbol{P_t} \frac{(\boldsymbol{\sigma_t} - 1)}{\boldsymbol{\sigma_t}} \boldsymbol{\beta} \right)^{\boldsymbol{\sigma_t} - 1} \boldsymbol{g_t}(\beta) d\beta h(\alpha) d\alpha. \tag{A41}$$

Hence, the aggregate price index in period $t$ and the mass of firms must satisfy the following relation:

$$\int \int \boldsymbol{\alpha} \left( \boldsymbol{P_t} \frac{(\boldsymbol{\sigma_t} - 1)}{\boldsymbol{\sigma_t}} \boldsymbol{\beta} \right)^{\boldsymbol{\sigma_t} - 1} \boldsymbol{g_t}(\beta) d\beta h(\alpha) d\alpha = M^{-1} \tag{A42}$$

We assume that parameter values are such that

$$\int_{\beta_L}^{\beta_H} (1 - \kappa_t) \pi(t, \alpha, \beta) g_t(\beta) d\beta \geq I_t(\alpha) \ \forall t, \alpha. \tag{A43}$$

The above condition guarantees that the market value of every firm is nonnegative at every date $t$. Hence, it is optimal for all firms to continue operations in every period.

## B.3 Equilibrium debt levels

Similar to the baseline model, each firm's optimal capital structure choice in any period $t$ solves (A32). We can then use arguments along the lines of the proof of Proposition 1.

**Proposition 4 (Optimal Debt Levels)**

1. *If $D_t^*(\alpha_L)$ is the optimal debt level for a firm with quality $\alpha_L$ in period $t$, then the optimal debt level chosen by a firm with quality $\alpha$, must be*

$$D_t^*(\alpha) = \left( \frac{\alpha}{\alpha_L} \right) D_t^*(\alpha_L). \tag{A44}$$

   *Moreover, in equilibrium, firms' bankruptcy thresholds in any period $t$ do not depend on their qualities, that is,*

$$\beta_B^*(t, \alpha, D_t^*(\alpha)) = \beta_B^*(t, \alpha_L, D_t^*(\alpha_L)) = \beta_B^*(t). \tag{A45}$$

2. *The optimal debt level chosen by a firm of quality $\alpha$ in period $t$ is strictly positive and satisfies*

$$D_t^*(\alpha) = \frac{\kappa_t(\sigma_t - 1)f_t\alpha}{(\kappa_t + (1-\kappa_t)\theta_t)\Lambda_t(\beta_B^*(t)) - \kappa_t(\sigma_t - 1)}, \tag{A46}$$

*where*

$$\Lambda_t(\beta) = \frac{\beta g_t(\beta)}{1 - G_t(\beta)}. \tag{A47}$$

## B.4 Product market equilibrium

We now characterize the product market equilibrium in each period, thereby completing our analysis of the full equilibrium of the model. By Proposition 4, equilibrium firm debt levels scale with their qualities in each period. By the scaling property, the bankruptcy threshold in period $t$ is the same for all firms. Hence, the bankruptcy equilibrium condition simplifies to

$$B : \pi_E^*(t, \alpha_L, \beta_B^*(t)) = (1-\kappa_t)(\pi^*(t, \alpha_L, \beta_B^*(s)) - D_t^*(\alpha_L)) = 0. \tag{A48}$$

The free entry condition specifies that the discounted expectation (w.r.t. the distribution of capital investments) of a firm's future earnings equals the initial human capital investment, $J$, at date 0, that is,

$$\begin{aligned} FE : J = \mathbb{E}\left[\sum_{t=0}^{\infty} e^{-\gamma_t t}\left(\int_{\alpha_L}^{\alpha_H}[-I_t(\alpha) + \int_{\beta_L}^{\beta_H}\pi_E^*(t,\alpha,\beta)g_t(\beta)d\beta]h(\alpha)d\alpha\right)\right] \\ + \sum_{t=0}^{\infty} e^{-\gamma_t t}\left(\int_{\alpha_L}^{\alpha_H} D_t^*(\alpha)\left[1 - G_t(\beta_B^*(t))\right]h(\alpha)d\alpha\right) \\ + \sum_{t=0}^{\infty} e^{-\gamma_t t}\left(\int_{\alpha_L}^{\alpha_H}\int_{\beta_L}^{\beta_B^*(t)}(1-\kappa_t)(1-\theta_t)\pi^*(t,\alpha,\beta)g_t(\beta)d\beta]h(\alpha)d\alpha\right) \end{aligned} \tag{A49}$$

The bankruptcy conditions, (A48) in all periods and the free entry condition, (A49), together determine the equilibrium mass of firms, $M^*$. Relation (A42) then pins down the equilibrium aggregate price index, $P_t^*$, in each period $t$. Conditions (A46) and (A48) together determine the equilibrium debt level and bankruptcy threshold in each period $t$.

We now argue that there exists a unique equilibrium mass of firms, $M^*$. Fix a candidate mass of firms, $M$. Relation (A42) pins down the aggregate price index, $P_t$, in each period. Moreover, $P_t$ declines with $M$. It then follows immediately from (A40) that a firm's operating profit in each period declines with $M$. By (A46) and the implicit function theorem, firms' optimal debt levels and after-tax profits decline with $M$. Consequently, the value of an entering firm, which is given by the R.H.S. of (A49) declines monotonically with $M$. Because $\lim_{M\to\infty} P_t = 0; \lim_{M\to 0} P_t = \infty$, there exists a unique $M^*$ that satisfies the free entry condition, (A49), which is the equilibrium mass of firms.

## B.5 Product market characteristics and capital structure

We now obtain the following proposition describing the effects of product market characteristics on firm leverage.

**Proposition 5 (Product market characteristics and leverage)**
*If $D_t^*(\alpha_L) < \overline{\pi}^*(t, \alpha_L)$ and $\Lambda_t'(\beta) \leq 0$, over the support, $[\beta_L, \beta_H]$, of the productivity distribution,*

*then a firm's debt level and, therefore, its book leverage in period $t$ increases with the fixed cost parameter, $f_t$, and the elasticity of substitution $\sigma_t$ in the period.*

Following the arguments of the proof of Proposition 3, it suffices to show that the bankruptcy threshold, $\frac{\partial \beta_B^*(t)}{\partial f_t}, \frac{\partial \beta_B^*(t)}{\partial \sigma_t} > 0$ increases with the realized values of the industry fixed cost parameter, $f_t$ , and the product substitutability, $\sigma_t$. To show this, consider the bankruptcy condition, (A4). By (A40), the following holds in any period $t$.

$$\frac{R_t^* \left( P_t^* \frac{(\sigma_t - 1)}{\sigma_t} \beta_B^*(t) \right)^{\sigma_t - 1}}{\sigma_t} - f_t \alpha = D_t^*(\alpha_L),$$

where $P_t^*$ is determined by (A42) with $M = M^*$. It is immediate from the above equation that $\frac{\partial \beta_B^*(t)}{\partial f_t} > 0$. To show that $\frac{\partial \beta_B^*(t)}{\partial \sigma_t} > 0$, we proceed as in the proof of Proposition 2 to rewrite the bankruptcy condition as follows.

$$\overline{\pi}_t^*(\alpha_L) = \left[ \left( \frac{\overline{\beta}(t)}{\beta_B^*(t)} \right)^{\sigma_t - 1} - 1 \right] f_t \alpha_L + \left( \frac{\overline{\beta}(t)}{\beta_B^*(t)} \right)^{\sigma_t - 1} D_t^*(\alpha_L).$$

From the above, we obtain

$$\int \frac{\alpha}{\alpha_L} \overline{\pi}_t^*(\alpha_L) h(\alpha) d\alpha = \int \overline{\pi}_t^*(\alpha) h(\alpha) d\alpha = \int \frac{\alpha}{\alpha_L} h(\alpha) d\alpha \left( \left[ \left( \frac{\overline{\beta}(t)}{\beta_B^*(t)} \right)^{\sigma_t - 1} - 1 \right] f_t \alpha_L + \left( \frac{\overline{\beta}(t)}{\beta_B^*(t)} \right)^{\sigma_t - 1} D_t^*(\alpha_L) \right) \tag{A50}$$

But

$$\int \overline{\pi}_t^*(\alpha) h(\alpha) d\alpha = \int \left( \frac{\overline{r}_t^*(\alpha)}{\sigma} - f_t \alpha \right) h(\alpha) d\alpha = \frac{R_t}{M^* \sigma_t} - f_t \int \alpha h(\alpha) d\alpha. \tag{A51}$$

where the last equality follows from (A39) and (A42)Plugging (A51) into (A50) and rearranging terms, we obtain

$$\frac{R_t}{M^*} = \sigma_t \left( \left[ \left( \frac{\overline{\beta}(t)}{\beta_B^*(t)} \right)^{\sigma_t - 1} - 1 \right] f_t \alpha_L + \left( \frac{\overline{\beta}(t)}{\beta_B^*(t)} \right)^{\sigma_t - 1} D_t^*(\alpha_L) \right) \int \alpha h(\alpha) d\alpha$$

The L.H.S. above does not vary with $\sigma_t$, while the R.H.S. increases with $\sigma_t$ for fixed $\beta_B^*(t)$ and decreases with $\beta_B^*(t)$ for fixed $\sigma_t$ . It then follows from the implicit function theorem that $\frac{\partial \beta_B^*(t)}{\partial \sigma_t} > 0$. This completes the arguments necessary to prove Proposition 5.

The proposition shows that the implications of the baseline model extend to the general dynamic model where firm capital structures, the industry fixed cost parameter, and the product substitutability can all vary stochastically over time.

## Appendix C: Extended model with firm-level fixed production costs

We extend the baseline model in Section 3 to incorporate the effect of *firm-level* fixed production costs on financial leverage. We introduce an additional consumption/production period so that the model now has four periods with the terminal date being date 4. Consider a firm with quality $\alpha$ and productivity $\beta$. At the beginning of period 4 (that is, at date 3), the firm experiences a *firm-specific* shock to its fixed production cost that is determined by a parameter, $\eta$, (distinct from the industry-wide fixed production cost parameter $f$), which is independently drawn from a distribution $K(\eta)$ with density $k(\eta)$ and support $[\eta_L, \eta_H]$. *After* the realization of $\eta$, the firm makes an additional physical capital investment, $I'(\alpha, \beta, \eta)$, that could depend on its quality and productivity as well as the realized fixed production cost parameter. As the realization of $\eta$ is known when the firm makes the investment, the firm faces no uncertainty about its production cost when it makes the additional investment. We can also view $I'(\alpha, \beta, \eta)$ as a working capital investment to continue the firm's operations.

Assume that the market size is $(1-\epsilon)R$ in period 3 and $\epsilon R$ in the period 4 where $\epsilon > 0$ is a parameter that could represent the relative lengths of the two periods. The firm finances the investment, $I'(\alpha, \beta, \eta)$, at date 3 through additional debt and equity issuance. All payoffs occur at the terminal date 4 with all debt—that is, the debt issued to finance the initial investment at date 1, $D_1$, and the additional investment at date 3, $D_2$ —also being due at date 4. The firm-specific production cost also scales with firm quality and is given by $\eta\alpha$. Because the firm knows $\eta$ when it makes the additional investment, its financing choice could depend on $\eta$. Accordingly, let $D_2(\alpha, \beta, \eta)$ denote the level of additional debt issued by the firm. We assume that the firm faces a collateral constraint, which specifies that $D_2(\alpha, \beta, \eta)$ cannot exceed the profit the firm generates in period 4.

Proceeding as in Section 3.1.3, we can show that the profits generated by the firm in the third and fourth periods are

$$\pi_1(\alpha, \beta) = \frac{\alpha(1-\epsilon)R(P^{\frac{(\sigma-1)}{\sigma}}\beta)^{\sigma-1}}{\sigma} - f\alpha. \tag{A52}$$

$$\pi_2(\alpha, \beta, \eta) = \frac{\alpha\epsilon R(P^{\frac{(\sigma-1)}{\sigma}}\beta)^{\sigma-1}}{\sigma} - \eta\alpha. \tag{A53}$$

Following Section 3.2, an equilibrium of the economy is characterized by (i) a mass $M^*$ of firms (and hence $M^*$ differentiated products) in each period; (ii) an aggregate price index $P^*$; (iii) the optimal financing choices of firms at dates 1 and 3 that are determined by the debt levels $\{D_1^*(\alpha); \alpha \in [\alpha_L, \alpha_H]\}$ ; $\{D_2^*(\alpha, \beta, \eta); \alpha \in [\alpha_L, \alpha_H], \beta \in [\beta_L, \beta_H], \eta \in [\eta_L, \eta_H]\}$ ; and (iv) the bankruptcy thresholds $\{\beta_B^*(\alpha, \beta, \eta)\}$ that could, in principle, depend on firm quality $\alpha$, productivity $\beta$, and the firm-specific fixed production cost parameter $\eta$.

We derive the equilibrium via backward induction beginning with period 4. Because the firm faces no uncertainty when it finances the additional investment, $I'(\alpha, \beta, \eta)$, at date 3, its optimal choice of debt level, $D_2^*(\alpha, \beta, \eta)$, solves

$$D_2^*(\alpha, \beta, \eta) = \arg \max_{D \leq \pi_2^*(\alpha, \beta, \eta)} (1-\kappa)\pi_2^*(\alpha, \beta, \eta) + \kappa D \tag{A54}$$

From the above, we immediately see that is optimal for the firm to set

$$D_2^*(\alpha, \beta, \eta) = \pi_2^*(\alpha, \beta, \eta) \tag{A55}$$

In other words, because the firm faces no uncertainty in the final period, it is optimal for the firm to choose *all debt* financing where it sets the debt level equal to the profit it generates over the period.

We see that (A55) implies that the profit generated in period 4 goes entirely towards making the debt payment, $D_2^*(\alpha, \beta, \eta)$. Hence, to analyze the financing decision at date 1, we can proceed exactly as we did in Section 4. Specifically, the following bankruptcy condition must be satisfied.

$$B : (1-\kappa)(\pi_1^*(\alpha, \beta_B^*(\alpha)) - D_1^*(\alpha)) = 0, \ \forall \ \alpha \in [\alpha_L, \alpha_H]. \tag{A56}$$

The above continues to be true because of (A55) so that the debt payment $D_1^*(\alpha)$ must be paid from the profit, $\pi_1^*(\alpha, \beta_B^*(\alpha))$, generated by production in the third period as in the baseline model.

The free entry condition now incorporates the additional period of production and is given by

$$FE\text{: } J + \int_{\alpha_L}^{\alpha_H} I(\alpha)h(\alpha)d\alpha + \int_{\alpha_L}^{\alpha_H}\int_{\beta_L}^{\beta_H}\int_{\eta_L}^{\eta_H} I^{'}(\alpha,\beta,\eta)k(\eta)g(\beta)h(\alpha)d\eta d\beta d\alpha = \tag{A57}$$
$$\int_{\alpha_L}^{\alpha_H}[\int_{\beta_B^*(\alpha)}^{\beta_H}(1-\kappa)\pi_1^*(\alpha,\beta)g(\beta)d\beta]h(\alpha)d\alpha + \int_{\alpha_L}^{\alpha_H}\kappa D_1^*(\alpha)\left[1-G(\beta_B^*(\alpha))\right]h(\alpha)d\alpha$$
$$+\int_{\alpha_L}^{\alpha_H}\int_{\beta_L}^{\beta_B^*(\alpha)}(1-\kappa)[(1-\theta)\pi_1^*(\alpha,\beta)g(\beta)d\beta]h(\alpha)d\alpha$$
$$+\int_{\eta_L}^{\eta_H}\left[\int_{\alpha_L}^{\alpha_H}[\int_{\beta_L}^{\beta_H}\pi_2^*(\alpha,\beta,\eta)g(\beta)d\beta]h(\alpha)d\alpha\right]k(\eta)d\eta.$$

The last term on the R.H.S. above follows from the fact that the additional investment, $I^{'}(\alpha,\beta,\eta)$, at the beginning of period 4 is fully debt-financed. Finally, we have the product market clearing conditions for periods 3 and 4.

$$PMC:\ (1-\epsilon)R = M^*\int_{\alpha_L}^{\alpha_H}\left[\int_{\beta_L}^{\beta_H} r_1^*(\alpha,\beta)g(\beta)d\beta\right]h(\alpha)d\alpha, \tag{A58}$$
$$\epsilon R = M^*\int_{\eta_L}^{\eta_H}[\int_{\alpha_L}^{\alpha_H}\left[\int_{\beta_L}^{\beta_H} r_2^*(\alpha,\beta)g(\beta)d\beta\right]h(\alpha)d\alpha]k(\eta)d\eta, \tag{A59}$$

where

$$r_1^*(\alpha,\beta) = \frac{\alpha(1-\epsilon)R(P^*\frac{(\sigma-1)}{\sigma}\beta)^{\sigma-1}}{\sigma}, \tag{A60}$$
$$r_2^*(\alpha,\beta) = \frac{\alpha\epsilon R(P^*\frac{(\sigma-1)}{\sigma}\beta)^{\sigma-1}}{\sigma}. \tag{A61}$$

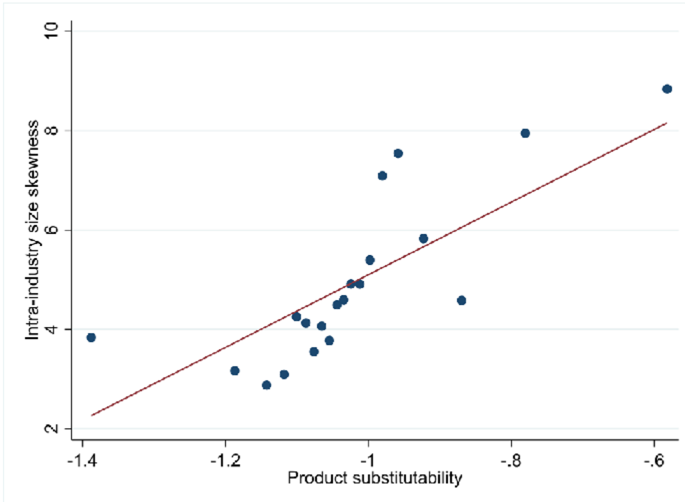
The rest of the analysis proceeds exactly as in Section 4 with the results being qualitatively unchanged. From (A55), we see that, if the firm faces a higher fixed production cost $\eta$, it chooses a lower debt level, $D_2^*(\alpha,\beta,\eta)$. This negative association between borrowing and firm-specific 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. This simple formalization with the additional debt choice simply supports our empirical tests including the firm-level operating leverage measure as another control variable.

## Appendix D: Definition of variables

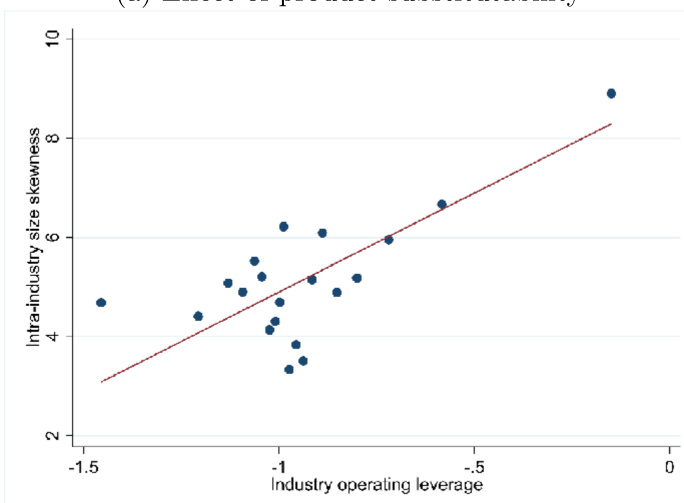
- Book leverage: (short-term debt (dlc) + long-term debt (dltt))/total assets (at)
- Long-term book leverage: long-term debt (dltt)/total assets (at)
- Total book leverage: (short-term debt (dlc) + long-term debt (dltt) + operating lease value)/(total assets (at) + operating lease value), where operating lease value is estimated as the rental expense (xrent) plus the present value (using a 10% discount rate) of operating leases commitments (mrc) for the next 5 years, that is, xrent + $\frac{1}{1.1}$×mrc1 + $\frac{1}{1.1^2}$×mrc2 + $\frac{1}{1.1^3}$×mrc3 + $\frac{1}{1.1^4}$×mrc4 + $\frac{1}{1.1^5}$×mrc5

- Market leverage: (short-term debt (dlc) + long-term debt (dltt))/(short-term debt (dlc) + long-term debt (dltt) + market value of equity), where market value of equity is stock price (prcce_f) times common shares outstanding (cshpri)
- Product substitutability: the negative value of the industry average of price-cost margin (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 fixed cost: 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 fixed cost: 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 (at), where total assets are deflated by the GDP deflator
- Market-to-book: the market value of total assets scaled by the book value of total assets (at), where the market value of total assets is market equity (prcce_f×cshpri) + long-term and short-term debt (dltt+dlc) + preferred stock liquidating value (pstkl) − deferred taxes and investment tax credits (txditc)
- Profitability: return on assets (ROA), which is computed as operating income before depreciation (oibdp)/total assets (at) minus the industry average return on assets
- Asset tangibility: net PPE (property, plant and equipment; ppent)/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 (dvc) is positive and zero otherwise
- Intra-industry profit skewness: skewness of firm operating profit within each industry-year, where profits are first demeaned at the firm level.

# Appendix E: Figures and Tables




(a) Effect of product substitutability




(b) Effect of industry fixed costs

Figure 2: Industry profit skewness.

These figures show unconditional correlations between intra-industry skewness of operating profit and industry product market variables, product substitutability(Figure (a)) and industry fixed cost(Figure (b)) in our baseline sample of Compustat firms from 1982 to 2014. Industries are defined at the three-digit SIC level. All variables are defined in Appendix D. 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 SIC level in the baseline analysis. All variables are defined in Appendix D. 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 variable.

| Panel A: Leverage variables | | | | | | |
|---|---|---|---|---|---|---|
| | N | Mean | StDev | p25 | p50 | p75 |
| Book leverage | 72,994 | 0.232 | 0.206 | 0.047 | 0.201 | 0.356 |
| Long-term book leverage | 72,994 | 0.176 | 0.183 | 0.008 | 0.132 | 0.281 |
| Total book leverage | 59,476 | 0.307 | 0.200 | 0.146 | 0.286 | 0.430 |
| Market leverage | 72,517 | 0.247 | 0.246 | 0.031 | 0.176 | 0.393 |
| Panel B: Firm variables | | | | | | |
| | N | Mean | StDev | p25 | p50 | p75 |
| Firm fixed cost | 72,994 | -0.811 | 0.409 | -1.022 | -0.891 | -0.645 |
| Firm size | 72,994 | 5.437 | 2.182 | 3.825 | 5.345 | 6.906 |
| Market-to-book | 72,994 | 1.550 | 1.924 | 0.733 | 1.047 | 1.700 |
| Profitability | 72,994 | 0.120 | 0.255 | 0.015 | 0.105 | 0.231 |
| Asset tangibility | 72,994 | 0.292 | 0.225 | 0.111 | 0.234 | 0.415 |
| Cash flow volatility | 72,994 | 0.118 | 0.315 | 0.035 | 0.061 | 0.112 |
| Dividend payer | 72,994 | 0.370 | 0.483 | 0 | 0 | 1 |
| Panel C: Industry variables | | | | | | |
| | N | Mean | StDev | p25 | p50 | p75 |
| Product substitutability | 72,994 | -1.017 | 0.136 | -1.084 | -1.035 | -0.974 |
| Industry fixed cost | 72,994 | -0.941 | 0.256 | -1.049 | -0.980 | -0.875 |
| Market Size | 72,994 | 10.76 | 1.378 | 9.847 | 10.93 | 11.79 |
| Panel D: Correlation coefficients | | | | | | |
| | Book leverage | Product substitutability | Industry operating leverage | Market size | Firm operating leverage | |
| Book leverage | 1 | | | | | |
| Product substitutability | -0.153 | 1 | | | | |
| Industry fixed cost | -0.011 | -0.066 | 1 | | | |
| Market size | -0.103 | 0.226 | 0.101 | 1 | | |
| Firm fixed cost | -0.101 | 0.182 | 0.057 | 0.103 | 1 | |

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 D. 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.

| | Baseline | | Single segment | |
|---|---|---|---|---|
| Variables | (1) | (2) | (3) | (4) |
| Product substitutability | 0.045*** | 0.071*** | 0.046** | 0.070*** |
| | (3.081) | (4.822) | (2.478) | (3.769) |
| Industry fixed cost | 0.006* | 0.008** | 0.009** | 0.009** |
| | (1.759) | (2.566) | (2.024) | (2.391) |
| Market size | -0.010*** | -0.004* | -0.008*** | 0.0004 |
| | (-4.888) | (-1.726) | (-2.585) | (0.098) |
| Firm fixed cost | -0.028*** | -0.008*** | -0.025*** | -0.009*** |
| | (-9.300) | (-3.239) | (-7.500) | (-3.131) |
| Firm size | 0.015*** | 0.026*** | 0.014*** | 0.022*** |
| | (14.953) | (9.383) | (11.738) | (6.637) |
| Market-to-book | -0.007*** | -0.003*** | -0.006*** | -0.003*** |
| | (-6.903) | (-4.071) | (-5.435) | (-3.590) |
| Profitability | -0.090*** | -0.076*** | -0.085*** | -0.075*** |
| | (-13.740) | (-10.441) | (-12.114) | (-8.949) |
| Asset tangibility | 0.205*** | 0.154*** | 0.235*** | 0.167*** |
| | (16.055) | (9.881) | (15.278) | (8.415) |
| Cash flow volatility | 0.004 | 0.011* | 0.005 | 0.009 |
| | (0.939) | (1.785) | (1.179) | (1.331) |
| Dividend payer | -0.085*** | -0.026*** | -0.085*** | -0.016*** |
| | (-22.055) | (-6.298) | (-18.625) | (-3.374) |
| Year FE | Yes | Yes | Yes | Yes |
| Industry FE | Yes | No | Yes | No |
| Firm FE | No | Yes | No | Yes |
| Observations | 72,994 | 72,994 | 49,078 | 49,078 |
| Adjusted $R^2$ | 0.224 | 0.641 | 0.230 | 0.652 |

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 D. Standard errors, reported in parentheses, are adjusted for within-firm clustering. Significance at the 10%, 5%, and 1% level is indicated by *, **, and ***, respectively.

| Variables | Long-term book leverage (1) | Total book leverage (2) | Market leverage (3) |
|---|---|---|---|
| Product substitutability | 0.039*** | 0.078*** | 0.109*** |
| | (2.880) | (5.030) | (7.251) |
| Industry fixed cost | 0.008*** | 0.007** | 0.010*** |
| | (2.714) | (2.232) | (2.953) |
| Market size | -0.003* | -0.003 | -0.001 |
| | (-1.674) | (-1.533) | (-0.638) |
| Firm fixed cost | -0.006*** | -0.007*** | -0.005* |
| | (-2.761) | (-2.756) | (-1.851) |
| Firm size | 0.024*** | 0.009*** | 0.044*** |
| | (9.822) | (3.089) | (15.603) |
| Market-to-book | -0.001* | -0.005*** | -0.011*** |
| | (-1.735) | (-6.313) | (-12.603) |
| Profitability | -0.044*** | -0.084*** | -0.106*** |
| | (-8.029) | (-11.093) | (-14.318) |
| Asset tangibility | 0.121*** | 0.150*** | 0.188*** |
| | (8.635) | (9.465) | (12.208) |
| Cash flow volatility | 0.007* | 0.005 | 0.007 |
| | (1.738) | (0.596) | (1.281) |
| Dividend payer | -0.023*** | -0.022*** | -0.043*** |
| | (-6.047) | (-5.052) | (-9.176) |
| Year FE | Yes | Yes | Yes |
| Firm FE | Yes | Yes | Yes |
| Observations | 72,994 | 59,476 | 72,517 |
| Adjusted $R^2$ | 0.614 | 0.673 | 0.683 |

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. Columns (1) and (2) show the results using product substitutability 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 product substitutability variables by measuring operating costs as the sum of material costs and production workers' wages in Column (1) and as the sum of material costs, total pay,and energy in Column (2). Columns (3) and (4) show the results using the alternate operating leverage variables: the ratio of SG&A to assets in Column (3) and that of SG&A less R&D to assets in Column (4). Columns (5) and (6) present the results using the alternate industry classifications: the four-digit SIC level (Column (5)) and Hoberg-Phillips (HP) (2010, 2016) 10-K Text-based Fixed Industry Classification (FIC-400)(Column (6)). In all regressions, we lag independent variables by one year, and include firm and year fixed effects. All variables are defined in Appendix D. 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.

| | Census product substitutability | | Alternate operating leverage | | SIC4 | HP |
|---|---|---|---|---|---|---|
| Variables | (1) | (2) | (3) | (4) | (5) | (6) |
| Product substitutability | 0.018*** | 0.029*** | 0.045*** | 0.046*** | 0.060*** | 0.065*** |
| | (2.641) | (2.711) | (3.847) | (3.982) | (5.109) | (4.872) |
| Industry fixed cost | 0.017*** | 0.016** | 0.031* | 0.035** | 0.006* | 0.019** |
| | (2.626) | (2.568) | (1.894) | (2.235) | (1.819) | (2.015) |
| Market size | -0.012*** | -0.011*** | -0.005*** | -0.005*** | -0.002 | -0.0003 |
| | (-3.673) | (-3.405) | (-2.926) | (-2.904) | (-1.214) | (-0.180) |
| Firm fixed cost | -0.006 | -0.006 | -0.003 | 0.004 | -0.007*** | -0.004 |
| | (-1.457) | (-1.469) | (-0.435) | (0.789) | (-2.696) | (-1.247) |
| Firm size | 0.030*** | 0.030*** | 0.026*** | 0.026*** | 0.025*** | 0.027*** |
| | (8.074) | (8.090) | (11.919) | (12.315) | (8.841) | (7.626) |
| Market-to-book | -0.003*** | -0.003*** | -0.003*** | -0.003*** | -0.003*** | -0.005*** |
| | (-3.289) | (-3.283) | (-5.620) | (-5.573) | (-3.859) | (-4.208) |
| Profitability | -0.091*** | -0.092*** | -0.053*** | -0.051*** | -0.055*** | -0.117*** |
| | (-10.108) | (-10.007) | (-10.254) | (-10.517) | (-9.319) | (-9.737) |
| Asset tangibility | 0.145*** | 0.145*** | 0.171*** | 0.170*** | 0.157*** | 0.129*** |
| | (6.625) | (6.609) | (13.830) | (13.773) | (9.941) | (5.688) |
| Cash flow volatility | 0.022 | 0.021 | 0.002 | 0.003 | 0.012* | -0.007 |
| | (1.446) | (1.448) | (0.565) | (0.589) | (1.946) | (-0.399) |
| Dividend payer | -0.028*** | -0.028*** | -0.033*** | -0.033*** | -0.024*** | -0.009* |
| | (-5.356) | (-5.353) | (-9.200) | (-9.227) | (-5.888) | (-1.665) |
| Year FE | Yes | Yes | Yes | Yes | Yes | Yes |
| Firm FE | Yes | Yes | Yes | Yes | Yes | Yes |
| Observations | 36,709 | 36,709 | 106,382 | 106,382 | 69,297 | 34,888 |
| Adjusted $R^2$ | 0.610 | 0.610 | 0.619 | 0.619 | 0.638 | 0.707 |

Table 5: Intra-industry profit distribution and book leverage.

We run firm-level panel regressions of book leverage on a proxy for intra-industry profit skewness, which is the skewness of firm operating profits within each industry-year with firm operating profits being first demeaned at the firm level, 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 D. 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. We use our baseline measure of firm-level operating leverage in Columns (1)-(4), whereas we use one of the alternate variables of firm-level operating leverage, the ratio of SG&A less R&D to assets in Columns (5)-(8). Standard errors, reported in parentheses, are adjusted for within-firm clustering. Significance at the 10%, 5%, and 1% level is indicated by *, **, and ***, respectively.

| | All firms | | Single segment | | All firms | | Single segment | |
|---|---|---|---|---|---|---|---|---|
| Variables | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) |
| Intra-industry profit skewness | 0.0005** | 0.0004* | 0.0006** | 0.0006*** | 0.0004** | 0.0005*** | 0.0006*** | 0.0007*** |
| | (2.153) | (1.932) | (2.503) | (2.690) | (2.368) | (2.908) | (2.995) | (3.541) |
| Market size | -0.011*** | -0.004* | -0.010*** | -0.0001 | -0.010*** | -0.005*** | -0.008*** | -0.002 |
| | (-5.207) | (-1.738) | (-2.906) | (-0.013) | (-6.310) | (-2.763) | (-3.414) | (-0.558) |
| Firm fixed cost | -0.028*** | -0.008*** | -0.025*** | -0.009*** | -0.008** | 0.005 | -0.002 | 0.008 |
| | (-9.204) | (-3.201) | (-7.456) | (-3.149) | (-2.056) | (1.090) | (-0.626) | (1.638) |
| Firm size | 0.015*** | 0.025*** | 0.014*** | 0.022*** | 0.014*** | 0.026*** | 0.014*** | 0.022*** |
| | (14.904) | (9.298) | (11.692) | (6.558) | (15.940) | (12.166) | (12.532) | (9.080) |
| Market-to-book | -0.007*** | -0.003*** | -0.006*** | -0.003*** | -0.006*** | -0.003*** | -0.005*** | -0.003*** |
| | (-6.845) | (-3.983) | (-5.415) | (-3.579) | (-10.293) | (-5.611) | (-8.531) | (-5.213) |
| Profitability | -0.087*** | -0.068*** | -0.083*** | -0.070*** | -0.060*** | -0.046*** | -0.054*** | -0.042*** |
| | (-13.959) | (-10.129) | (-12.233) | (-8.850) | (-14.597) | (-10.085) | (-12.671) | (-8.432) |
| Asset tangibility | 0.204*** | 0.155*** | 0.235*** | 0.168*** | 0.213*** | 0.171*** | 0.241*** | 0.188*** |
| | (16.035) | (9.901) | (15.276) | (8.463) | (21.091) | (13.831) | (20.110) | (12.761) |
| Cash flow volatility | 0.004 | 0.013** | 0.006 | 0.011 | 0.002 | 0.003 | 0.003 | 0.002 |
| | (1.095) | (2.047) | (1.301) | (1.580) | (0.924) | (0.781) | (1.014) | (0.549) |
| Dividend payer | -0.086*** | -0.026*** | -0.085*** | -0.016*** | -0.086*** | -0.033*** | -0.086*** | -0.024*** |
| | (-22.142) | (-6.423) | (-18.655) | (-3.422) | (-25.393) | (-9.251) | (-21.224) | (-6.042) |
| Year FE | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Industry FE | Yes | No | Yes | No | Yes | No | Yes | No |
| Firm FE | No | Yes | No | Yes | No | Yes | No | Yes |
| Observations | 72,994 | 72,994 | 49,078 | 49,078 | 106,382 | 106,382 | 72,935 | 72,935 |
| Adjusted $R^2$ | 0.224 | 0.640 | 0.230 | 0.652 | 0.224 | 0.619 | 0.231 | 0.630 |