# Industry Dynamics and Capital Structure (Non)Commitment*

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**Abstract**

We develop a competitive equilibrium model of leverage and industry dynamics absent of equity holders' commitment to future debt levels. Shareholders determine the debt adjustment together with production, entry and exit decisions in response to firm-specific technology shocks. Non-commitment gives rise to debt issuance, which increases the cost of debt financing. Consequently, the entry barrier is raised, hindering entries into the market. Meanwhile, the resultant higher output price alleviates debt-equity conflicts for firms already in the industry. More importantly, non-commitment increases the mass of high-leverage firms, reshaping the distribution of the firm universe and escalating industry turnover and leverage. The results are aligned with empirical distribution features, suggesting debt-equity conflicts at the firm level can have a profound influence on industry dynamics.

Keywords: Capital Structure, Leverage Ratchet Effect, Industry Dynamics, Product Market Competition

JEL: E21, E32, G12, G32

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# 1 Introduction

The debt-equity conflict is one of the core paradigms of corporate finance. Not only does it affect the value of corporate liabilities, but it also has prominent real effects, for example, asset substitution and inefficient underinvestment problems identified, respectively, by Jensen and Meckling (1976) and Myers (1977). While the real influence might be minor for an individual firm depending on its specific characteristics, it can rapidly add up to a significant magnitude at the industry level and therefore has profound ramifications for product market competition, output prices, and many other essential dimensions of industrial organization.

One consequence of debt-equity conflicts is shareholders' resistance to value-enhancing leverage reduction, for example, financially distressed firms' failure to recapitalize. A seminal paper by Admati et al. (2018) shows that, in the absence of commitment to future funding choices, shareholders not only have resistance to debt reductions, but also have a desire to increases the firm's leverage to the detriment of debt holders. They highlight the extensive consequences of such "leverage ratchet effect" on dynamics of capital structure and firm value. The corresponding welfare and policy implications indicate that this instance of debt-equity conflict can have a substantial effect on the entire industry. Several interesting questions emerge. Does the instance of conflict have effects on industry-level dynamics? If so, through which channels? And how quantitatively important are these channels? The present work attempts to unveil the inherent interaction between debt-equity conflicts at the individual firm level and industry dynamics through addressing these questions.

We embed debt-policy non-commitment in a competitive industry equilibrium model. While most of the existing work about capital structure and industry equilibrium assumes either all-equity financing (equity holders commit to all-time zero debt financing) or Leland-type fixed amount of debt (equity holders commit to same level of debt), our paper emphasizes debt-equity conflicts through non-commitment. It means that with debt in place, equity holders cannot commit *not* to change debt levels in the future and can issue or buy-back debt at market prices at any time. In particular, we build on the work of DeMarzo and He (2020), a continuous-time extension of Admati et al. (2018), who study a representative firm's leverage trajectory when equity holders are unable to commit to a future debt level in



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partial equilibrium. We develop an industry equilibrium model features a continuum of such strategic firms facing idiosyncratic technology shocks. While strategically deciding funding choices, equity holders also determine the firm's production, entry and exit decisions at the same time. The joint decision-making process reflects an intricate interaction between the firm's financing decision and product market competition. Specifically, on the one hand, the output price largely determines a firm's profitability and hence, directly affects its financing choices. On the other hand, the funding decisions, at the same time, affect the firm's entry and exit, shaping the product price and aggregate output.

The inability to commit to future debt choices means the equity holders can adjust the debt level at market prices at any time to maximize the equity value. In a competitive market, firms determine their own strategies in response to idiosyncratic shocks by taking the market price of output as exogenously given. Consistent with DeMarzo and He (2020), we find that, in the firm-level partial equilibrium, equity holders issue debt gradually and at a faster rate when the cash flow improves. Following a negative productivity shock, the debt issuance rate reduces, which leads to a passive reduction of leverage. More importantly, we show that, in a competitive industry equilibrium, the optimal financing choice is price dependent. All else equal, an increase in output price induces a more aggressive debt issuance policy, which in turn, alters the equilibrium price and shapes the industry dynamics.

Although an individual firm might grow, wither or exit the market depending on its idiosyncratic shock realization, the industry, as a whole, has a long-run equilibrium, in which there exists a stationary distribution of firms in the industry and all the aggregate variables are constant over time, including the equilibrium output price. We solve the stationary industry equilibrium in a debt-scaled EBIT state variable, which is proportional to a firm's interest coverage ratio and can be considered as a measure of the firm's leverage and financial condition. Moreover, in order to highlight the non-commitment effect quantitatively, we compare our equilibrium results to a counterfactual equilibrium in which firms commit to a constant debt level as in Leland (1998). The results imply that the inability to commit to future funding choices affects industry dynamics through two channels.

The first one is the price effect channel, and this channel has a different influence on potential entrants and incumbents. Specifically, as debt holders anticipate the equity hold-



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ers to issue more debt in the future, increasing the default risk and diluting their claims, debt financing becomes more costly. Thus, the expected firm value from entry diminishes, which raises the entry barrier and discourages potential entrants from entering the market. Consequently, market competition is reduced and product price in the equilibrium soars. Although non-commitment increases the default probability (compared to the case where firms are able to commit to a future debt level), the resulting reduction in market competition benefit the firms that are already in the industry (i.e. the incumbents) by improving their profitability, which to some extent, mitigates the adverse effect of non-commitment on default risk. Furthermore, the increase in output price also alleviates debt-equity conflicts and mitigates equity holders' appropriation incentives. In other words, we show that the rise in the equilibrium output price reduces agency costs induced by non-commitment behaviour.

The second one is the distribution effect channel. The fact that the equity holders can issue more debt over time in response to firm-specific technology shocks and cash flow changes reshapes the distribution of the entire firm universe. With non-commitment, a larger number of firms concentrate in the high leverage region, meaning an overall higher average industry leverage compared to the commitment case. We show that a higher proportion of firms stand close to the exit threshold and consequently, the frequency of firms' entry and exit increases, resulting in a higher turnover rate.[1]This means that the presence of non-commitment endangers firms stand close to the boundary, and meanwhile, create an edge for firms that are on the right tail of the distribution (i.e those with high EBIT to debt ratio).

These findings are consistent with the empirical distribution features observed. Figure 1 plots the normalized density of the ratio of earnings before interest and tax (EBIT) to debt (corresponds to our state variable) based on data from Compustat. As shown, the distribution is stable over time, with an average mean of 46.5% and median of 24.1%. In other words, the distribution is positively skewed, and a great proportion of firms clustering

[1]Note that in a stationary equilibrium, the rate of entry equals the rate of exit, leaving the total mass of incumbents in the industry unchanged. Non-commitment leads to an increase in the default rate, thereby raising the exit frequency. As a result of the stationary industry equilibrium, we also observe a higher frequency of entry even though entry is more difficult.



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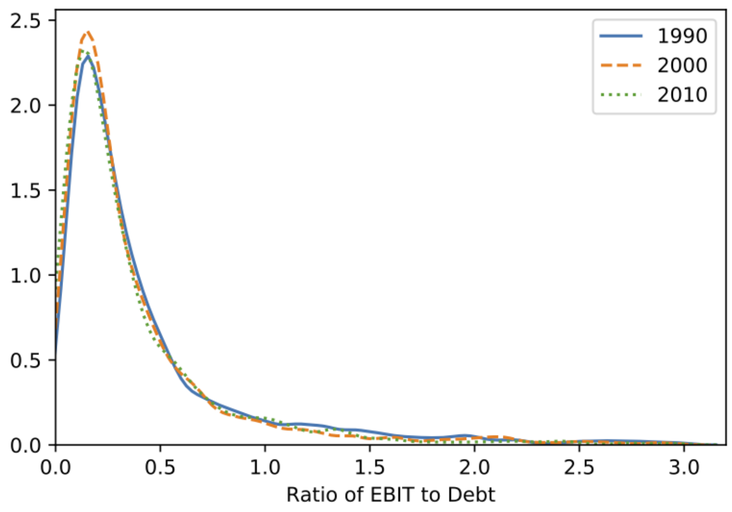


Figure 1: The probability densities of ratio of EBIT to debt for the U.S firms

The figure plot the probability densities of the ratio of EBIT to debt for the U.S public listed firms in 1990 (solid line), 2000 (dotted line), and 2010 (dash-dotted line). Debt is calculated as the sum of debt in current liabilities (DLC) and long-term debt (DLTT). Data source: Compustat

in the low-value area. Our model provides a micro foundation for the distribution and is able to quantitatively replicate its key characteristics. This means that the debt-equity conflict arising from the absence of leverage commitment not only helps to explain the debt dynamics at the firm level (see Admati et al. (2018) and DeMarzo and He (2020)), but also at the market level.

The distributional effect channel, in conjunction with the price effect channel, determines the industry dynamics. Our numerical results show that the price effect is the key driver for aggregate output, whereas the distribution effect significantly determines the industry leverage and turnover rate. Even though non-commitment reduces market competition and lifts the output price, reducing an individual firm's likelihood to exit the market, it does not overturn the high industry turnover rate. The reluctance to reduce leverage and the incentive to issue more debt over time to expropriate value put more firms close to the default boundary. In the stationary equilibrium, the absence of commitment has opposite influence on firms located on the two tails: it reinforces the advantage of financially healthy firms and amplifies the weakness of those on the brink of default. Such a selection effect is externalized through a high turnover rate.



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The paper contributes to the growing literature on non-commitment of debt policy.[2] Starting from Bizer and DeMarzo (1992) who study the role of commitment in the context of sequential borrowing, this strand of literature includes papers that examine how non-commitment influences a firm's dynamics from different perspectives: debt maturity (e.g. Brunnermeier and Oehmke (2013) and He and Milbradt (2016)), debt changes (e.g. Admati et al. (2018) and DeMarzo and He (2020)) and transaction cost (e.g. Benzoni et al. (2020)), as well as how this debt-equity conflict affects aggregate risk and welfare (e.g. Johnson, Liu and Yu (2018)). DeMarzo and He (2020) show that in a partial equilibrium model, equity holders, without debt policy commitment, keep issuing debt to exploit tax benefits. The tax benefits, however, are completely offset by the increase in credit spreads since creditors are concerned about the possibility of more future debt issuance. Johnson, Liu and Yu (2018) place the absence of commitment in the context of business cycle and investigate its real effect on macroeconomy. They highlight the time-varying expropriation incentive of shareholders and quantify cyclical private and social costs of non-commitment. Our work finishes the "last piece of the puzzle" studying the effect of non-commitment at firm, industry and macroeconomy levels. We accentuate its influence through the lens of exit and entry of firms in the industry and the corresponding industry dynamics implications. Our mechanism shows that firm-level leverage dynamics caused by debt-policy non-commitment account for the increases in the mass of low debt-scaled cashflow firms in the left tail, a key feature of the data that can not be explained by existing commitment models.

The present paper also relates to the strand of literature that studies industry dynamics in a stationary equilibrium framework developed by Hoepnhayn (1992a, 1992b) and Hopenhayn and Rogerson (1993). Hartman-Glaser, Lustig and Xiaolan (2019) present an optimal contracting problem in an industry equilibrium model to analyze the divergence of aggregate and firm-level capital shares. Miao (2005), most relevant to our work, studies the interaction between capital structure and production decisions, and highlights the feedback effect of output price on firms' financing decisions. He considers perpetual debt contracts with constant coupon payment, which means shareholders are committing to maintaining

[2]Broadly speaking, our paper also contributes to the literature on dynamic leverage that includes Fischer, Heinkel and Zechner (1989), Goldstein, Ju and Leland (2001), and Bolton, Wang and Yang (2020), and others.



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the debt policy. In this paper, we embed a non-commitment debt policy into a stationary equilibrium setup to study the interaction between capital structure and product market competition. In our model, the equity holders can issue or repurchase debt at any point of time at equilibrium debt prices, through which engraving industry dynamics with debt-equity conflicts. We obtain distinct industrial organization implications – a more positively skewed firm distribution, and higher market turnover rate and average leverage.

Another stand of industry equilibrium model is based on the framework developed by Leahy (1993) where the shocks are market-wide. Leahy (1993) analyzes the entry and exit of all-equity financing firms under perfect competition. Fries, Miller and Perraudin (1997) extend the Leahy (1993) by incorporating debt-financing. Lambrecht (2001) investigates entry, exit, and debt financing in a duopoly. Different from these papers, firms in our model encounter idiosyncratic technology shocks, and the shocks are independent, which means the uncertainty is at firm-level. The i.i.d shocks and Poisson death ensure the existence of a long-run stationary equilibrium and allow us to quantify the influence of non-commitment at the industry level.

The remainder of the paper is organized as follows. Section 2 sets up the model. Section 3 characterizes an individual firm's partial equilibrium result when equity holders cannot commit to future funding choice, and studies long-run stationary industry equilibrium. Section 4 analyzes the interaction between non-commitment and product market competition. Section 5 discusses its influence on industry output, turnover rate and leverage. Comparative statics with respect to various exogeneous shocks is also presented. Section 6 concludes.

# 2 The Model

We attempt to address the joint dynamics of individual firms' production and capital structure decisions, as well as the corresponding industry equilibrium implications and feedback effects. Toward this end, we build on the model of DeMarzo and He (2020) by incorporating product market competition. Individual firms have to make their production, financing as well as the entry and exit decisions simultaneously by taking the market price of the prod-



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uct as exogenously given. Meanwhile, these decisions jointly determine the market price and firm distribution in the industry equilibrium, which in turn affect individual firms' behaviour.

Time is continuous, and the horizon is infinite. In a risk-neutral setup, we consider a perfectly competitive industry in which both the product market and the debt market are competitive. The uncertainty is summarized by a complete probability space $(\Omega, \mathcal{F}, \mathcal{P})$, and the risk-free rate equals to $r$. There are a large number of firms in the industry, all of whom take input and output prices as exogenously given. Therefore, there are two types of equilibriums in this paper: a partial equilibrium in which individual firms are price takers and optimize their strategies accordingly, and an industry equilibrium where firms in the industry together characterize the output prices and aggregate features. In particular, we focus on the long-run stationary industry equilibrium such that all aggregate variables are constant and highlight the effect of lack of leverage commitment on both equilibriums.

## 2.1 Individual firm

There are numerous competitive firms facing identical and independent technology shocks that are governed by a geometric Brownian motion:

$$\frac{dw_{it}}{w_{it}} = \mu_w dt + \sigma_w dB_{it} \tag{1}$$

where $\mu_w$ and $\sigma_w$ are known constants and $dB_{it}$ is a standard Brownian motion that captures individual firm's idiosyncratic shock. This means the uncertainty is at the firm level. The subscript $i$ reflects the fact that technology shocks are firm-specific.[3] These i.i.d shocks imply that all firms are ex-ante identical in terms of distribution from which the shocks are drawn, but are ex-post distinct in terms of realizations of shocks. These idiosyncratic shocks also contribute to different capital structure dynamics among firms. Meanwhile, each firm

[3]In this paper, the subscript $i$ refers to firm-level decisions, i.e. the partial equilibrium case. Firms are heterogeneous in terms of realizations of technology shocks, which makes the optimal production rules and financing decisions differentiated from each other. However, since the shocks to individual firms are independent, according to Dixit and Pindyck (1994), the law of large number ensures that the industry aggregates are not random. All firms are identical up to the initial realizations of technology shocks, and there is a continuum of potential entrants. We omit the subscript $i$ when we discuss the industry equilibrium.



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encounters independent Poisson death shocks with intensity $\lambda$.[4]

### 2.1.1 Production problem

The production problem for an individual firm follows a standard setup as in Miao (2005). Given any amount of capital, $k$, the decreasing return to scale production function is given as

$$F(k) = k^{v} \quad \text{with} \quad v \in (0,1) \tag{2}$$

The cost of capital is $r + \delta$, where $\delta$ denotes the capital depreciation rate, and $r$ is the rental cost reflecting the opportunity cost of capitals. To simplify our analysis, we assume no other costs are incurred in the production process. The output price, $p$, is determined at the industry level and firms take it as exogenously given. Accordingly, the profit maximization problem for a firm in the industry is

$$\Pi_i(w_i, p) = \max_{k_i}(1 - \tau)(p\, w_i\, k_i^{v} - \delta k_i) - r\, k_i \tag{3}$$

where $\tau$ is the tax rate. The first-order condition implies the optimal capital employed ($k_i^{\star}$), output supply ($l_i^{\star}$) and after-tax profit function ($\Pi_i(w_i, p)$) are given as

$$k_i^{\star}(w_i, p) = w_i^{\gamma}\Big(\frac{p\, v}{\frac{r}{1-\tau} + \delta}\Big)^{\gamma} \tag{4}$$

$$l_i^{\star}(w_i, p) = w_i^{\gamma}\Big(\frac{pv}{\frac{r}{1-\tau} + \delta}\Big)^{v\gamma} \tag{5}$$

$$\Pi_i(w_i, p) = (1 - \tau)(h(p)w_i^{\gamma}) \equiv (1 - \tau)\pi_i(w_i, p) \tag{6}$$

where

$$\gamma = \frac{1}{1 - v} > 1 \tag{7}$$

$$h(p) = p^{\gamma}(1 - v)\Big(\frac{v}{\frac{r}{1-\tau} + \delta}\Big)^{v\gamma} \tag{8}$$

[4]Such Poisson shocks guarantee the existence of a stationary industry equilibrium in the presence of non-stationary individual technology shocks for firms.



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$\pi_i(w_i, p)$ represents the firm's operating cash flow, EBIT, generated by its asset in place. Note that individual firms adopt different production rules based on their technology level $w_i$.

### 2.1.2 Capital structure problem

Existing literature on industry dynamics often assumes equity holders commit to a certain debt level. In this paper, we highlight their non-commitment as in DeMarzo and He (2020), that is, the equity holders are unable to commit to future debt levels. They can continuously adjust debt at market prices to maximize equity values. Anticipating the equity holders' behaviour, the debt holders price the newly issued or repurchased debt accordingly. Correspondingly, the equity holders take the endogenously determined debt price $D_{it}$ into account while setting the adjustment policy.

Let $F_{it}$ be the aggregate face value of debt in place, and $c$ be the constant coupon rate. The debt matures exponentially at an amortization rate of $\xi > 0$, which means that at each point of time, an amount of $\xi F_{it} dt$ is retired and the equity holders have to pay $(c + \xi) F_{it} dt$ to avoid default.[5] In the event of default, $\psi \in [0, 1)$ fraction of the firm's unlevered value is preserved. We first focus on $\psi = 0$ and introduce positive recovery in Section 3.1.3. The equity holders of the firm can issue or repurchase debt at any time. Denote $d\Gamma_{it}$ the instantaneous adjustment policy with $d\Gamma_{it} = G_{it} dt$, where $G_{it} > (<)\, 0$ is the issuance (repurchase) rate. As a result, the amount of outstanding debt evolves according to

$$dF_{it} = (G_{it} - \xi F_{it}) dt \tag{9}$$

The residual cash flow to the shareholders at $t$ is given by

$$[\underbrace{(1 - \tau)(\pi_{it}(w_{it}, p) - cF_{it})}_{\text{Net Income}} + \underbrace{D_{it} G_{it}}_{\text{Debt adjustment}} - \underbrace{\xi F_{it}}_{\text{debt principle repayment}}] dt \tag{10}$$

Taking the output prices, $p$, and debt price, $D_{it}$, as given, the equity holders simultaneously determine the optimal investment policy, $k^{\star}_{it}$, the debt policy $G^{\star}_{it}$ and the default

[5] The maturity of debt is $\frac{1}{\xi}$ if no adjustment is allowed.



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policy $T_d \in (0, \infty)$ to maximize equity values. Default is triggered when the net cash flow $\pi_{it}$ (productivity $w_i$) falls below some level where the equity holders are no longer willing to pour additional money to meet the debt obligations. Together with the optimal operating cash flow $\pi_{it}$ given in (6), the optimization problem for the equity holders of an individual firm can be written as

$$E_{it}(w_i, F_i; p) = \tag{11}$$
$$\max_{G_i, T_d} \mathbb{E}_t \Big[ \int_t^{T_d} e^{-(r+\lambda)(s-t)} \Big( (1-\tau)(\pi_{it}(w_i, p) - cF_{it}) + D_{it}G_{it} - \xi F_{it} \Big) ds \,|\, w_{it} = w, F_{it} = F \Big]$$

As the recovery rate is zero, the equilibrium debt price, $D_{it}$, is, therefore, the present value of all the coupon and principal payments until default, which is given by the following:

$$D_{it}(w_i, F_i; p) = \mathbb{E}_t \Big[ \int_t^{T_d} e^{-(r+\lambda)(s-t)} (c + \xi) dt \,|\, w_{it} = w, F_{it} = F \Big] \tag{12}$$

### 2.1.3 Entry decision

Firms also need to determine their entry policy. At each point in time, there is a continuum of potential entrants. The new entrants encounter a fixed one-off sunk cost $c_e$. Upon entry, the individual firm's initial technology shock is drawn independently from a distribution $\Upsilon_w \sim U(\underline{w}, \overline{w})$, which means that all entrants are identical upon the initial draw. To control for exogenous heterogeneity and simplify the analysis, we assume the initial debt value is the same.[6] Firms are innocent about the initial values of the draws, and all draws are i.i.d, implying the entry and exit condition is the same for all firms. Denote $V(w, F)$ as the value of a new entrant. In a competitive equilibrium, a firm enters the industry when

[6] Firms do not know their initial productivity types, it is, therefore, reasonable to assume that they all have the same level of initial debt, through which we are able to ensure that all firms are ex-ante identical. Recognizing their initial types and subsequent realizations of the technology shocks induce firms to adjust in response to their own productivity levels. It means that the subsequent debt adjustment path is optimal given the technology shocks and initial debt value. We later show in section 3 that if the technology level turns out to be low relative to the debt holding, the equity holders will response by issuing debt at a rate that is smaller than the amortization rate, inducing a passive and gradual reduction of outstanding debt. For high productivity level, the opposite holds.



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the expected value from entry equals the cost incurred, i.e

$$\int_{\underline{w}}^{\overline{w}} V(w, F)\upsilon_w dw \;=\; c_e \tag{13}$$

where $\upsilon_w$ is the probability density functions of the distribution $\Upsilon_w$. Firms recognize their initial types after the initial draws, and thereafter, the technology shocks encountered evolves according to the diffusion process specified in (1). Subsequent adjustments in production and financing decisions in response to firm-specific shocks create heterogeneities across firms.

## 2.2 The industry

The industry demand function is iso-elastic and given by

$$p \;=\; L^{-\frac{1}{\epsilon}} \tag{14}$$

where $\epsilon > 0$ is the price elasticity of demand, and $L$ is the industry total output.

We are interested in the long-run steady state of the industry, in which there is a stationary distribution of surviving firms $\chi$. Note that $\chi$ is not a probability measure, and we later show that the distribution is characterized by a density function $\kappa$. Firms exit the industry when the technology shock is below the exiting threshold $w_d(p)$, which means the survival region is $[w_d(p), +\infty)$. In other words, $\chi(w)$ describe the mass of firms at $w$, and for any $\mathcal{B} \subseteq [w_d(p), +\infty)$, $\chi(\mathcal{B})$ can be interpreted as the mass of surviving firms with technology shocks level in the set $\mathcal{B}$. The stationary distribution function allows us to compute various aggregate variables; for example, the industry output supply:

$$L \;=\; \int_{w_d}^{\infty} l(w, p)\chi(dw) \;=\; p^{-\epsilon} \tag{15}$$

The industry equilibrium is thus characterized by a set of constant aggregate industry-wide variables $(p^\star, T_d, \chi^\star)$, where $p^\star$ is the equilibrium output price, $T_d$ is the common exit policy, and $\chi^\star$ is the stationary distribution of surviving firms in the industry. The industry equilibrium is obtained by the following:



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- Equity holders of firms determine their optimal production and leverage policy according to (11) by taking the output price $p$ as exogenously given;
- Debt holders price any newly issued/repurchased debt according to (12);
- The entry condition (13) holds for all potential entrants;
- Market clears through the demand function $p^\star = L(\chi^\star, p^\star)^{-\frac{1}{\epsilon}}$;
- The distribution $\chi^\star$ is stationary over the surviving region.

# 3 Partial Equilibrium and Stationary Industrial Equilibrium

In this section, we solve for the optimal policies at firm level (the partial equilibrium) and characterizes the industry equilibrium. We consider the influence of positive recovery at default in section 3.1.3.

## 3.1 Partial equilibrium

### 3.1.1 Debt adjustment policy

By the standard dynamic programming argument, the corresponding Hamilton–Jacobi–Bellman equation (HJB) for the shareholders based on (11) is

$$\underbrace{(r + \lambda)E_i(w_i, F_i)}_{\text{required return}} = \max_{G_i} \underbrace{(1 - \tau)\Big(h(p)w_i^\gamma - cF_i\Big)}_{\text{net income}} + \underbrace{D_iG_i - \xi F_i}_{\text{rollover loss}} + \underbrace{(G_i - \xi F_i)E_{iF}}_{\text{evolution from change in F}} + \underbrace{\mu_w w_i E_{iw} + \frac{1}{2}\sigma_w^2 w_i^2 E_{iww}}_{\text{evolution from change in technology shock}} \tag{16}$$



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The HJB equation is linear in $G_i$, and the first order condition shows

$$D_i(w_i, F_i; p) = -E_{iF}(w_i, F_i; p) \tag{17}$$

Equation (17) suggests that the lack of commitment imposes a negative effect on debt prices, which induces the equity holders to adjust debt in a continuous manner and avoid discrete adjustments.[7] The first-order condition also implies that in a smooth equilibrium, the marginal benefits of issuing debt (obtaining $D_i$) is equal to the marginal cost of the changing debt burden on share value ($-E_{iF}$). Substituting the first-order condition into (16) shows that the equity value can be solved as if $G_i = 0$, i.e., the equity holders commit not to adjust debt. It means that if the shareholders are free to change the debt level, they will adjust to a level such that the marginal revenue equals the marginal cost, where they essentially obtain no marginal surplus from further debt adjustment. As a result, the equilibrium equity value under non-commitment is the same as the value under strict commitment of no adjustment.

For the debt price, equation (12) generates a differential equation

$$\underbrace{(r + \lambda)D_{it}(w_i, F_i)}_{\text{required return}} = \underbrace{c}_{\text{coupon}} + \underbrace{\xi(1 - D_{it})}_{\text{debt amortization}} + \underbrace{(G_i^\star - \xi F_i)D_{iF}}_{\text{evolution of debt from F}} + \underbrace{\mu_w w_i D_{iw} + \frac{1}{2}\sigma_w^2 w_i^2 D_{iww}}_{\text{evolution from technology shock}} \tag{18}$$

Examining these two differential equations together allows us to obtain the optimal debt adjustment policy as

$$G_i^\star = \frac{\tau c}{E_{iFF}} = -\frac{\tau c}{D_{iF}} \tag{19}$$

Provided that $E_i$ is convex in $F_i$, (19) implies that as long as the tax benefit is strictly positive, i.e., $\tau > 0$, equity holders always have an incentive to increase the debt holding in a smooth manner and have no intention to reduce debt voluntarily. The fact that the equilibrium equity value can be derived as if $G_i = 0$ does not imply that the optimal

[7] As proven in DeMarzo and He (2020), equity holders never repurchase debts if tax benefits are positive. Moreover, they prove that as long as the total firm value is strictly convex in the face value $F$ (the debt price is strictly decreasing in $F$), discrete adjustments are suboptimal for the shareholders. Aligned with their argument, we focus on the set of special Markov-perfect equilibrium in which equity holders find it optimal to adjust debt level smoothly and continuously, that is, the smooth equilibrium. We verify the convexity in section 3.1.2.



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adjustment rate is zero. With $G_i = 0$, the first-order condition (17) is violated as tax benefits overpass issuance costs incurred. As $G_i$ increases gradually, the benefits shrink as default risk jumps to the point where the condition (17) binds. In other words, the shareholders find it optimal to issue debt at a positive rate specified by (19), with which the marginal default cost offsets the marginal tax benefit. These results are in line with the DeMarzo and He (2020).

More importantly, different from DeMarzo and He (2020), both the equity value and debt value depend on the equilibrium output price $p$, which makes the optimal issuance policy also $p$-dependent. Recall that the optimal investment policy (4) is also a function of the output price $p$. This indicates a price feedback effect on firms' financial policies.

### 3.1.2 Optimal financing decisions

The structure of equation (16) suggests that it is more convenient to work with $w_i^\gamma$ instead of $w_i$. We define $z_i \equiv w_i^\gamma$ and apply the Itô's lemma,

$$\frac{dz_{it}}{z_{it}} = \Big(\mu_w\gamma + \frac{1}{2}\sigma_w^2\gamma(\gamma - 1)\Big)dt + \sigma_w\gamma dB_{it} \equiv \mu_z dt + \sigma_z dB_{it} \tag{20}$$

$z_i$ follows another geometric Brownian motion with constant drift $\mu_z$ and volatility $\sigma_z$. Furthermore, with the homothetic setting and constant moments of the shock process, we conjecture and verify that the equity value $E_i(z_i, F_i)$ and debt price $D_i(z_i, F_i)$ are homogeneous such that

$$E_i(z_i, F_i) = E_i(\frac{z_i}{F_i}, 1)F \equiv e_i(y_i)F_i \tag{21}$$

$$D_i(z_i, F_i) = D_i(\frac{z_i}{F_i}, 1) \equiv d_i(y_i) \tag{22}$$

where $y_i \equiv \frac{z_i}{F_i}$. From equation (6), $h(p)y_i = \frac{h(p)w_i^\gamma}{F_i} = \frac{\pi_i(w_i,p)}{F_i}$, which is proportional to the firm's interest coverage ratio, $\frac{\pi_i(w_i,p)}{cF_i}$.[8] Thus, $y_i$, the debt-scaled EBIT, is a state variable that can reflect the firm's leverage position, i.e. a measure of the firm's financial condition.

[8]The process followed by $h(p)y_i$ is the same as the one followed by $y_i$.



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One could then show that the debt-scaled cashflow evolves according to

$$\frac{dy_{it}}{y_{it}} = (\mu_z - (g_{it} - \xi))dt + \sigma_z dB_t, \quad \text{with} \quad g_{it} = \frac{G_{it}}{F_{it}} \tag{23}$$

where $g_{it}$ is an endogenously determined growth rate of debt and $g_{it} - \xi$ represents the net growth rate. The stochastic process has a drift term compounded of the expected growth rate of cash flow, $\mu_z$, debt amortization rate, $\xi$, as well as issuance rate $g_{it}$. Higher debt issuance rate leads to a lower expected growth rate of debt-scaled cash flow, while a larger amortization rate increases the growth rate. We can now solve for the partial equilibrium in closed form with the debt-scaled variables.

### *A. Equity value*

To derive the scaled equity value, we substitute equation (21) into (19) and (16), which yields the following proposition

**Proposition 1** *With zero recovery $\psi = 0$, the scaled equity value is given by*

$$\begin{aligned} e_i(y_i;p) &= (1-\tau)\Big[\frac{h(p)}{r+\lambda-\mu_z} - \frac{c+\frac{\xi}{(1-\tau)}}{r+\lambda+\xi} + \frac{1}{1+\alpha}\frac{c+\frac{\xi}{(1-\tau)}}{r+\lambda+\xi}\Big(\frac{y_i}{y_d(p)}\Big)^{-\alpha}\Big] \\ &= \underbrace{\phi(p)y_i - \rho}_{\text{after-tax present value of operating profit}} + \underbrace{\frac{\rho}{1+\alpha}\Big(\frac{y_i}{y_d(p)}\Big)^{-\alpha}}_{\text{value of default option}} \end{aligned} \tag{24}$$

*where*

$$\phi(p) \equiv \frac{h(p)(1-\tau)}{r+\lambda-\mu_z} \equiv h(p)c_\phi \tag{25}$$

$$\rho \equiv \frac{(1-\tau)c+\xi}{r+\lambda+\xi} \tag{26}$$

$$\alpha \equiv \frac{\mu_z + \xi - \frac{1}{2}\sigma_z^2 + \sqrt{(\mu_z+\xi-\frac{1}{2}\sigma_z^2)^2 + 2\sigma_z^2(r+\lambda+\xi)}}{\sigma_z^2} \tag{27}$$

*The optimal default boundary, $y_d(p)$, satisfies the smooth-pasting condition $\frac{\partial e_i(y_i)}{\partial y_i}|_{y_i=y_d} = 0$ and is given by*

$$y_d(p) = \frac{\alpha}{1+\alpha}\frac{r+\lambda-\mu_z}{(1-\tau)h(p)}\frac{(1-\tau)c+\xi}{r+\lambda+\xi} = \frac{\alpha}{1+\alpha}\frac{\rho}{\phi(p)} \tag{28}$$



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Equation (24) shows that the scaled equity value consists of the after-tax present value of operating profit and the option value of default, where the former one is equal to the after-tax present value of profit flows minus the debt service cost.

Liquidation is triggered when the scaled cash flow falls below $y_d(p)$. The default threshold given in equation (28) equals to the ratio of debt service cost $\rho$ to the firm's unlevered valuation multiplier $\phi(p)$, times a factor $\frac{\alpha}{1+\alpha}$ that reflects the option value of default. Note that the default threshold is independent of realizations of firm-specific shocks $y_i$, but depends on the shock process parameters $\mu_z$ and $\sigma_z$. Therefore, the default boundary also defines the industry exit threshold, which is the same for all firms as they are price takers in the competitive equilibrium, and their idiosyncratic shocks are drawn independently from a common process.

### *B. Debt price*

After obtaining the equity value, one can obtain the debt price by substituting equation (24) into the first order condition (17), which gives the following:

**Proposition 2** *With zero recovery rate, $\psi = 0$, the debt price is given by*

$$d_i(y_i; p) = -e_{iF} = \rho\Big(1 - \Big(\frac{y_i}{y_d(p)}\Big)^{-\alpha}\Big) = \frac{c(1-\tau)+\xi}{r+\xi+\lambda}\Big(1 - \underbrace{\Big(\frac{y_i}{y_d(p)}\Big)^{-\alpha}}_{\textit{default probability}}\Big) \tag{29}$$

The proposition implies that the debt price is increasing in the scaled cash flow $y_i$, in other words, decreasing in the amount of oustanding debt $F_i$.[9]

### *C. Debt adjustment*

Upon entry, the equity holders start to adjust debt policy according to (19). Having obtained the equity and debt value, we are able to derive the debt issuance policy $g_i$ by

[9] The debt price is decreasing in $F$ is equivalent to the equity value being convex in $F$, which verifies the necessary condition for a smooth equilibrium (continuous adjustment). See footnote 7. DeMarzo and He (2020) prove that the partial equilibrium results, in which equity holders adopt a smooth debt issuance policy, is the unique Markov-perfect equilibrium. In our model, although our partial equilibrium results are price dependent, individuals firms are all price takers which means the argument presented in DeMarzo and He (2020) is valid within our content. Because the equity value is convex in $y$ and the debt price is increasing in $y$ (decreasing in $F$), the equity holders always prefer a smooth issuance policy instead of a discrete one.



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substituting (29) into (19). The result is shown in the following proposition

**Proposition 3** *With zero recovery rate, the endogenous scaled debt issuance rate is given by*

$$g_i^\star(y_i;p) = \frac{\tau c}{\rho\alpha}\left(\frac{y_i}{y_d(p)}\right)^{\alpha} \tag{30}$$

The proposition once again shows that equity holders always have the intention to issue more debt to exploit tax benefits, and such intention increases in $y$ and decreases in the default probability. As a result, the firm is going to issue debt at a faster rate when the scaled cashflow increases, which happens either when the total amount of debt $F_i$ shrinks (default probability decreases), or when there is an improvement in the production technology (profitability increases and default probability decreases). For small $y_i$, the issuance rate, althought remains positive, can drop below the amortization rate $\xi$, which leads to a passive reduction of the debt level.[10]

### *D. Firm value*

Given the above results, we can derive the unscaled firm value based on (21) and (22)

**Corollary 1** *With zero recovery rate, the unscaled total firm value is*

$$V_i(y_i, F_i;p) = (e_i(y_i;p) + d_i(y_i;p))F_i \equiv v_i(y_i;p)F_i = F_i\left[\phi(p)y_i - \rho\frac{\alpha}{1+\alpha}\left(\frac{y_i}{y_d(p)}\right)^{-\alpha}\right] \tag{31}$$

*where $v_i(y_i;p)$ denotes the debt-scaled total firm value.*

It is important to note that the product market competition affects individual firms' partial equilibrium through the output price $p$. Such price feedback effect is described by the following

**Proposition 4** *All else equal, an increase in the product market price $p$ increases the equity value $e_i(y_i;p)$, the debt value $d_i(y_i;p)$, the debt issuance rate $g_i(y_i;p)$ but decreases the default*

[10]Note that the proposition suggests that there is an optimal rate of adjustmen, but it does not implies there exists an optimal level of debt. Nevertheless, given an initial state $(y_{i0}, F_{i0})$, the equity holders adjusts debt at $g_i^\star$, which yields an optimal path of the firm's leverage in response to exogenous shocks.



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*boundary $y_d(p)$. Mathematically, we have*

$$\frac{\partial e_i(y_i;p)}{\partial p} > 0 \quad , \frac{\partial d_i(y_i;p)}{\partial p} > 0 \frac{\partial y_d(p)}{\partial p} < 0 \quad , \frac{\partial g_i(y_i;p)}{\partial p} > 0 \tag{32}$$

Increases in the output price improve profitability for firms in the industry, which, on the one hand, increases the equity value and, on the other hand, reduces the default probability and increases the debt value. As a result, equity holders adopt a more aggressive debt adjustment policy by issuing new debt at a faster rate.

### 3.1.3 Positive recovery value

We have been assuming the recovery rate is zero in the event of liquidation. What if the firm has a positive recovery value in default, and the equity holders can dilute the claim of existing debt holders and appropriate the value. Specifically, suppose the firm has a liquidation value

$$\mathscr{R}_i(y_i;p) = \psi \frac{(1-\tau)h(p)y_i}{r+\lambda-\mu_z} = \psi\phi(p)y_i \tag{33}$$

where $\psi \in [0,1)$ is the recovery rate of the unlevered asset value. Different from the commitment case where existing debt holders can restrict equity holders' future debt policy, equity holders under the noncommitment case can issues debt at market prices, and the debt holders are incapable of restricting further debt issuance. This gives shareholders an advantage in liquidation as they can receive the entire recovery value by issuing an arbitrarily large amount of debt just before default and pay out as dividend, through which diluting the existing creditors' claims and leaving debt holders with zero money on the table.[11] Using a similar dynamic programming method, we obtain the following proposition that describes the firm's optimal capital structure and financing decisions with positive recovery:

[11]In order to simplify the analysis, we restrict our attention to pari passu debt, which means that all proceeds from the liquidation process are paid pro-rata to the creditors based on the amount of the claims. Thus, equityholders issue debt at the expense of existing creditors' claims being diluted. Equityholders also have a stronger incentive to dilute debtholders' claim prior to default by issuing more new debt and payout as dividends. Thus, in contrast to the commitment case, equity holders receive the default value in the non-commitment case.



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**Proposition 5** *With positive liquidation value, that is, $\psi \in (0,1)$, the partial equilibrium equity value, $e_i^R(y_i;p)$, debt value, $d_i^R(y_i;p)$, default boundary, $y_d^R(p)$, debt issuance policy, $g_i^R(y_i)$, and unscaled firm value $V_i^R(y_i,F_i;p)$, are given by:* [12]

$$e_i^R(y_i;p) = e_i((1-\psi)y_i;p) + \mathscr{R}_i(y_i;p) \tag{34}$$
$$= \phi(p)y_i - \rho\Big(1 - \frac{1}{1+\alpha}\Big(\frac{(1-\psi)y_i}{y_d(p)}\Big)^{-\alpha}\Big) = \phi(p)y_i - \rho\Big(1 - \frac{1}{1+\alpha}\Big(\frac{y_i}{y_d^R(p)}\Big)^{-\alpha}\Big)$$
$$d_i^R(y_i;p) = d_i((1-\psi)y_i;p) = \rho\Big(1 - \Big(\frac{(1-\psi)y_i}{y_d(p)}\Big)^{-\alpha}\Big) = \rho\Big(1 - \Big(\frac{y_i}{y_d^R(p)}\Big)^{-\alpha}\Big) \tag{35}$$
$$y_d^R(p) = \frac{y_d(p)}{(1-\psi)} = \frac{\alpha}{1+\alpha}\frac{\rho}{(1-\psi)\phi(p)} \tag{36}$$
$$g_i^R(y_i;p) = g_i^*((1-\psi)y_i;p) = \frac{\tau c}{\rho\alpha}\Big(\frac{(1-\psi)y_i}{y_d(p)}\Big)^{-\alpha} = \frac{\tau c}{\rho\alpha}\Big(\frac{y_i}{y_d^R(p)}\Big)^{-\alpha} \tag{37}$$
$$V_i^R(y_i,F_i;p) = \Big(\phi(p)y_i - \rho\frac{\alpha}{1+\alpha}\Big(\frac{(1-\psi)y_i}{y_d(p)}\Big)^{-\alpha}\Big)F_i \equiv v_i^R(y_i,F_i;p)F_i \tag{38}$$
$$= \Big(\phi(p)y_i - \rho\frac{\alpha}{1+\alpha}\Big(\frac{y_i}{y_d^R(p)}\Big)^{-\alpha}\Big)F_i$$

*where $y_d(p)$ is default boundary in the zero recovery case defined in* (28).

One could easily see that, by setting $\psi = 0$, the proposition is reduced back to the zero-recovery case. All else equal, compared with the zero recovery case, both the equity value and the default boundary increase in the recovery rate as the shareholders are able to get the proceeds at liquidation. In the meanwhile, a positive liquidation value also makes the debt issuance policy more responsive to changes in the scaled cashflow $y_i$. Anticipating the dilution effect upon default, the debt holders give a lower price to newly issued debt.

## 3.2 Stationary Industry Equilibrium

In this section, we derive the stationary industry equilibrium, particularly, the equilibrium price $p^\star$ and the long-run firm distribution $\chi$.

[12] The superscript $R$ indicates positive recovery value.



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### 3.2.1 Equilibrium price

Having characterized the partial equilibrium of individual firms, we can obtain the industry equilibrium price, $p^\star$, from the entry condition (13). Rewriting the entry condition in the new state variable $y$ gives

$$\int_{\underline{y}}^{\overline{y}} V(y, F; p^\star)\upsilon_y dy = c_e \tag{39}$$

where $\upsilon_y$ is the density function of the initial draw of $y$.[13] We assume $\upsilon_y$ is a uniform distribution on $[\underline{y}, \overline{y}] \subset (0, \infty)$. Substituting the probability density function $\upsilon_y$ into the condition (39) gives:

$$\int_{\underline{y}}^{\overline{y}} \frac{V(y, F; p^\star)}{\overline{y} - \underline{y}} dy = c_e \tag{40}$$

Substituting the unscaled firm value in equation (38) shows

**Proposition 6** *The entry condition is the same for all the firms, as they are ex-ante identical. The market equilibrium price of the output, $p^\star$, satisfies the following equation*

$$c_e = \frac{F}{\overline{y} - \underline{y}}\Big[\frac{1}{2}\phi(p^\star)(\overline{y}^2 - \underline{y}^2) - \frac{\rho^{\alpha+1}}{1-\alpha}\Big(\frac{\alpha}{1+\alpha}\Big)^{\alpha+1}\frac{\overline{y}^{1-\alpha} - \underline{y}^{1-\alpha}}{(1-\psi)^{-\alpha}\phi(p^\star)^{-\alpha}}\Big] \tag{41}$$

*where $\phi(p)$ is defined in equation (25) and $\psi \in [0, 1)$ is the rate of recovery.*

We numerically solve for the equilibrium price $p^\star$ in section 4.4. We show that it is an increasing function of the entry cost $c_e$. Higher entry cost defers entrance because firms require a higher expected return to participate, leading to lower market competition. The comparative static in section 5.4 illustrates how the output price changes in exogenous factors such as technology growth and tax rate.

[13] Because $y \equiv \frac{w^\gamma}{F}$ and the initial value of $F$ is fixed for all firms, the density function for initial shock $w$ can be obtained if the density function for $y$ is known. We also assume $\underline{y} > y_d$ so that firms do not exit the industry immediately after the initial draw.



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### 3.2.2 Equilibrium distribution

Recall from the process for the scaled cashflow $y$ given in (23), we substitute in the optimal issuance policy (19) and obtain

$$\frac{dy}{y} = (M_1 - M_2 y^{\alpha})dt + \sigma_z dB_t \tag{42}$$

where $M_1$ and $M_2$ are constants defined as

$$M_1 \equiv \mu_z + \xi \tag{43}$$

$$M_2 \equiv \frac{\tau c}{\rho\alpha}\Big(\frac{\alpha}{1+\alpha}\frac{\rho}{(1-\psi)\phi(p)}\Big)^{-\alpha} = \frac{\tau c}{\rho\alpha}(y_d^R(y;p))^{-\alpha} \tag{44}$$

Equation (42) describes the evolution dynamics of $y$, which has a time-varying drift. To derive the long-run stationary distribution, $\chi$, we adopt the steady state analysis method demonstrated in Hopenhayn (1992a) and Dixit and Pindyck (1994). There is a continuum number of firms, all of which encounter independent shocks. Hence, the long-run stationary industry aggregates exist because of the law of large numbers. The aggregate output, produced by a group of firms whose composition changes over time, is constant, and the aggregate population distribution of firms also exists and is stationary. Given the industry output price $p^{\star}$ derived from (41) and the exit boundary $y_d^R$ given in (36), the stationary distribution $\chi$ is characterized by a density function $\kappa(y)$, which is a solution to a Kolmogorov forward equation.[14] The intuition underlying the derivation is: at each state $y$, the distribution is stationary as long as the arrival rate of new firms (either because of new entrants or technology shock to incumbents) equals the exit rate (either because of Poisson death or technology shock to incumbents), i.e., the mass of exits just offsets the mass of entries. We leave the full derivation to the appendix. Note that $M_2$ embeds the equity holders' time-varying debt adjustment policy, highlighting the potential influence of non-commitment on the distribution of the firm universe. The following proposition describes the density function $\kappa(y)$.

[14] Let $N$ denotes the entry rate representing the stationary stream of new entrants. $N\kappa(y)$ then represents the density of firms at $y$. As we show in the proof, the entry rate is just a scaling factor and does not alter the distribution properties. In other words, the density function $\kappa(y)$ reflects the stationary distribution $\chi$ up to a scale factor $N$.



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**Proposition 7** *The equilibrium density function, $\kappa(y)$ is the solution to the following set of ordinary differential equations*

*A. for $y_d^R < y < \underline{y}$,*

$$\frac{1}{2}\sigma_z^2 y^2 \kappa''(y) - (2\sigma_z^2 - M_1 + y^\alpha M_2) y\,\kappa'(x) - (\sigma_z^2 - \lambda - M_1 + y^\alpha(1+\alpha)M_2)\kappa(x) = 0 \quad (45)$$

*B. for $\underline{y} < y < \overline{y}$*

$$\frac{1}{2}\sigma_y^2 y^2 \kappa''(y) - (2\sigma_y^2 - M_1 + y^\alpha M_2) y\,\kappa'(x) - (\sigma_y^2 - \lambda - M_1 + y^\alpha(1+\alpha)M_2)\kappa(x) + \frac{y - \underline{y}}{\overline{y} - \underline{y}} = 0 \quad (46)$$

*C. for $\overline{y} < y$,*

$$\frac{1}{2}\sigma_y^2 y^2 \kappa''(y) - (2\sigma_y^2 - M_1 + y^\alpha M_2) y\,\kappa'(x) - (\sigma_y^2 - \lambda - M_1 + y^\alpha(1+\alpha)M_2)\kappa(x) = 0 \quad (47)$$

*The solution to the system of ODE is given by*

$$\kappa(y) = \begin{cases} G_1^a \kappa_1^a(y) + G_1^b \kappa_1^b(y) & \text{if } \; y_d^R < y < \underline{y} \\ G_2^a \kappa_2^a(y) + G_2^b \kappa_2^b(y) + \kappa_2^c(y) & \text{if } \; \underline{y} < y < \overline{y} \\ G_3^a \kappa_3^a(y) + G_3^b \kappa_3^b(y) & \text{if } \; \overline{y} < y \end{cases} \quad (48)$$

*where the the constant $G_i^a$, $G_i^b$ has to be determined via the boundary conditions described in* (69) - (71) *in Appendix.*

Closed-form expressions for the aggregate industry-wide variables are not available. Standard numerical methods are adopted.

## 3.3 A benchmark: debt commitment

Before the numerical results, as a useful benchmark, we introduce a baseline model – the Leland (1998) commitment model, where the equity holders commit to maintaining a stationary debt policy. Leland (1998) assumes that the firm commits to replace the maturing debt with the same amount of newly issued debt, i.e. in the context of our model, $g_t = \xi$ for



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all $t$. We use a superscript of $L$ to represent the Leland commitment case. The debt-scaled cash flow, therefore, evolves according to a standard geometric Brownian motion:

$$\frac{dy_t}{y_t} = \mu_z dt + \sigma_z dB_t \tag{49}$$

To highlight the effects of non-commitment, we present the major results of the commitment model and compare them with the non-commitment results in section 4 and 5.

***A. Equity value under commitment***

The scaled equity value $e^L(y;p)$ in the presence of commitment follows

$$e_i^L(y_i;p) = \frac{c\,\tau}{r+\lambda}\left(1-\left(\frac{y_i}{y_d^L}\right)^{-\alpha^L}\right) - \frac{c+\xi}{r+\lambda+\xi}\left(1-\left(\frac{y_i}{y_d^L}\right)^{-\beta^L}\right) \tag{50}$$

$$+\frac{(1-\tau)h(p)}{r+\lambda-\mu_z}\left(y_i - \psi y_d^L\left(\frac{y_i}{y_d^L}\right)^{-\beta^L} - y_d^L(1-\psi)\left(\frac{y_i}{y_d^L}\right)^{-\alpha^L}\right) \tag{51}$$

$$\text{where } \alpha^L = \frac{(\mu_z - \frac{\sigma_z^2}{2}) + \sqrt{(\mu_z - \frac{\sigma_z^2}{2})^2 + 2\sigma_z^2(r+\lambda)}}{\sigma_z^2}$$

$$\beta^L = \frac{\mu_z - \frac{\sigma_z^2}{2} + \sqrt{(\mu_z - \frac{\sigma_z^2}{2})^2 + 2\sigma_z^2(r+\lambda+\xi)}}{\sigma_z^2} \tag{52}$$

The default boundary from the smooth-pasting condition is

$$y_d^L = \frac{\alpha^L(r+\lambda-\mu)}{(1+\alpha^L(1-\psi)+\beta^L\psi)(1-\tau)h(p)}\left(\frac{\beta^L(c+\xi)}{\alpha^L(r+\lambda+\xi)} - \frac{c\tau}{r+\lambda}\right) \tag{53}$$

***B. Debt value under commitment***

The scaled debt value $d_i^L(y_i;p)$ is given by

$$d_i^L(y_i;p) = \frac{c+\xi}{r+\lambda+\xi}\left(1-\left(\frac{y_i}{y_d^L}\right)^{-\beta^L}\right) + \psi\frac{(1-\tau)h(p)}{r+\lambda-\mu_z}y_d^L\left(\frac{y_i}{y_d^L}\right)^{-\beta^L} \tag{54}$$

Compared with (35), the last term in equation (54) highlights one of the important difference between the commitment and the noncommitment case. With a commitment to future debt policy, the liquidation value goes to the creditors while the value is attributed to the



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equity holders in the non-commitment case. As we mentioned before, this is because the shareholders can issue an arbitrarily large amount of debt prior to default to dilute creditors' claims and expropriate the recovery value. The dilution effect induces a devaluation on debt absent of commitment.

***C. Industry equilibrium under commitment***

The commiment industry equilibrium can be derived similarly. The equilibrium output price, $p^L$, satisfies the following:

$$c_e = \frac{F}{\overline{y} - \underline{y}}\Big[\frac{c\,\tau}{r + \lambda}(\overline{y} - \underline{y}) + \frac{1}{2}\phi(p^L)(\overline{y}^2 - \underline{y}^2) \\ - \Big(\frac{c\,\tau}{r + \lambda} + \phi(p^L)(1 - \psi)y_d^L(p)\Big)\frac{(y_d^L)^{\alpha^L}}{1 - \alpha^L}(\overline{y}^{1-\alpha^L} - \underline{y}^{1-\alpha^L})\Big] \tag{55}$$

The equilibrium distribution density function $\kappa^L(y)$ is the solution to another set of ordinary differential equations. It is in line with what has been shown in proposition 7 by replacing $y_d^R$ with $y_d^L$, $M_1$ with $M_1^L = \mu_z$ and $M_2$ with $M_2^L = 0$.

In what follows, we present the main results based on numerical analysis. We first discuss the partial equilibrium result in section 4, and followed by the industry dynamics result in section 5.

# 4 Product Market and Firms' Financial Policies

To examine the implications of the model, we first fit the model directly to aggregate level statistics using the simulated method of moments (SMM). The purpose of the structural estimation is two-fold. First, we want to see whether the model performs well in matching with empirical moments. Second, the estimation allows us to identify parameters which can be used in subsequent numerical analysis to quantify the interaction between firms' financial policies and product market, and assess the non-commitment influence.



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## 4.1 Parameter estimation

Since our focus is to highlight the interaction between debt policy non-commitment and industry dynamics, we first calibrate several parameters that the model does not directly address. The parameter values are given in Table 1. In Panel A, we choose the parameter values that are broadly consistent with those used in the literature of standard structural credit risk models and business cycles. Specifically, we set the risk-free rate $r = 4\%$ to match the average three-month Treasury Bill Rate. We set the corporate tax rate $\tau = 34\%$, which is aligned with He and Xiong (2012). The Poisson death intensity $\eta = 5\%$ comes from the 9% annual turnover rate net of the 4% default rate documented in Miao (2005). The depreciation rate $\delta$ is set at 0.1 in line with business cycle literature. The coupon rate is set at 8%. We set the price elasticity of demand at $\epsilon = 0.75$. This number is within the range estimated by Philips (1995). Finally, we follow Hopenhayn (1992b) and Miao (2005), and normalize the equilibrium output price to $p^0 = 1$.[15]

We fit the model to a collection of real data moments corresponding to the model moments: the distribution of the ratio of cash flow to debt; the cash flow growth rate and volatility of an average firm; the industry's average leverage; the industry's average turnover rate. Admittedly, choosing empirical moments to match quantities in the model necessarily requires some subjective judgements. The ratio of cash flow to debt is measured as EBIT over the sum of short term (DLC) and long-term debt (DLTT). Data are from Compustat between 1990 and 2010. We exclude firms of which the EBIT and/or debt is non-positive. The turnover rate is the average establishment's birth and death rate from Business Dynamics Statistics between 2004 and 2016. The data of average market leverage is taken from Barclay et al. (2006).

Table 2 shows the resulting model fit. In terms of unconditional real and financial moments, our model does a good job in matching many salient features of the data. In particular, the model captures the positive skewness of the cash flow to debt ratio's dis-

[15] We are using aggregate-level statistics covering all U.S. publicly listed firms, and the SMM estimation aims to match market-wide distribution moments. For the moment conditions that are related to the firm distribution properties (median, mean, skewness and mode), the output price does not alter the distribution features. For the moment conditions such as average industry leverage and turnover rate, the price is simply an industry scalling variable.



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tribution, with mean, median and skewness being 0.225, 0.202 and 2.211, respectively. If equity holders cannot commit to debt policy, the distribution is more positively skewed, thinner tailed with more firms concentrated in the small value area. As a contrast, the outstanding debt stays still under debt policy commitment case, and the distribution solely depends on the dynamics of technology shocks, leaving out an important driving force. The non-commitment debt policy substantially affects the industry dynamics via its influence on the distribution of the firm universe, which is elaborated in Section 5.

Panel B of Table 1 shows the parameter estimates. To facilitate subsequent numerical analysis, we use estimated parameters, together with calibrated parameters, to discuss the interaction between the product market and individual firms' financial decisions.

## 4.2 Output price and financial policy

Proposition 4 demonstrates the effect of the product market price $p$ on individual firms' equity value, $e_i(y_i; p)$, debt price, $d_i(y_i; p)$, debt issuance policy, $g_i(y_i; p)$ and the exit boundary $y_d(p)$. All firms are price takers in the competitive industry, and there is a continuum of potential new entrants, which means the entry and exit of a particular firm do not influence the equilibrium price. In other words, equity holders and debt holders of firms adjust policies in response to idiosyncratic shocks, by taking price as given. The proposition proves that both equity and debt value increase with the equilibrium output price. The exit threshold decreases with $p$, which implies that firms can stay in the industry for a longer period when the market price of output is higher. The underlying driving force is the cash flow effect. As equation (6) shows, a greater market price $p$ leads to higher EBIT and incentivizes equity holders to postpone default, boosting both equity value and debt value.

More importantly, equity holders adopt a more aggressive debt issuance policy when the output price increases, that is, the debt issuance rate $g_i(y_i; p)$ increases in the price $p$. An increase in the output price improves firms' profitability, thereby lowering the default boundary. A lower default boundary also induces a higher debt value, which means that proceeds from debt issuance increases. Therefore, facing a lower likelihood of default, the equity holders issue debt at a faster rate to exploit the tax benefit. The result suggests



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that, in industries with higher profitability for incumbents, we expect more aggressive debt adjustments of firms.

### 4.3 Output price and agency cost

One manifestation of debt-equity conflicts is inefficient liquidation policy. Equity holders choose a liquidation threshold that maximizes equity value, instead of total firm value. Because the first-best liquidation policy cannot be imposed ex-post, the equity holders often shut down the firm earlier than what they would do in the first-best scenario. In order to study the influence output price on agency cost, we compare the default boundary under non-commitment ($y_d^R(p)$) with the one under commitment ($y_d^L(p)$). In particular, we study how the difference between the two default policies changes when the equilibrium output price changes.

The absence of commitment to future debt policies further intensifies the conflict between shareholders and creditors. Creditors cannot restraint equity holders from future debt issuance, and consequently, the ratchet up of leverage increases the likelihood of default. This implies that all else equal, the default threshold under the non-commitment case ($y_d^R(p)$) is higher than the one under the commitment case ($y_d^L(p)$). Such an effect is even more substantial when the recovery rate is nonzero as shareholders can transfer the liquidation value to themselves by issuing debt and paying out as dividends. As can be seen in Equation (36), the default threshold increases as the recovery rate $\psi$ increases, reflecting an increase in agency cost. Therefore, the differences in the default policies can measures the agency costs arise from non-commitment behaviour.

Proposition 4 shows that the output price affects agency costs through the following two channels. First, a higher output price leads to a lower default threshold. This is because firms' profitability (default probability) is positively (negatively) related to the market output price. Moreover, the increases in profitability together with the decreases in the default option value make the shareholders willing to wait longer before shutting down the firm.[16] Second, Proposition 4 also demonstrates that equity holders issue debt at a faster

[16]The first component of the equity value functions (Equations (24) and (34)) represents the influence



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pace to appropriate more value when the output price is higher. This seems to contradict with the first channel where agency cost decreases as output price increases. By taking a closer look at the debt issuance policy (Equations (30) and (37))), we can see that the more aggressive debt issuance policy comes from decreasing default probability. The drops in default likelihood raise debt prices and allow shareholders to issue more debt. In other words, the second channel is indeed nested in the first channel, and a higher output price does reduce agency costs. The two channels also further support the use of the difference in the default boundary as a measure of agency cost. This measure reflects not only the direct feedback effect of price on profitability, but also the indirect feedback effect of price on the issuance behaviour.

Figure 2 depicts the two default policies $y_d^L(p)$ and $y_d^R(p)$. An increase in the output price delays defaults under both circumstances. Noticeably, it shows that the effect is more salient under non-commitment – the default boundary falls more and faster than under the commitment case. These suggest that increased market output price *does* reduce agency cost induced by the absence of commitment to debt policy, measured as the difference between the two default boundaries. Improvement in profitability from an increase in output price makes default more expensive. Thus, the equity holders prefer to postpone liquidation to benefit from the increases in share values and to expropriate the tax benefits from further debt issuance. The discussion leads to the following corollary:

**Corollary 2** *The agency cost, measured as the difference between the two default policies, $y_d^L(p)$ and $y_d^R(p)$, decreases with the equilibrium product market price $p$.*

The corollary suggests that the shareholders' expropriation incentives rise (fall) when firm valuations or profitability are low (high), which echoes the findings of Johnson, Liu and Yu (2019). The following section shows that the equilibrium output price is higher in the non-commitment case than in the commitment case. Therefore, for firms in the industry, the agency cost induced by non-commitment to debt policies is alleviated through the decrease in market competition.

of increases in profitability on equity values, while the second component of the equations stands for the default option value. The first component increases in $p$, while the default option value decreases in $p$.



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## 4.4 Non-commitment and output price

Thus far, we study how the output price influences individual firms' policies by taking the price as exogenous given. We now turn to the effect of non-commitment financial policies on the product market competition, in particular, the output price.

Aligned with the DeMarzo and He (2020), we find that the total enterprise value under commitment is higher than its counterpart without commitment under most circumstances, which is shown in Figure 3. The exceptions can occur under two scenarios. First is when the firm is closed to the default boundary. The equity holders with Leland-type commitment are "stubborn" and keep issuing the same amount of debt (the debt issuance rate is a constant equal to $\xi$), while in the non-commitment case, the equity holders issue debt at a slower pace, which passively reduces the total amount of debt outstanding (the debt issuances rate is lower than the amortization rate). The second case is when the scaled cash flow is extremely high, in which the rises in equity values dominate. For most circumstance, the total enterprise value is lower under the non-commitment scenario. The lower valuation is mainly driven by costlier debt financing without commitment, as debt holders price in the possibility of more future debt issuance and default. Although equity value rises under non-commitment, the debt value becomes much lower and dominates the influences on the total enterprise value.

Recall that the equilibrium output price, $p^\star$, is determined through the entry condition

$$\int_{\underline{y}}^{\overline{y}} V(y, F; p^\star) \upsilon_y dy \, = \, c_e$$

and satisfies equation (41) in Proposition 6. Given the initial shock distribution $\Upsilon_y = \mathcal{U}(\underline{y}, \overline{y})$, we can see that the lower firm valuation in most circumstances leads to an increase in output price $p$ under the noncommitment compared to the commitment case.[17] This gives the following corollary

[17] We impose an assumption that $\underline{y} > y_d(p)$ and verifies the assumption in equilibrium. The assumption guarantee that the initial draws are above the exit boundary and new entrants do not drop out immediately. The initial shock distribution range is estimated to be $(0.781, 1.782)$ shown in table 1, which means the initial states do not fall into the extreme categories. The persistence of the technology shocks process and continuous adjustment of debt policy means the influence of exception states on the output price is moderate.



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**Corollary 3** *The product market price $p$ is higher under the noncommitment case than under the commiment case.*

The result is also verified in Table 3, where we present the comparative statics results (discuss in more details in section 5.4). The table shows that the non-commitment industry prices are always above their commitment counterparts. In the equilibrium, the lower valuation keeps more entries at the bay, hindering potential entries to the market and boosting the output price. This means that, on the one hand, the lack of commitment to debt policy implicitly increases the entry criteria and make new entry more difficult. On the other hand, once a firm enters the market, the higher product price creates an edge for firms in the industry (i.e. incumbents) to operate.

# 5 Industry Dynamics

The interaction between output price and the firm's non-commitment to debt policy has profound implications on industry-level dynamics, including the firm's distribution, aggregate output, turnover rate as well as average industry leverage. The absence of commitment to debt policy influences aggregates dynamics through two channels. First, the "price effect" channel: non-commitment alters the expected firm value, thereby changing the equilibrium price through the entry condition, and affecting the degree of market competition as discussed in section 4.4. Second, the "distribution effect" channel: it reshapes the distribution of the firm universe, which characterise many equilibrium features.

In order to quantify and disentangle the two channels, we use the commitment model result as a benchmark. Specifically, we first compute the commitment output price $p^L$ from equation (55), and use it to derive the firm distribution, exit boundary, turnover rate, aggregate output and industry level leverage for both commitment and non-commitment cases. By using the same price, the comparison between the two cases abstains from compounding price effect and demonstrates the distribution effect only. Next, we solve for the non-commitment output price $p^\star$ from equation (41) and recompute all the non-commitment variables with $p^\star$, which gives the gross effect. Comparison between this full



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non-commitment case with the one under $p^L$ reveals the price effect. The results are shown in Table 4.

## 5.1 Default risk

The differences of the default boundaries (column 4, 8, and 13 of Table 4) shows the influence of non-commitment on the default risk. In other words, the comparison shows the effect on the periphery of the firm universe distribution. The inability to commit induces leverage ratchet effect, which means an overall higher level of debt. As a result, the default risk is increased significantly.

As an example, given an initial debt level $F = 3$ and a recovery rate $\psi = 0.55$, equity holders without commitment would walk away from the debt when scaled cash flow drops to 0.0938 while the threshold becomes two thirds smaller with commitment (0.0390). The default boundary is 0.0959 if only the distribution effect is taken into account. It means the price feedback effect, to some extent, mitigates the elevated default risk. It is because costlier debt financing deters potential entrants from entering the market and raise the equilibrium output price, creating an advantage for those already inside the industry and lowering the incumbents' default probability. Consequently, the price feedback effect and distribution effect move in the opposite direction in influencing the default risk and partially offsets each other. Although the price feedback effect decreases the exit threshold slightly, the distribution effect still dominates. Moreover, Table 4 shows that the difference between default boundaries with and without commitment decreases with the output price and confirms corollary 2.

Table 4 also shows that the effect of positive recovery rate on default risk is reversed under non-commitment compared with the commitment case. A higher recovery rate lowers the commitment default boundary as debtholders receive the recovery value upon liquidation and a higher recovery rate increases debt values rather than equity values. Therefore, equity holders postpone liquidation as they receive nothing upon default. On the contrary, the default threshold rises with recovery rate absent commitment. From equation (37), we can show $\frac{\partial y_d^R}{\partial \psi} > 0$. This is because, in the absence of debt policy commitment, equity holders



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can issue a large amount of debt in the imminence of default and appropriate the liquidation value. It is the equity holders rather than the debt holders receive the recovery value, which effectively accelerates the default.

### 5.2 Turnover

We define the turnover rate of entry as the ratio of the mass of entrants to the mass of incumbents in stationary equilibrium.[18] The turnover rate of exit is defined in a similar fashion and equals the ratio of the mass of exit to the mass of incumbents. In a stationary equilibrium, the turnover rate of entry equals the turnover rate of exit, with which the total mass of industry incumbents remains constant.

The turnover rate columns in Table 4 shows that the inability to commit to a debt policy greatly raises the industry turnover rate. The turnover rates are around 15% for the non-commitment model, while in the commitment model, the rates are less than 8%. The resultant higher frequency of firms' entry is equivalent to a higher frequency of firms' exit. Under non-commitment, the default rate increases substantially compared to the commitment case, resulting in a higher exit rate. This is mainly driven by the distributional effect channel. Intuitively, under non-commitment setup, two separate yet related forces drive firms to exit the market. First, similar to firms with commitment, a series of adverse technology shocks can deteriorate the cash flow and lead to default and exit. Second, even though a firm's technology might be sound and solid, a slow deleveraging of higher debt level from the past can still end its operations. The second force is unique to firms that are unable to commit to debt policy, driving up the turnover rate in equilibrium. As has been shown in the partial equilibrium result in section 3.1.2, shareholders are reluctant to buy back debt and have the intention to issue more. Such leverage ratchet effect generates higher leverage compared to the commitment case, amplifies the influence of the second force and implies that a large proportion of firms stand close to the default boundary, manifesting into a high default rate, hence, a high turnover rate.

Figure 4 compares the firm distribution under the industry with commitment and the one

[18]The explicit expressions for the turnover rate is given in (72) in the appendix.



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without by examing the two distribution density functions $\kappa(y)$ and $\kappa^L(y)$ as well as the corresponding cumulative distribution functions (CDF). The non-commitment case is plotted in dotted lines while the commitment case is presented in solid lines. Panel A shows that the distribution absent of commitment is more positively skewed and has a thinner tail, which means a larger number of firms concentrated in the region with small debt-scaled cashflow $y_i$. Panel B shows the CDF with non-commitment is first-order stochastically dominated by the one with commitment. The distribution features demonstrated in Panel A also aligns with the empirical distribution shown earlier in Figure 1, where we plot the distribution of the ratio of EBIT to debt for U.S publicly listed firms. Our model is able to generate an industry distribution that is more consistent with empirical observation, suggesting that the absence of commitment is an important component to understand market-wide financing decisions. The persistence of debt-equity conflicts among individual firms can have a profound aggregate effect at the industry level.

The price effect moves in the opposite direction in the sense that non-commitment debt policy raises the equilibrium output price, which lowers the exit threshold for firms in the industry and hence slightly decreases the turnover rate. The price effect, however, is rather minuscule and does not overturn the distributional effect. Moreover, this also means the absence of commitment has an opposite effect on firms in the two tails of the distribution: it endangers firm on the brink of default and provides an edge for firms with high $y$.

## 5.3 Industry leverage

Although the scaled cash flow $y$ is proportional to the interest coverage ratio and can be regarded as a measure of leverage, we follow the literature and define the market leverage as

$$\frac{d_i(y;p)}{e_i(y_i;p)+d_i(y_i;p)} \tag{56}$$

and compute the average industry leverage. Table 4 shows that the industry leverage increases significantly when equity holders cannot commit to debt policies. For example, with $F = 6$ and $\psi = 0.55$, the average industry leverage in presence of and in absence of commitment is 19.221% and 23.974%, respectively. Again, the increase is mostly attributable



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to the distributional effect channel with a larger proportion of the firms clustering in higher leverage spectrum. Similar to the feedback effects on default risk and turnover, the price effect slightly offsets the distributional effect. For current incumbents in the market, increased output price raises both debt and equity value, causing firms' leverage to fall and reducing the overall industry leverage.

A higher recovery rate has two effects on a firm's leverage. Since the equity holders can expropriate the liquidation value, default is less costly, and the equity holders default sooner compared to the zero recovery case. The positive recovery value, on the one hand, increases the equity value, and on the other hand, lowers the debt value. The result in Table 4 shows that the increase in equity value dominates the corresponding decreases in debt value, causing the industry leverage to fall with the recovery rate.

Overall, non-commitment to debt policy lowers aggregate output but substantially increase the industry leverage and turnover rate. While the price effect exclusively determines the aggregate output, the distributional effect plays a more quantitatively significant role in shaping industry dynamics.

## 5.4 Comparative statics

Firms may react differently to parameter changes if they are restrained by debt commitment, which could lead to distinct industry dynamics. To further understand the interaction between firms' financial decisions and industry dynamics, we examine comparative statics of the industry equilibrium, and the results are shown in Table 3. Consistent with the previous discussion, the table shows that non-commitment induces greater default risk, more frequent turnover, higher average leverage and more positive skewed firm distribution.

***A. Technology growth***

Panel A of Table 3 presents the influence of variations in the technology growth rate $\mu_w$. On the one hand, the increase in the technology growth rate boosts the expected firm value and intensifies product market competition. As a result, the equilibrium output price drops, and the industry output grows. The price effect channel suggests that a lower output



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price squeezes firms' profitability and lifts the exit boundary.

On the other hand, a high technology growth provides an edge for firms in the industry to lever on, through which amplifies the leverage ratchet effect and drives the increases in the average industry leverage. The compound effect of lower output price and increases in debt amounts means more firms are concentrated in the small debt-scaled cashflow region. Although debt financing becomes more expensive, firms become more robust as they are required to have high productivity in order to stay in the industry, thus, the turnover rate decreases.

### *B. Technology riskness*

Panel B of Table 3 illustrates the influence of technology riskiness. On the one hand, an increase in productivity volatility makes the option of waiting to default more valuable and postpons liquidation. Increases in potential upside benefits result in higher expected entry value and encourage entry, pushing up the degree of competition and lowering the output price. On the other hand, the increases in technology riskiness make debt financing more expensive and dampen the debt issuance motivation, reducing the industry leverage and turnover rate. The distribution effect channel implies a decrease in the the skewness of firm distribution.

### *C. Coupon rate*

Panel C of Table 3 shows that the increase in coupon rate $c$ has two effects. It increases the cost of debt service, but at the same time, generates greater tax benefits. The former force increases the default probability and dominates the latter, which results in lower expected firm value and discourages new entry. The decreases in competition lead to a higher output price and therefore, lower output. The latter force induces the equity holders to issue debt at a faster rate to exploit the benefits and raises the industry leverage. Two forces reinforce each other and lead to a higher market turnover rate.

### *D. Tax rate*

Panel E of Table 3 shows how changes in the corporate tax rate influence the industry dynamics. Taxation has a negative effect on the firm's cash flow, which reduces the total firm



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value. As a result, the equilibrium output prices increases and total output level decreases. Meanwhile, the tax benefits from debt issuance rise, prompting the equity holders to leverage up more aggressively. The tax benefits also induce the shareholders to delay defaults. Thus, the overall leverage level increases and the density function shifts to the left.

***E. Entry cost***

Panel F presents the effect of the entry cost. Although an increase $c_e$ does not alter a firm's cash flow and firm values of the incumbents, it increases the entry barriers. Higher $c_e$ makes entry more difficult, through which protects existing firms and reduces the degree of market competition. Thus, the equilibrium output price soars, and the resulting price effect leads to a lower default boundary of incumbent and smaller turnover rate. Higher market price also enables firms to issue debt more aggressively, building up higher industry leverage.

***F. Price elasticity***

In a perfectly competitive market, all firms are price takers, which means a single firm's policies has no effect on the market price. Moreover, the results demonstrated in section 3 shows that the stationary distribution features: the output prices and the firm distribution density function do not depend on $\epsilon$. Nevertheless, the total market output is increasing in the price elasticity.

# 6 Conclusion

At the time of writing, Saudi Arabia launched the oil price war on March 10th, 2020 and unleashed shockwaves across the energy sector, causing the biggest stock market crash since the financial crisis and jeopardizing many highly levered US energy firms with financial distress and even bankruptcy risk. The reshuffling within the sector, as a result, will further cause fluctuation in oil price as well as variations in the survivors' balance sheets. The incident highlights the importance of understanding the interaction between firms' financing decisions, market competition and industry dynamics. We study this interaction in a framework where equity holders cannot commit to future debt levels. The results show



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that equity holders have an incentive to increase debt over time to exploit the tax benefits, even though the increased debt level takes a toll on the firm value. This incentive depends on the industry output price, and therefore, has profound industry and macroeconomic consequences. Our results highlight two novel channels through which the equity holders' inability to commit affect industry dynamics.

The first is through a price effect. Noncommitment by equity holders significantly increases the cost of debt financing and reduces entry into the market. Consequently, aggregate output shrinks and the output price increases. The higher output price, meaning higher entry barrier, while hinders potential entries, improves the profitability of incumbents, thereby alleviating debt-equity conflicts. The second is through a distribution effect. The leverage dynamics caused by continuous debt issuance in response to idiosyncratic technology shocks shapes the distribution of the firm universe, determining the industry turnover rate and leverage. By embedding non-commitment into the interdependency between firm's capital structure and industry dynamics, we provide a micro-foundation to the firm distribution features observed from the data. We show that the highly positively skewed industry distribution of firms, i.e. the increase in the mass of low debt-scaled cashflow firms in the left tail, can be attributed the absence of debt-policy commitment at the firm level. This indicates that debt-equity conflicts at the firm level can be aggregated and have a profound industry consequence.

Our paper has important implications for welfare and industry policy design. For example, in industries with more dispersed debt holders, the non-commitment consequence can be more salient. It can increase the divergence of firms in the two tails of the distribution, suggesting regulators to reevaluate different measures to enhance efficiency. Relaxing regulation might reduce the entry cost, intensify the market competition and lower the product price. The lowered output price, however, exacerbates the debt-equity conflicts and escalates the agency cost of the incumbents. Whether the lower price outweighs the increased agency cost in terms of social welfare becomes an economically important question. We leave it for future research.



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# A Appendix

**Proof of Proposition 1**

By substituting (21) and the optimal debt issurance policy (19) into the HJB of $E(w, F)$, (16) shows that

$$(r+\lambda+\xi)e_i(y;p) \;=\; (h(p)y_i - c - \xi) - \tau(h(p)y_i - c) + (\mu_z + \xi - g_i)y_i\frac{\partial e_i(y_i;p)}{\partial y} + \frac{1}{2}\sigma_z^2 y_i^2 \frac{\partial^2 e_i(y;p)}{\partial y^2} \tag{57}$$

As mentioned in the discussion, the debt issuance policy is such that the equity holders act as if no adjustment is needed in the equilibrium. Therefore, in solving for the equity value, we plug in $g_i = 0$ from the first-order condition. This results in a linear second-order ordinary differential equation, which can be solved by incorporating the corresponding boundary conditions. One of the boundary conditions imposed is when $y \to \infty$, where the default is irrelevant, and debt is essentially risk-free. Consequently, we could obtain the "no default" value of the equity as

$$\overline{e_i(y_i;p)} \;=\; \frac{h(p)y_i(1\,-\,\tau)}{r\,+\,\lambda\,-\,\mu_z} - \frac{(1\,-\,\tau)c\,+\,\xi}{r\,+\,\lambda\,+\,\xi} \;=\; \phi(p)y_i\,-\,\rho \tag{58}$$

The first term is the unlevered asset value, while the second term is the present value of the tax shield net of debt value. However, the equity holders abandon the firm when the debt-scaled cash flow drops below the default boundary $y_d(p)$. Moreover, the smooth pasting condition helps to determine the optimal default/exit threshold. The two conditions are

$$e_i(y_d;p) = 0 \;\text{ and }\; \frac{\partial e_i(y_i;p)}{\partial y_i}|_{y_i = y_d} \;=\; 0 \tag{59}$$

Based on the two conditions, together with (58), one could show that the equity value satisfies (24) with the constant $\alpha$ and the abandoment threshold $y_b$ defined as in (27) and (28) respectively. ■

**Proof of Proposition 2**



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From the first order condition (17), the debt value can be derived by

$$d_i(y_i;p) = -\frac{\partial e_i(y_i;p)}{\partial F_i} = y_i \frac{\partial e_i(y_i;p)}{\partial y_i} - e_i(y_i;p) \tag{60}$$

Substituting equation (24) into the above condition shows that the debt value as in (29). ■

**Proof of Proposition 3**

The optimal debt adjustment policy is based on (19), which implies

$$g_i(y_i;p) = \frac{G_i^\star}{F_i} = \frac{-\tau c}{F_i D_{iF}} = \frac{\tau c}{y_i^2 \frac{\partial^2 e_i(y_i;p)}{\partial y_i^2}} \tag{61}$$

Subsitution of equation (24) into the above condition shows the optimal adjustment rate (30).

■

**Proof of Proposition 4**

The proposition follows directly by taking the partial derivative of $e_i(y_i;p), d_i(y_i;p), y_d(p)$ and $g_i(y_i;p)$ given in equation (24), (29), (28) and (30) with respect to $p$. ■

**Proof of Proposition 5**

With positive recovery rate $\psi$, the results can be obtained by the same method used in the proofs of Proposition 1 - 3. The differences lie in the boundary conditions for the equity value. With non-commitment debt policy, the liquidation value is captured by the shareholders, which means the boundary conditions specified in (59) becomes the following:

$$e_i^R(y_d^R;p) = \mathscr{R}_i(y_i;p) = \psi\phi(p)y_i \text{ and } \frac{\partial e_i^R(y_i;p)}{\partial y_i}|_{y_i=y_d^R} = 0 \tag{62}$$

The remaining results following similarly. ■

**Proof of Proposition 6**

Given an initial debt value $F$ and the uniform distribution $\Upsilon_y$. The entry condition (39)



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becomes

$$
\begin{aligned}
c_e &= \int_{\underline{y}}^{\overline{y}} F \, \frac{v^R(y,F;p)}{\overline{y} - \underline{y}} dy = \frac{F}{\overline{y} - \underline{y}} \int_{\underline{y}}^{\overline{y}} \Big( \phi(p) y - \rho \frac{\alpha}{1+\alpha} y^{-\alpha} (y_d^R)^{\alpha} \Big) dy \\
&= \frac{F}{\overline{y} - \underline{y}} \Big[ \frac{1}{2} \phi(p) y^2 - \Big( \frac{\alpha}{1+\alpha} \Big)^{\alpha+1} \rho^{\alpha+1} \Big( \frac{1}{(1-\psi)\phi(p)} \Big)^{\alpha} \frac{y^{1-\alpha}}{1-\alpha} \Big] |_{\underline{y}}^{\overline{y}} \qquad (63) \\
&= \frac{F}{\overline{y} - \underline{y}} \Big[ \frac{1}{2} \phi(p^\star)(\overline{y}^2 - \underline{y}^2) - \frac{\rho^{\alpha+1}}{1-\alpha} \Big( \frac{\alpha}{1+\alpha} \Big)^{\alpha+1} \frac{\overline{y}^{1-\alpha} - \underline{y}^{1-\alpha}}{(1-\psi)^{-\alpha} \phi(p^\star)^{-\alpha}} \Big]
\end{aligned}
$$

For the commitment case, the entry condition becomes:

$$
\begin{aligned}
c_e &= \int_{\underline{y}}^{\overline{y}} F \, \frac{v^L(y,F;p)}{\overline{y} - \underline{y}} dy = \frac{F}{\overline{y} - \underline{y}} \int_{\underline{y}}^{\overline{y}} \Big[ \frac{c\tau}{r+\lambda} + \phi(p) y - \Big( \frac{c\tau}{r+\lambda} + \phi(p)(1-\psi) y_d^L \Big) (y_d^L)^{\alpha^L} y^{-\alpha^L} \Big] \\
&= \frac{F}{\overline{y} - \underline{y}} \Big[ \frac{c\tau}{r+\lambda} y + \frac{1}{2} \phi(p) y^2 - \Big( \frac{c\tau}{r+\lambda} + \phi(p)(1-\psi) y_d^L \Big) \frac{(y_d^L)^{\alpha^L}}{1-\alpha^L} y^{1-\alpha^L} \Big] |_{\underline{y}}^{\overline{y}} \qquad (64) \\
&= \frac{F}{\overline{y} - \underline{y}} \Big[ \frac{c\,\tau}{r+\lambda} (\overline{y} - \underline{y}) + \frac{1}{2} \phi(p^L)(\overline{y}^2 - \underline{y}^2) \\
&- \Big( \frac{c\,\tau}{r+\lambda} + \phi(p^L)(1-\psi) y_d^L(p) \Big) \frac{(y_d^L)^{\alpha^L}}{1-\alpha^L} (\overline{y}^{1-\alpha^L} - \underline{y}^{1-\alpha^L}) \Big]
\end{aligned}
$$

■

**Proof of Proposition 7**

We adopt the method presented in Dixit and Pindyc (1994) and Hopenhayn (1992). We are working with the state variable $y$ that follows the diffusion process described by equation (42). The derivation of the distribution of firms in the industry is based on the Kolmogorov forward equations, which are differential equations that describe the time-evolution of a distribution. Here, we are particularly interested in the scaled-density function $\kappa$ that describes the stationary distribution of firms in the industry. The actual density function of the distribution is in fact $N\kappa(y)$ where $N$ is the entry rate. Nevertheless, as shown in Dixit and Pindyc (1994), the $N$ is a common factor that can be cancelled out without altering the distribution density features. Therefore, it is enough to focus on the density function $\kappa(y)$.

Because new entry only occurs only in the region $[\underline{y}, \overline{y}]$, exit due to default occurs in the region $(-\infty, y_d]$ and exit through Poisson death occurs across $(y_b, +\infty)$, the evolution of the



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firm distribution needs to be discussed separately in each region. The general Kolmogorov equation written on the process (42) is given by

$$\frac{\partial \kappa(y,t)}{\partial t} = \underbrace{-\frac{\partial}{\partial y}(\mu(y)\kappa(y,t)) + \frac{1}{2}\frac{\partial^2}{\partial^2 y}(\sigma^2(y)\kappa(y,t))}_{\text{change due to the movement of incumbents}} - \underbrace{\lambda\kappa(y,t)}_{\text{exit from poisson shock}} + \underbrace{f(y,t)}_{\text{new entry}} \tag{65}$$

where $\mu(y) = M_1 - M_2 y^{-\alpha}$ and $\sigma(y) = \sigma_z$. We are interesting in the stationary distribution over time, i.e. $\frac{\partial \kappa}{\partial t} = 0$, which means that the industrial equilibrium distribution is time-invariant and depends on $y$ only, i.e. $\kappa(y)$. In other words, at each $y$, the number of new entrants to $y$ offset the number of firms leaving $y$, leaving the number of firms at $y$ stationary. Based on the value of $y$, we have the following according to (65).

A. For $y_d^R < y < \underline{y}$, changes comes from movement of incumbents and exit due to Poisson death, and no new entry occurs in this region. Therefore,

$$\begin{aligned} 0 &= -\frac{\partial}{\partial y}(\mu(y)\kappa(y)) + \frac{1}{2}\frac{\partial^2}{\partial^2 y}(\sigma^2(y)\kappa(y)) - \lambda\kappa(y) \\ &= \frac{1}{2}\sigma_z^2 y^2 \kappa''(y) - (2\sigma_z^2 - M_1 + y^\alpha M_2) y\, \kappa'(x) - (\sigma_z^2 - \lambda - M_1 + y^\alpha(1+\alpha)M_2)\kappa(x) \end{aligned} \tag{66}$$

B. For $\underline{y} < y < \overline{y}$, new entrants appear and they draw initial shocks independently from the distribution $\Upsilon_y$. This implies new entry occurs at the rate $\frac{y-\underline{y}}{\overline{y}-\underline{y}}$ which gives

$$\begin{aligned} 0 &= -\frac{\partial}{\partial y}(\mu(y)\kappa(y)) + \frac{1}{2}\frac{\partial^2}{\partial^2 y}(\sigma^2(y)\kappa(y)) - \lambda\kappa(y) + f(y) \\ &= \frac{1}{2}\sigma_y^2 y^2 \kappa''(y) - (2\sigma_y^2 - M_1 + y^\alpha M_2) y \kappa'(x) - (\sigma_y^2 - \lambda - M_1 + y^\alpha(1+\alpha)M_2)\kappa(x) + \frac{y - \underline{y}}{\overline{y} - \underline{y}} \end{aligned} \tag{67}$$

C. For $\overline{y} < y$, there are no new entrants, and changes come from the evolution of incumbents and Poisson death, which leads to

$$\begin{aligned} 0 &= -\frac{\partial}{\partial y}(\mu(y)\kappa(y)) + \frac{1}{2}\frac{\partial^2}{\partial^2 y}(\sigma^2(y)\kappa(y)) - \lambda\kappa(y) \\ &= \frac{1}{2}\sigma_z^2 y^2 \kappa''(y) - (2\sigma_z^2 - M_1 + y^\alpha M_2) y\, \kappa'(x) - (\sigma_z^2 - \lambda - M_1 + y^\alpha(1+\alpha)M_2)\kappa(x) \end{aligned} \tag{68}$$



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There are six boundary conditions that apply to the system of ordinary differential equation.

$$\kappa(y_d^R) \;=\; 0; \qquad \int_{y_d}^{+\infty} \kappa(y)dy \;<\; \infty; \tag{69}$$

$$\lim_{y \uparrow \underline{y}} \kappa(y) \;=\; \lim_{y \downarrow \underline{y}} \kappa(y); \qquad \lim_{y \uparrow \overline{y}} \kappa(y) \;=\; \lim_{y \downarrow \overline{y}} \kappa(y); \tag{70}$$

$$\lim_{y \uparrow \underline{y}} \kappa'(y) \;=\; \lim_{y \downarrow \underline{y}} \kappa'(y); \qquad \lim_{y \uparrow \overline{y}} \kappa'(y) \;=\; \lim_{y \downarrow \overline{y}} \kappa'(y) \tag{71}$$

The first condition in (69) suggests that once the boundary $y_d$ is hitted, firms default and exit the industry immediately, while the second condition means that the total number of incumbents in the industry must be finite. Equations in (70) and (71) follow Karatzas and Shreve (2012) to ensure the density function is sufficiently smooth. The density function $\kappa$ over $[y_d^R, +\infty])$ is then ready to be solved numerically by integrating the system of ODEs ((66), (67) and (68)) with the boundaries conditions (69) - (71). Given the distribution density, we can write down some industry equilibrium variables:

$$\text{Turnover rate} \;=\; \frac{1}{\int_{y_d^R}^{\infty} \kappa(y)dy} \tag{72}$$

$$\text{Average industry leverage} \;=\; \frac{\int_{y_d^R}^{\infty} \kappa(y)d(y)/(e(y)+d(y))dy}{\int_{y_d^R}^{\infty} \kappa(y)dy} \tag{73}$$

■

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Table 1: Baseline parameters

| Parameter | Notation | Value |
|---|---|---|
| Panel A: Parameter Calibrated | | |
| Depreciation Rate | $\delta$ | 0.10 |
| Risk-Free Rate | $r$ | 0.04 |
| Corporate Tax Rate | $\tau$ | 0.34 |
| Coupon Rate | $c$ | 0.08 |
| Poisson Death | $\lambda$ | 0.04 |
| Price Elasticity | $\epsilon$ | 0.75 |
| Panel B: Parameter Estimates | | |
| Return to Scale: | $\nu$ | 0.334 |
| Shock Drift | $\mu_z$ | 0.010 |
| Shock Volatility | $\sigma_z$ | 0.154 |
| Debt Amortization | $\xi$ | 0.028 |
| Recovery Rate | $\psi$ | 0.550 |
| Entry Lower Bound | $\underline{y}$ | 0.781 |
| Entry Upper Bound | $\overline{y}$ | 1.782 |

The table shows the parameter values that are used in subsequent numerical analysis. Panel A presents the calibrated parameter values that are used in the model estimation by the method of simulated moments (SMM), while Panel B illustrates the estimated parameters from the SMM estimation.



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Table 2: Data and model moments

| Moment | Model | Data |
|---|---|---|
| Cash flow to Debt Ratio: median | 0.202 | 0.241 |
| Cash flow to Debt Ratio: mean | 0.225 | 0.465 |
| Cash flow to Debt Ratio: mode | 0.168 | 0.138 |
| Cash flow to Debt Ratio: skewness | 2.211 | 2.197 |
| Average Industry Leverage | 0.237 | 0.250 |
| Average Turnover Rate | 0.156 | 0.100 |
| Cash flow Growth Rate | 0.024 | 0.025 |
| Cash flow Volatility | 0.231 | 0.250 |

The table shows the data moments and the corresponding model moments estimated by the simulated method of moment (SMM). The calibrated parameters used in the SMM are: depreciation rate ($\delta$) = 0.10, risk-free rate ($r$) = 0.04, corporate tax rate ($\tau$) = 0.34, coupon rate ($c$) = 0.08, Poisson death intensity ($\lambda$) = 0.04, price elasticity ($\epsilon$) = 0.75.



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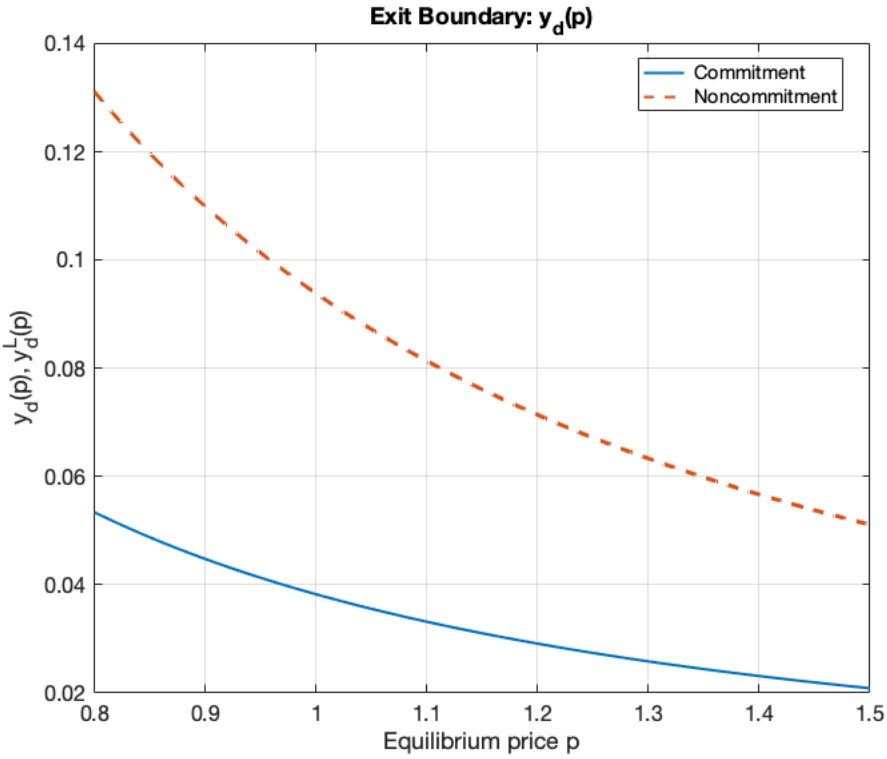


Figure 2: Default boundary and industrial equilibrium output price

The figure compares the default boundary between the noncommitment model and the commitment baseline model. It plots the two default boundaries as functions of the equilibrium price. The dashed line illustrates the noncommitment default boundary $y_d(p)$, and the solid line represents the default threshold with commitment $y_d^L(p)$. The solid line represents the noncommitment default boundary $y_b(p)$, and the dashed line illustrates the Leland default boundary $y_b^{\xi}(p)$. The calibrated parameters values are: depreciation rate $(\delta)$ $= 0.10$, risk-free rate $(r) = 0.04$, corporate tax rate $(\tau) = 0.34$, coupon rate $(c) = 0.08$, Poisson death intensity $(\lambda) = 0.04$, price elasticity $(\epsilon) = 0.75$. The SMM estimated parameter values are: return to scale $(v) = 0.334$, shock drift $(\mu_z) = 0.01$, shock volatility $(\sigma_z) = 0.154$, debt amortization rate $(\xi) = 0.028$, entry lower bound $(\underline{y}) = 0.781$, and entry upper bound $(\overline{y}) = 1.782$.



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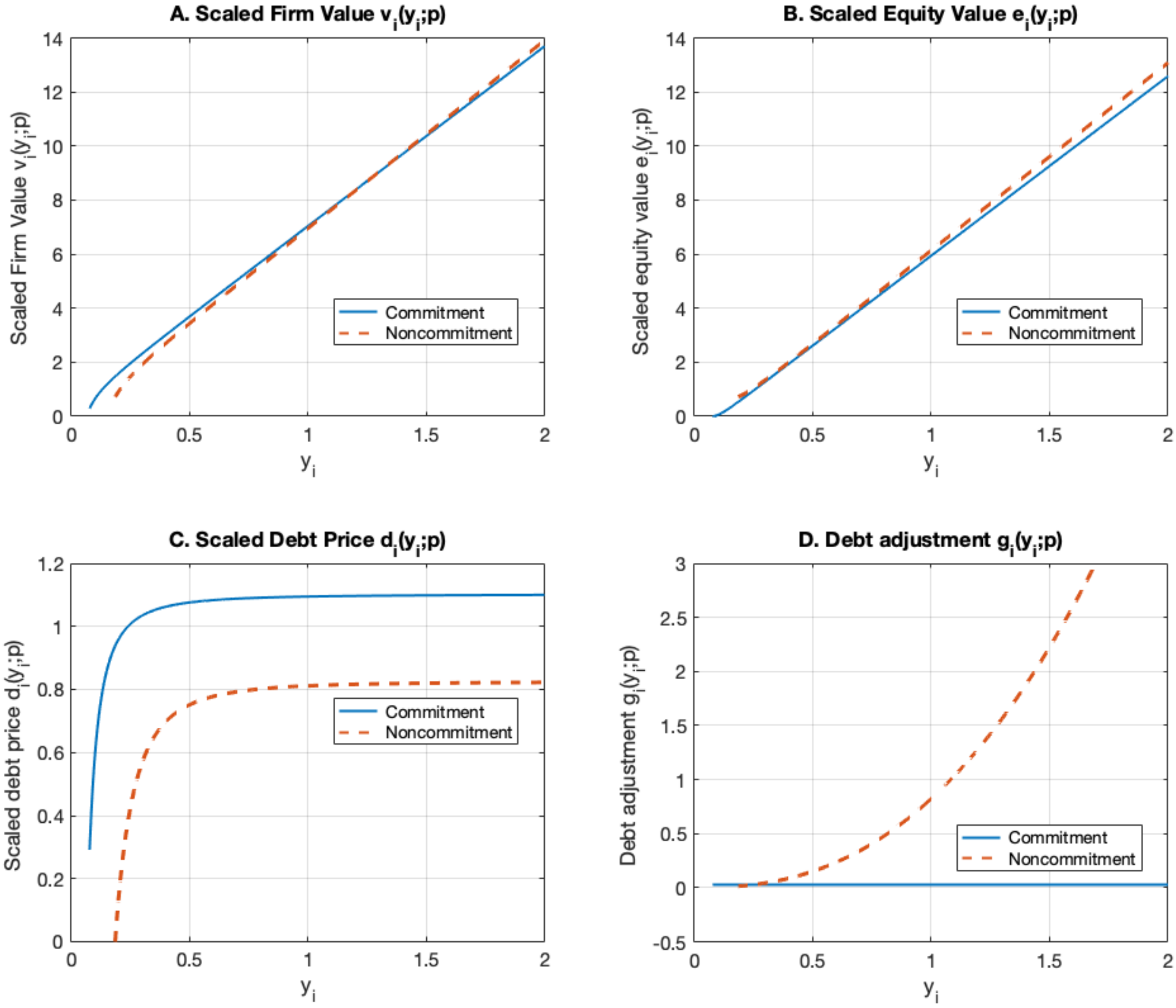


Figure 3: Partial equilibrium comparison

The figure compares the partial equilibrium between the noncommitment model and the commitment model (both with positive recovery rate). Panel A plots the firm's noncommitment, and commitment scale total firm value, $v_i^R(y_i; p*)$ and $v_i^L(y_i; p^L)$, Panel B plots the scaled equity values, $e_i^R(y_i; p*)$ and $e_i^L(y_i; p^L)$, Panel C plots the scaled debt values, $d_i^R(y_i; p*)$ and $d_i^L(y_i; p^L)$, and Panel D plots the debt adjustment policies, $g_i^R(y_i; p*)$ and $g_i^L(y_i; p^L)$ as function of the market output price $p$. The dashed line represents the noncommitment case, while the solid line refers to the commitment case. The output prices are: $p^* = 0.6306$, and $p^L = 0.6122$. The calibrated parameters values are: depreciation rate $(\delta) = 0.10$, risk-free rate $(r) = 0.04$, corporate tax rate $(\tau) = 0.34$, coupon rate $(c) = 0.08$, Poisson death intensity $(\lambda) = 0.04$, price elasticity $(\epsilon) = 0.75$. The SMM estimated parameter values are: return to scale $(v) = 0.334$, shock drift $(\mu_z) = 0.01$, shock volatility $(\sigma_z) = 0.154$, debt amortization rate $(\xi) = 0.028$, entry lower bound $(\underline{y}) = 0.781$, and entry upper bound $(\overline{y}) = 1.782$.



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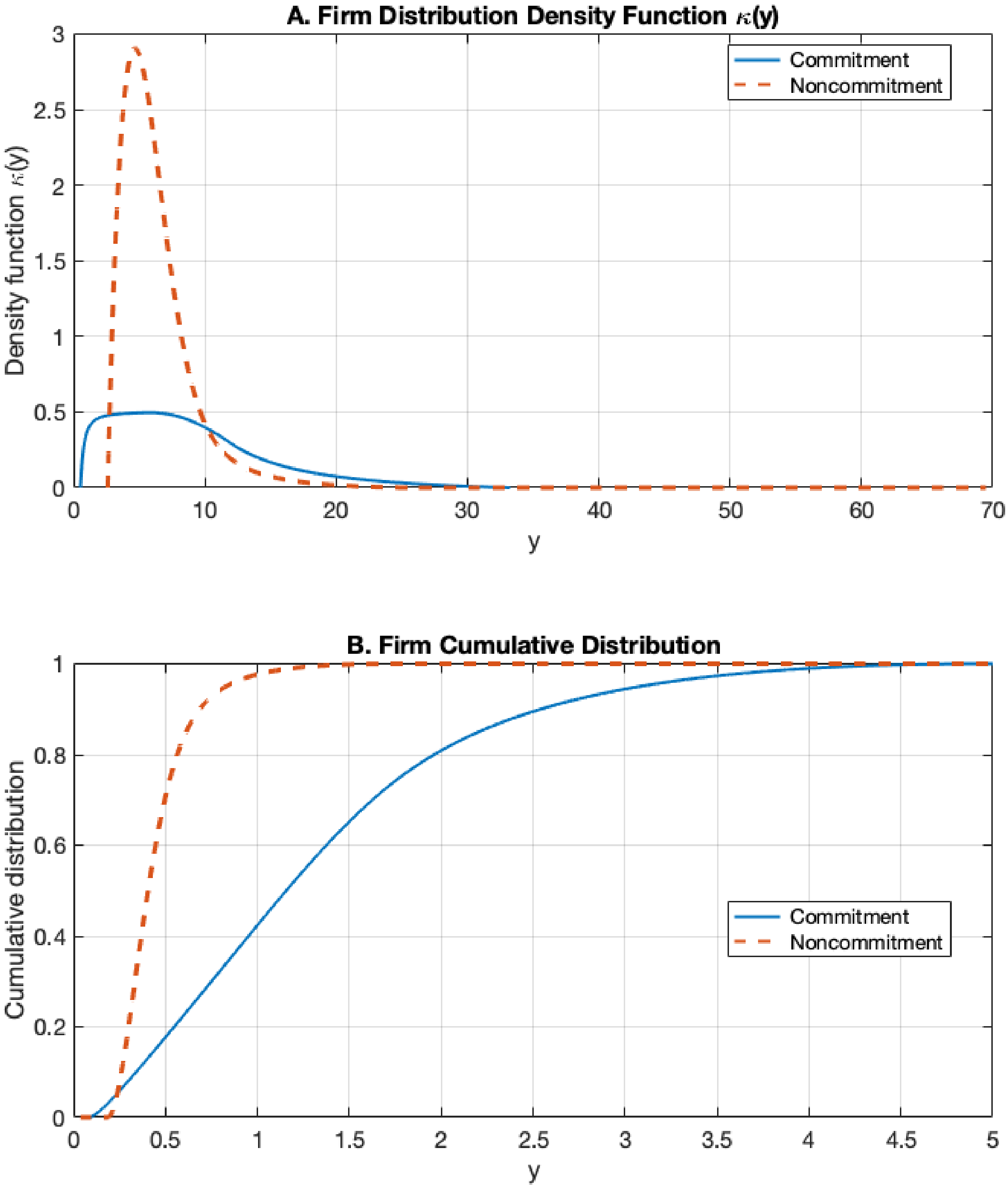


Figure 4: Firm distribution with and without debt policy commitment

This figure compares the firm distribution between the noncommitment model and the commitment model. Panel A and B plot respectively, the distribution density function and the normalized cumulative distribution function in the debt-scaled cashflow $y$. The dashed line represents the noncommitment case, while the solid line refers to the commitment case. The output prices are: $p^* = 0.6306$, and $p^L = 0.6122$. The calibrated parameters values are: depreciation rate $(\delta) = 0.10$, risk-free rate $(r) = 0.04$, corporate tax rate $(\tau) = 0.34$, coupon rate $(c) = 0.08$, Poisson death intensity $(\lambda) = 0.04$, price elasticity $(\epsilon) = 0.75$. The SMM estimated parameter values are: return to scale $(v) = 0.334$, shock drift $(\mu_z) = 0.01$, shock volatility $(\sigma_z) = 0.154$, debt amortization rate $(\xi) = 0.028$, entry lower bound $(\underline{y}) = 0.781$, and entry upper bound $(\overline{y}) = 1.782$.



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Table 3: Comparative statics

| Parameter | Value | Industry Price | Exit Threshold | Turnover Rate | Industry Output | Industry Leverage | Skewness |
|---|---|---|---|---|---|---|---|
| A. $\mu_z$ | 0.5% | 0.701 | 0.183 | 15.68% | 1.305 | 23.49% | 1.813 |
| | 1.0% | 0.631 | 0.187 | 15.46% | 1.413 | 23.97% | 1.866 |
| | 3.0% | 0.314 | 0.201 | 14.76% | 2.386 | 25.69% | 1.970 |
| B. $\sigma_z$ | 10% | 0.677 | 0.220 | 14.71% | 1.340 | 30.01% | 2.445 |
| | 15% | 0.631 | 0.187 | 15.46% | 1.413 | 23.97% | 1.866 |
| | 30% | 0.374 | 0.122 | 19.24% | 2.092 | 16.02% | 1.475 |
| C. $c$ | 0.040 | 0.630 | 0.126 | 13.34% | 1.414 | 23.00% | 2.427 |
| | 0.080 | 0.631 | 0.187 | 15.46% | 1.413 | 23.97% | 1.866 |
| | 0.120 | 0.631 | 0.248 | 16.63% | 1.412 | 24.49% | 1.443 |
| D. $\tau$ | 27% | 0.582 | 0.200 | 13.46% | 1.500 | 23.25% | 1.520 |
| | 34% | 0.631 | 0.187 | 15.46% | 1.413 | 23.97% | 1.866 |
| | 40% | 0.680 | 0.176 | 17.34% | 1.335 | 24.45% | 2.156 |
| E. $c_e$ | 40.000 | 0.521 | 0.250 | 15.62% | 1.632 | 24.21% | 1.348 |
| | 53.401 | 0.631 | 0.187 | 15.46% | 1.413 | 23.97% | 1.866 |
| | 70.000 | 0.755 | 0.143 | 15.38% | 1.235 | 23.84% | 2.416 |
| F. $\epsilon$ | 0.400 | 0.680 | 0.176 | 15.92% | 1.167 | 24.08% | 2.033 |
| | 0.750 | 0.680 | 0.176 | 15.92% | 1.335 | 24.08% | 2.033 |
| | 0.800 | 0.680 | 0.176 | 15.92% | 1.361 | 24.08% | 2.033 |

This table presents the comparative statics for selected parameter values. The industry price is the output price $p^\star$ derived from equation (41), the exit threshold is the default boundary $y_d^R(p)$ given in (36), the turnover rate is calculated based on (72), the industry output is the aggregate output $L$ computed from industry demand function (14), the industry leverage is based on equation (73), while the skewness is the third moments of the normalized density function of the firm distribution. The baseline parameter values are shown in Tabel 1. Specifically, the calibrated parameters values are: depreciation rate ($\delta$) = 0.10, risk-free rate ($r$) = 0.04, corporate tax rate ($\tau$) = 0.34, coupon rate ($c$) = 0.08, Poisson death intensity ($\lambda$) = 0.04, price elasticity ($\epsilon$) = 0.75. The SMM estimated parameter values are: return to scale ($v$) = 0.334, shock drift ($\mu_z$) = 0.01, shock volatility ($\sigma_z$) = 0.154, debt amortization rate ($\xi$) = 0.028, entry lower bound ($\underline{y}$) = 0.781, and entry upper bound ($\overline{y}$) = 1.782.



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Table 4: Price and distributional effects

| | | Distributional Effects | | | | | | | | | | Gross Effects | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| $F$ | $\psi$ | Commitment Model | | | | | Non Commitment Model | | | | | Non Commitment Model | | | | |
| | | Price $p^L$ | Default Threshold | Turnover Rate | Industry Output | Industry Leverage | Price $p^L$ | Default Threshold | Turnover Rate | Industry Output | Industry Leverage | Price $p^\star$ | Default Threshold | Turnover Rate | Industry Output | Industry Leverage |
| 3 | 0.00 | 0.9855 | 0.0415 | 8.334% | 1.0110 | 11.541% | 0.9855 | 0.0431 | 15.298% | 1.0110 | 58.797% | 1.0000 | 0.0422 | 15.297% | 1.0000 | 58.795% |
| 3 | 0.55 | 0.9855 | 0.0390 | 8.316% | 1.0110 | 11.729% | 0.9855 | 0.0959 | 15.325% | 1.0110 | 23.740% | 1.0000 | 0.0938 | 15.323% | 1.0000 | 23.736% |
| 6 | 0.00 | 0.6125 | 0.0847 | 8.664% | 1.4443 | 18.849% | 0.6125 | 0.0881 | 15.319% | 1.4443 | 58.913% | 0.6303 | 0.0844 | 15.316% | 1.4136 | 58.899% |
| 6 | 0.55 | 0.6122 | 0.0797 | 8.624% | 1.4448 | 19.221% | 0.6122 | 0.1960 | 15.475% | 1.4448 | 24.003% | 0.6306 | 0.1875 | 15.456% | 1.4132 | 23.974% |

The table disentangles the noncommitment effect. The initial face value of debt can take 3 or 6, while the recovery rate $\psi$ takes the value of 0 or 0.55, where the latter one is the SMM estimated recovery rate. The distribution effects are obtained by comparing the noncommitment model results with those under the commitment model using the same baseline Leland commitment output price $p^L$. To obtain the gross effect of lack of commitment on the industry equilibrium, we compare the full noncommitment result with the Leland commitment result. The price columns are the equilibrium prices derived from the corresponding entry conditions: equation (55) for $p^L$ and equation (41) for $p^\star$. The default threshold columns refer to $y_d^L(p)$ and $y_d^R(p)$ for the commitment model and noncommitment model respectively. The turnover rate is defined in equation (72), and the industry leverage is defined in (73). The remaining parameter value follows the baseline parameter values shown in Table 1. Specifically, the calibrated parameters values are: depreciation rate $(\delta) = 0.10$, risk-free rate $(r) = 0.04$, corporate tax rate $(\tau) = 0.34$, coupon rate $(c) = 0.08$, Poisson death intensity $(\lambda) = 0.04$, price elasticity $(\epsilon) = 0.75$. The SMM estimated parameter values are: return to scale $(v) = 0.334$, shock drift $(\mu_z) = 0.01$, shock volatility $(\sigma_z) = 0.154$, debt amortization rate $(\xi) = 0.028$, entry lower bound $(\underline{y}) = 0.781$, and entry upper bound $(\overline{y}) = 1.782$.



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