

# Imperfect competition in financial markets and capital structure<sup>1</sup>

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## Abstract

We consider a model of corporate finance with imperfectly competitive financial markets. Firms can finance projects either via debt or via equity. Because of asymmetric information about firms' growth opportunities, equity financing involves a dilution cost. Nevertheless, equity emerges in equilibrium whenever financial markets are sufficiently concentrated. In the latter case, best firms issue debt while the less profitable firms are equity-financed. We also show that strategic interaction between oligopolistic investors results in multiple equilibria. If an investor chooses to buy more debt, the price of debt decreases, so the best equity-issuing firms switch from equity to debt financing. This in turn decreases average quality of equity-financed pool, so other investors also shift towards more debt. The multiplicity of equilibria may provide a simple explanation of volatility of stock returns, and stock market crashes.

*Keywords: capital structure, pecking order theory of finance, oligopoly in financial markets, second degree price discrimination*

*JEL Codes: D43, G32, L13*

# 1 Introduction

The choice of capital structure is one of the central issues in corporate finance. The cornerstone paper by Modigliani and Miller (1958) established that capital structure is irrelevant as long as financial markets are perfect. Since the real world suggests that financing decisions do matter, corporate finance literature has come up with a number of theories that introduce various imperfections of financial markets to explain costs and benefits of debt and equity finance. The three most influential theories explain capital structure by taxes (the trade-off theory), asymmetric information (the pecking order theory), and by the effect of capital structure on incentives (the agency theory). There is still no consensus on which theory outperforms the others when taken to the data (Myers, 2000, Baker and Wurgler, 2002, Mayer and Sussman, 2004, Welch, 2004, Leary and Roberts, 2006).

In this paper, we consider a model of capital structure based on the pecking order theory (Myers and Majluf, 1984). Due to asymmetric information external funds are costly, so the firm prefers to finance investments internally. If the internal funds are not sufficient then the firm raises capital through debt rather than through equity. Rational investors realize that firms that prefer to issue equity are the ones with lower NPV projects and discount their shares accordingly. Since the financial markets are perfectly competitive, this *dilution cost* is passed back onto the firm in the form of a higher cost of capital. In other words, in the presence of asymmetric information, firms prefer to raise funds via securities that are less information sensitive, that is debt.

We consider a situation where investors have market power. There are many reasons to believe that financial markets are not perfectly competitive. Financial services require reputational capital; information accumulation and processing also create economies of scale and barriers to entry (Dell'Arricia et al., 1999). Not surprisingly, after Glass-Steagall Act was repealed in 1999, the global financial market has been increasingly dominated by a few “global, universal banks of new generation” (Calomiris, 2002) that are providing both commercial and investment banking services (as well as other financial services) and command a substantial market share in virtually all financial markets.<sup>1</sup> Also, as many small firms cannot overcome the fixed costs of reaching out to global markets, they have to

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<sup>1</sup>According to Thomson Financial ([www.thomson.com](http://www.thomson.com)) nine largest financial groups (Goldman Sachs, Lehman Brothers, Merrill Lynch, Morgan Stanley Dean Witter, Citi/Salomon Smith Barney, JP Morgan, Credit Suisse First Boston, Deutsche Bank, and UBS Warburg) control more than 50% in *every* major financial market; in many markets top five financial intermediaries control up to 70% of the market.

seek finance in local financial markets that are highly concentrated (Petersen and Rajan, 1994, 1995).

Why does imperfect competition matter for capital structure? Once the investors are large and behave strategically, the logic of conventional capital structure theories falls apart. Under perfect competition, the investors' costs are passed onto the firm because investors earn zero rents on all financial instruments. Oligopolistic financial intermediaries, on the other hand, receive positive rents, and these rents may differ for debt and equity investments. Since firms choose capital structure depending on their growth opportunities, investors can use capital structure as a means of the second degree price discrimination (similarly to using monetary and barter contracts in Guriev and Kvassov, 2004). The purpose of discrimination is to extract higher fees from more profitable firms. We find that equilibrium capital structure is different in competitive and concentrated markets. For expositional clarity we assume away all possible costs of debt financing. In this case, in line with the pecking order theory, debt crowds out equity as long as financial markets are sufficiently competitive. However, as markets become more concentrated, equity financing does emerge in equilibrium. Concentration of market power results in a substantial wedge between the oligopolistic interest rate and investors' cost of funds. Hence, there is a pool of firms that would borrow at rates which are below the market rate but still above investors' cost of funds. In order to serve these firms without sacrificing revenues from lending at a high rate to existing borrowers, investors use capital structure as a screening device. The better firms still prefer debt, while the less profitable firms are happy to issue equity.

What makes our paper more than just another model of capital structure is the study of strategic interaction that results in multiple equilibria. As we show, these equilibria differ in terms both capital structure and asset prices even though investors are fully rational. This in turn provides a very simple rationale for stock market volatility, bubbles and crashes without resorting to assumptions on bounded rationality or limits to arbitrage. The intuition for multiplicity of equilibria is the strategic complementarity of portfolio choices by investors.<sup>2</sup> Suppose that an investor decides to move from debt to equity. This raises interest rate on debt so that some firms that used to borrow can no longer afford debt finance. These firms switch to equity which improves average quality of equity financed pool of firms (all debt-financed firms are better than equity-financed ones). This

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<sup>2</sup>Our model is an application of Bulow et al.'s multi-market oligopoly model in the case where demands rather than costs are interrelated across markets (as in Section VI.K of Bulow et al., 1985).

makes equity investment more attractive so other investors also choose to shift from debt to equity. We show that multiple equilibria do exist for a range of parameter values.

Our analysis has two kinds of empirical implications. First, *ceteris paribus* both across countries and over time, higher concentration of financial market power should result in greater reliance on equity finance. Second, the stock price volatility is higher for intermediate ranges of concentration. If markets are perfectly competitive, there is a unique equilibrium where debt finance prevails; if markets are too concentrated, there is only one equilibrium with high share of equity financing. Unfortunately, both predictions are hard to test as there are many other determinants of capital structure that are correlated with changes in concentration of debt and equity markets. In particular, the cross-country test of our hypothesis is problematic as legal protection of outside shareholders in the US results in a widespread use of equity even though the US financial markets are very competitive (La Porta et al., 1998). As for the within-US experience over time, it is rather consistent with our results: the consolidation of financial industry in 1990s was accompanied by a growth in equity finance and in higher stock market volatility. In any case, finding appropriate instruments or locating a suitable natural experiment remains a subject for future empirical work.

*Literature.* Market concentration is not the only explanation of coexistence of debt and equity under asymmetric information. In the pecking order literature equity finance may emerge in equilibrium either if debt is costly or if information production is endogenous. In Bolton and Freixas (2000), both bank loans and public debt coexist in equilibrium with equity. Although equity financing involves a dilution cost, it still emerges in equilibrium since debt financing is also costly. Banks need to raise funds themselves and, therefore, bear intermediation costs, while bond financing involves inefficient liquidation. Since dispersed bondholders cannot overcome the free-rider problem, they are less likely to be flexible ex post (unlike banks). Again, each firm chooses the capital structure which is the least costly one for the investors since the perfect competition in financial markets translates investors' costs into a higher cost of capital for the firm. Other potential costs of excessive leverage include costs of bankruptcy and agency costs of debt (Bradley et al., 1984). Cooney and Kalay (1993), consider the case of asymmetric information about both mean and volatility of the project returns; equity finance emerges in equilibrium. In Boot and Thakor (1993) and in Fulghieri and Lukin (2001), equity issues provide incentives for investors to produce information hence bringing stock price closer to fundamentals and increasing issuer's revenues.

While most of the capital structure literature studies perfectly competitive financial markets, there are a few papers that focus on imperfect competition. Petersen and Rajan (1995) consider a model of a monopolistic creditor that performs better than competitive market because it is able to form long-term ties and internalize the debtor's benefits from investment. In many ways, this arrangement is similar to our equity financing (which also emerges in highly concentrated markets). Petersen and Rajan, however, do not consider oligopoly and therefore do not describe the effects of strategic interactions.

There is also a literature on market microstructure (e.g. Brunnermeier, 2001, ch. 3) that explicitly models the competition between market makers in financial markets. Our setting is most similar to Biais et al. (2000) who consider oligopolistic uninformed market makers screening informed traders. However, the market microstructure models study a single financial market while we focus on the situation where investors interact strategically in two markets (debt and equity) using capital structure to screen firms.

Our paper is also related to the literature on bubbles and crashes, and on IPO waves. While our model does not describe bubbles (defined as deviations of stock prices from their fundamental values) we do show that there are multiple equilibria with different stock returns and volumes of stock issued; in this respect our paper is similar to Allen and Gale (2003) who discuss crises that are driven by endogenous change in fundamental value per se. Our model provides a rational explanation for the widespread market timing; the fact that firms issue equity when stock price is high and repurchase when low (Baker and Wurgler, 2002) can be explained by multiplicity of equilibria. Also, our rationale for stock market crashes is somewhat similar to the one in Abreu and Brunnermeier (2000) who explain persistent bubbles by coordination failure between rational arbitragers over time. Our analysis is also related to Asparouhova (2006) who studies, theoretically and experimentally, a setting with competitive lending to heterogeneous entrepreneurs under asymmetric information on their risks. To screen the borrowers, the lenders offer menus of debt contracts; the experimental results are consistent with theory predicting non-existence of equilibria for certain parameter values.

The rest of the paper is structured as follows. In Section 2 we set up the model. In Section 3 we fully characterize the equilibria in a special case where distribution of firms satisfies monotone hazard rate condition; we show that if market structure is sufficiently concentrated there may be two stable equilibria: one with debt and equity finance, and the other one with debt finance only. We also consider an example without the monotone hazard rate condition where there are multiple equilibria with equity. Section 4 discusses

extensions. Section 5 concludes and describes empirical implications.

## 2 The model

### 2.1 The setting

There are two periods: *ex ante*  $t = 1$  (financing and investments) and *ex post*  $t = 2$  (realization of returns and payoffs to investors). Discount rates are normalized to 1. There are a finite number of investors and a continuum of firms normalized to 1.

*Firms.* Each firm has an individual investment project that requires 1 unit of funds in the first period and brings gross return  $\pi$  in the second period. The return is the firm's private information at the time of financing but is publicly observable *ex post*. The firms' types  $\pi$  are distributed on  $[\underline{\pi}, \bar{\pi}]$  with c.d.f.  $F(\cdot)$  without mass points. Firms have no cash and, therefore, have to rely on either debt or equity. Until Section 4 we rule out a possibility of issuing both equity and debt.<sup>3</sup>

Firms act in the interests of their existing shareholders. After production takes place and payoffs are realized, firms are liquidated. The firms' outside options are normalized to zero.

*Investors.* There are  $N$  investors. Investors are financial intermediaries who have unlimited access to funds at a constant cost  $\rho$  (e.g., an interest rate to be paid to the ultimate providers of funds). The investors can choose how much to invest in bonds or stocks. The investors have market power and behave strategically; they take into account the impact of their strategies on the market prices of debt and equity.

It is important to emphasize that continuum of firms and a finite number of investors does not imply that investors are scarce and projects are in infinite supply. Vice versa, the number of projects is limited (normalized to 1), and investors can bring in an unlimited amount of resources (at a marginal cost  $\rho$ ).

*Debt.* In this model we do not distinguish between bank loans and bonds. The debt contract is standard: "borrow  $D$  in the first period, pay back  $rD$  in the second period; if the repayment is not made, the creditors take over the firm." The return on debt,  $r$ , is endogenous and is determined in an (imperfectly competitive) market equilibrium model.

We assume that there is an infinitesimal cost of bankruptcy. If the firm is indifferent between repaying or undergoing bankruptcy, it always chooses repayment. In the first

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<sup>3</sup>One can assume that each method of finance may involve a fixed cost, e.g. same for debt and equity.

period the firm has no uncertainty about its second-period returns. As a result, the firm never borrows more than it can pay back and default on debt never happens.

The first-period price of a debt contract that promises to pay the investor \$1 is  $p = 1/r$ .

*Equity.* The equity market is a market for individual firms' shares. However, since firms' private information is not available to the market, all shares are traded at the same price per share,  $P$ . For an equity issuing firm,  $P$  is its market capitalization. In order to raised one unit of funds, such a firm issues  $1/P$  shares.

We also introduce returns on equity,  $R$ . If an investor buys  $\alpha$  shares (in any firm) she invests  $\alpha P$  in the first period and expects to get  $\alpha PR$  in the second period. Unlike the straightforward relationship between price and returns to debt,  $pr = 1$ , the return on equity is not a simple function of its price. The expected returns on equity are calculated by rational investors who evaluate the average profitability of equity-financed firms; the set of firms who opt for equity financing is endogenous. The expression for the return on equity is derived below.

*Notation.* Let  $G(x)$  be an average returns conditional on returns being below  $x$ :

$$G(x) = E(\pi | \pi < x) = \frac{1}{F(x)} \int_{\underline{\pi}}^x \pi f(\pi) d\pi,$$

where  $f(\cdot)$  is the density function.

Let  $\pi^*$  denote the firm for which  $G(\pi^*) = \rho$  and suppose that equity is issued by all firms with profits below a certain level  $x$ . Then  $G(x)$  is the expected profits of equity-financed firms. Therefore,  $\pi^*$  is the threshold level for which the average profit of equity-financed firms is still above investors' costs of funds,  $\rho$ . In other words,  $\pi^*$  is the lowest  $r$  such that the average firm below  $r$  is worth investing in:  $E(\pi | \pi < r) = \rho$ .

*Assumptions.* The following two assumptions simplify the structure of equilibria assuring that at most two stable equilibria exist.

- A1. Monotone hazard rate (MHR).  $(1 - F(x))/f(x)$  is a non-increasing function.
- A2.  $x - G(x)$  is an increasing function.

In Section 3.3 we relax these assumptions and show that while the structure of equilibria remains similar, their number may increase.

## 2.2 Demand for finance

Consider the decision of a firm of type  $\pi$  given the market prices of debt,  $p$ , and equity,  $P$ . The firm can finance the project either by borrowing one unit or by issuing shares. If the firm borrows its payoff is  $\pi - r$ . If the firm relies on equity it has to sell  $1/P$  shares

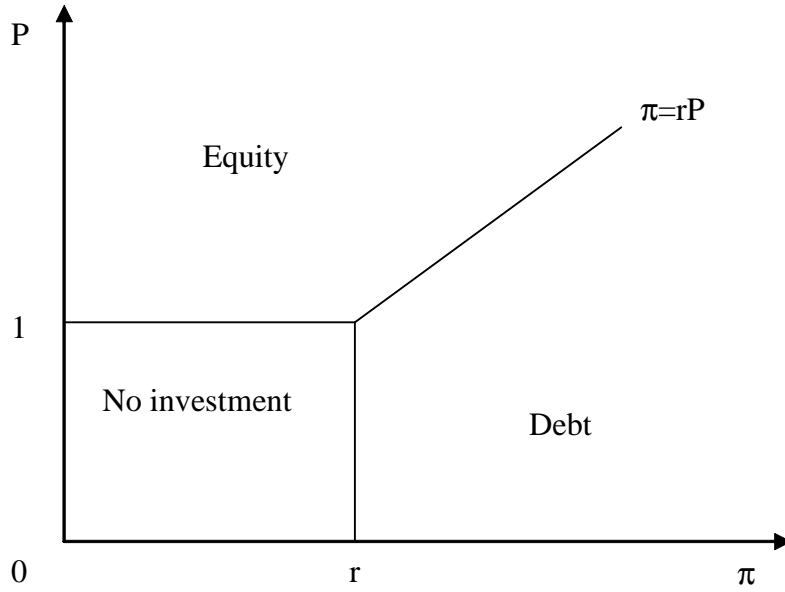


Figure 1: The choice of capital structure. A firm with profit  $\pi$  facing interest rate  $r$  on debt and equity price  $P$  chooses either debt or equity financing or no investment at all.

and its payoff is  $\pi - \pi/P$ . Thus, the firm undertakes the project if  $\pi - \min\{r, \pi/P\} \geq 0$ . The capital structure, illustrated in Figure 1, is:

1. If  $P < 1$  there is no equity financing. Good firms ( $\pi > r$ ) borrow, other firms ( $\pi < r$ ) do not undertake the project. Firms with  $\pi = r$  are indifferent between borrowing and not undertaking the project.
2. If  $P > 1$  all firms undertake the project. Better firms ( $\pi > rP$ ) borrow, other firms ( $\pi < rP$ ) issue equity. The return on equity is  $R = \frac{G(rP)}{P}$ . Firms with  $\pi = rP$  are indifferent between debt and equity financing.
3. If  $P = 1$  better firms ( $\pi > r$ ) borrow, while other firms ( $\pi \leq r$ ) are indifferent between issuing equity or not undertaking the project. The return on equity is  $R = G(r)$ .

There is no debt financing if  $\pi < r$  and there is no equity financing if  $P < 1$ . The former condition is straightforward; the latter is related to the fact that each firm needs to raise a unit of funds. The firms cannot sell shares at prices below 1 because raising capital for the project requires giving out more than 100% of equity.

The market demand for debt finance (the total amount that companies want to raise through borrowing) is

$$D(r, P) = 1 - F(r \max\{P, 1\})$$

while the demand for equity finance is

$$E(r, P) = \begin{cases} 0, & P < 1 \\ [0, F(rP)], & P = 1 \\ F(rP), & P > 1 \end{cases}$$

The total issue of shares is  $E(r, P)/P$ .

The inverse demand functions  $r(D, E)$  and  $P(D, E)$  are:

$$\begin{cases} \text{If } E = 0 \text{ then } P \in [0, 1] \text{ and } r \text{ solves } F(r) = 1 - D(r, P), \\ \text{If } E > 0 \text{ and } D + E < 1, \text{ then } P = 1 \text{ and } r \text{ solves } F(r) = 1 - D(r, 1), \\ \text{If } E > 0 \text{ and } D + E = 1, \text{ then } P \geq 1 \text{ and } r \text{ solves } F(r) = 1 - D(r, P), \\ \text{If } E > 0 \text{ and } D + E > 1, \text{ there are no finite prices.} \end{cases} \quad (1)$$

Note that for some values of  $D$  and  $E$  the price  $P$  is not uniquely determined and can take on a continuum of values. It does not matter when  $P < 1$  and equity is not issued. However, when  $P > 1$  it may become a problem, since different values of  $P$  result in different payoffs; higher price implies less outside equity issued and therefore higher payoffs of firms' incumbents at the expense of outside investors. In all cases the dollar amount raised via equity issue is the same, but outsiders obtain either a large stake (if  $P$  is close to 1) or a very small stake in the company (if  $P$  is high). It turns out however that this indeterminacy issue is not important; there are no equilibria with  $P > 1$ .

### 3 The analysis

#### 3.1 Perfect competition

As a benchmark, consider the case of perfectly competitive financial markets. When investors are price takers, the interest rate on debt is equal to the marginal cost of funds:  $r = \rho$ , and  $p = 1/\rho$ . Equity finance is ruled out in equilibrium. If there were non-trivial equity issues, they should have also brought return  $\rho$ . Therefore  $\rho = R = \frac{1}{P}G(rP)$ . Using  $r = \rho$ , we obtain  $rP = G(rP)$ , contrary to the Assumption A2 that  $G(x) < x$  for all  $x$ .

Thus, perfect competition implements the first best. All efficient firms ( $\pi \geq \rho$ ) are financed, all inefficient firms are closed down. Equity is crowded out by debt because

equity financing involves a dilution cost due to asymmetric information. This is exactly what a pecking order theory would imply in the absence of bankruptcy costs and costs of financial distress. This result is also similar to Akerlof's analysis of the lemons' problem. In equilibrium with competitive investors, equity should bring the same returns as debt. But since only the *best* equity-financed firms  $\pi = rP$  have returns equal to the interest rate on debt, the *average* equity-financed firm has quality below  $rP$  and is not attractive to investors.

### 3.2 Structure of equilibria

In this section we consider a market equilibrium where  $N$  identical investors interact strategically and solve for a Nash-Cournot equilibrium.<sup>4</sup> Each investor chooses a two-dimensional strategy: how much to invest in debt  $D_i$  and how much to invest in equity  $E_i$ . Essentially, the problem is similar to a multiproduct oligopoly: there are two products (debt and equity) and two prices ( $p = 1/r$  and  $P$ ). As in the conventional Cournot model, investors know the inverse demand functions  $r(\sum_{i=1}^N D_i, \sum_{i=1}^N E_i)$  and  $P(\sum_{i=1}^N D_i, \sum_{i=1}^N E_i)$  given by (1).

The payoff of investor  $i$  is

$$(r - \rho)D_i + (R - \rho)E_i \quad (2)$$

where  $R = \frac{1}{P}G(rP)$ . The investor chooses her investment strategy  $(D_i, E_i)$  taking into account the strategies of other investors:  $D_{-i} = \sum_{j \neq i} D_j$ ,  $E_{-i} = \sum_{j \neq i} E_j$ .

To describe the structure of equilibria we introduce additional notation:

$$N^D = \frac{1 - F(\pi^*)}{(\pi^* - \rho)f(\pi^*)}, \quad N^{ED} = 1 + N^D. \quad (3)$$

**Proposition 1** *Under the assumptions A1 and A2, the structure of equilibria is:*

1. *If  $N \geq N^D$  there exists a (stable) equilibrium where only debt financing is used ( $P < 1$ ). The interest rate on debt  $r = r^D(N)$  solves*

$$r - \rho = \frac{1 - F(r)}{Nf(r)}. \quad (4)$$

*Firms with  $\pi \geq r$  borrow; firms with  $\pi < r$  do not undertake the project.*

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<sup>4</sup>We extend the model of oligopolistic nonlinear pricing by Oren et al. (1983) to the multi-market case.

2. If  $N \leq N^{ED}$  there exists a (stable) equilibrium where both debt and equity are used. The price of equity is  $P = 1$ , the interest rate on debt solves

$$r - G(r) = \frac{1 - F(r)}{(N - 1) f(r)}. \quad (5)$$

Firms with  $\pi \geq r$  borrow, firms with  $\pi < r$  issue equity.

3. If  $N \in (N^D, N^{ED})$  there exists an (unstable) equilibrium where both equity and debt are used. The price of equity is  $P = 1$ , the interest rate on debt is  $r = \pi^*$ . Firms with  $\pi \geq r$  borrow, firms with  $\pi < r$  use equity or do not undertake the project.

The comparative statics of equilibria with respect to market structure  $N$  is illustrated in Figure 2. If the financial markets are perfectly competitive,  $N \rightarrow \infty$ , then equity is completely crowded out by debt and there exists the unique equilibrium which approximates the first best,  $r^D(N) \rightarrow \rho$ . If the financial markets are highly concentrated, then there exists the unique equilibrium in which all firms are financed: good firms borrow and bad firms issue equity.<sup>5</sup> In the intermediate range of concentration there can exist multiple equilibria.

The intuition behind the structure of equilibria is quite straightforward. First, because financial markets are imperfectly competitive, the interest rate on debt is set above investors' cost of funds and the markup,  $r - \rho$ , decreases with  $N$ . Second, at every level of concentration,  $N$ , the interest rate on debt in equilibrium with both equity and debt is higher than in equilibrium with debt only. The incentives to raise interest rates (through reduced lending) in an equilibrium without equity are lower; by increasing interest rates the investors earn higher returns from borrowers but lose clients. In an equilibrium with both debt and equity higher interest rates generate higher returns on borrowers and, in addition, firms who stop borrowing do not drop out but switch to equity finance and bring additional profits to investors. Third, an equilibrium with equity exists if and only if the interest rate on debt is sufficiently high,  $r \geq \pi^*$ , so that the average quality of equity-financed firms is also high,  $G(r) \geq G(\pi^*) = \rho$ , while an equilibrium without equity requires the opposite,  $r \leq \pi^*$ .

Multiple equilibria emerge because of the strategic complementarities generated by the return-on-equity externality. When an investor decides to lend more the interest rate on

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<sup>5</sup>This result is consistent with Petersen and Rajan (1995) who show that a monopoly lender is more likely to form a relationship with the firm effectively obtaining a stake in firm's future profits, similar to equity financing in our model.

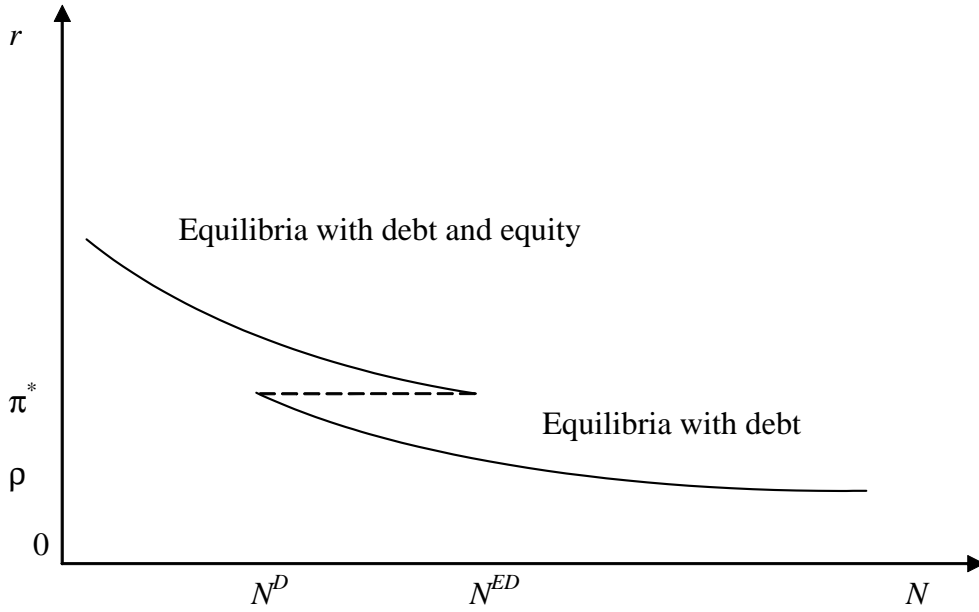


Figure 2: Equilibria structure. The graph shows the equilibrium interest rate on debt  $r$  as a function of the number of financial intermediaries  $N$ . Whenever  $r > \pi^*$ , an average firm with  $\pi < r$  is worth investing in ( $E(\pi|\pi < r) > \rho$ ); equity is issued in equilibrium. The dashed line denotes the unstable equilibria.

debt is pushed down, as a result the best firms in the equity-financed pool switch to debt financing (to borrow from the very same investor). Once the best firms leave the pool its average quality declines. The incentives to invest in equity lower and other investors also prefer to switch to debt finance. This positive feedback also explains why equilibria with  $r = \pi^*$  are unstable for  $N \in (N^D, N^{ED})$ . In such equilibria every investor is indifferent between investing in equity and not investing. When an investor decides to lend more, others follow suit and the system moves to an equilibrium with debt and low interest rate,  $r^D(N) < \pi^*$ . When an investor decides to cut lending interest rates go up, average quality of equity-financed firms improves, others invest more in equity and less in debt, and, as a result, the market moves to the debt-equity equilibrium with a high interest rate,  $r^{ED}(N) > \pi^*$ .

**Welfare analysis.** Whenever both equilibria coexist the equilibrium without equity is more efficient in terms of social welfare. In the equilibrium without equity efficient

firms with  $\pi \in (\rho, r^D(N))$  are not financed resulting in the deadweight loss of  $\int_{\rho}^{r^D(N)} (\pi - \rho) f(\pi) d\pi$ . In the equilibrium with equity investors cannot discriminate among firms within the equity pool,  $\pi \in [0, r^{ED}(N)]$ . As a result, inefficient firms  $\pi \in [0, \rho)$  are also financed resulting in the deadweight loss of  $\int_{\pi}^{\rho} (\rho - \pi) f(\pi) d\pi$ . The equilibrium without equity is less inefficient when the average firm that is denied financing should not have been financed in the first best:  $G(r^D(N)) < \rho$ . This condition is equivalent to  $r^D(N) < \pi^*$  which follows from the existence of the equilibrium without equity.

Certainly, the welfare results should not be interpreted literally as a call to outlaw equity financing. First, we assume away all the costs of debt. Second, it is very likely that due to imperfections in the primary markets for funds for the banks, their costs of funds  $\rho$  is above social cost of funds. Therefore when equity finance helps to implement projects with returns below  $\rho$ , it may actually be socially optimal.

**Example.** Consider  $f(\pi) = 1/(\bar{\pi} - \underline{\pi})$  for  $\pi \in [\underline{\pi}, \bar{\pi}]$ . Uniform distribution satisfies both assumptions A1 and A2, so there can be at most two stable equilibria: one with debt, and the other one with debt and equity. Indeed,  $G(\pi) = (\pi + \underline{\pi})/2$ ,  $\pi^* = 2\rho - \underline{\pi}$ ,  $N^{ED} = (\bar{\pi} - \rho)/(\rho - \underline{\pi})$ ,  $N^D = N^{ED} - 1$ . The equilibrium with debt financing exists whenever  $N \geq N^D$ , in this equilibrium the interest rate is  $r^D(N) = (N\rho + \bar{\pi})/(N + 1)$ ; the deadweight loss is  $(\bar{\pi} - \rho)^2 / [2(N + 1)^2(\bar{\pi} - \underline{\pi})]$ . The equilibrium with debt and equity financing exists whenever  $N \leq N^{ED}$ , the interest rate is  $r^{ED}(N) = ((N - 1)\underline{\pi} + 2\bar{\pi})/(N + 1)$ ; the deadweight loss is  $(\rho - \underline{\pi})^2 / [2(\bar{\pi} - \underline{\pi})]$ .

**Monopoly.** We do not consider the special case of monopolistic investor, but it is easy to show that it is formally equivalent to the solution above at  $N = 1$ . The only difference is that there are no multiple equilibria: the monopolist chooses the one which is best for him. If  $E\pi > \rho$ , the monopolistic equilibrium is one with equity  $P = 1$ ,  $r = \bar{\pi}$ ; actually there is no debt in this equilibrium. If  $E\pi < \rho < \bar{\pi}$ , there is debt and no equity:  $P < 1$ ,  $r = r^D(1)$ .

### 3.3 An example: Multiple equilibria with equity

This Section provides an example illustrating that once the assumptions A1 and A2 are relaxed, there can exist multiple equilibria of each type. In particular, it shows that there can be two equilibria with equity which differ in terms of both stock returns and amounts of equity financing.

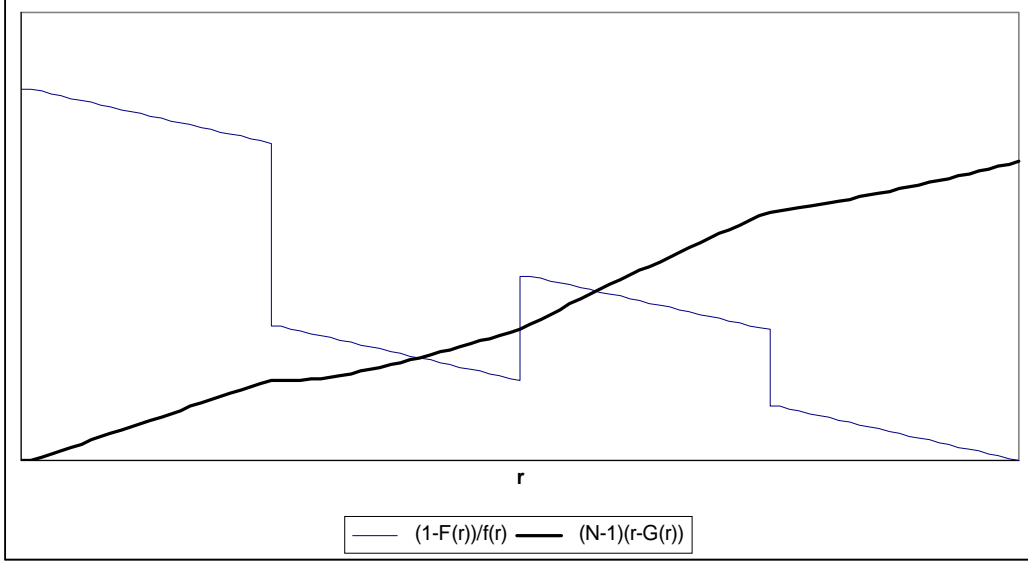


Figure 3: Multiple equilibria with equity. The thick line depicts the left-hand side of (5); the thin line is the right-hand side.

Suppose that  $\pi$  is distributed on  $[\underline{\pi}, \bar{\pi}]$  with the density function:

$$f(\pi) = \begin{cases} 0.6/(\bar{\pi} - \underline{\pi}), & \text{if } \underline{\pi} \leq \pi < 0.75\underline{\pi} + 0.25\bar{\pi} \\ 1.4/(\bar{\pi} - \underline{\pi}), & \text{if } 0.75\underline{\pi} + 0.25\bar{\pi} \leq \pi < 0.5\underline{\pi} + 0.5\bar{\pi} \\ 0.6/(\bar{\pi} - \underline{\pi}), & \text{if } 0.5\underline{\pi} + 0.5\bar{\pi} \leq \pi < 0.25\underline{\pi} + 0.75\bar{\pi} \\ 1.4/(\bar{\pi} - \underline{\pi}), & \text{if } 0.25\underline{\pi} + 0.75\bar{\pi} \leq \pi \leq \bar{\pi} \end{cases}$$

which does not satisfy the monotone hazard ratio property (see Figure 3).

The equilibrium with both debt and equity exists whenever a solution  $r^{ED}(N)$  to (5) exists and satisfies  $r^{ED}(N) > \pi^*$ . Since the monotone hazard ratio property does not hold, the solution may not be unique. Figure 3 shows that for  $N = 4$  there are two solutions  $r_1^{ED}(N) = \underline{\pi} + 0.40(\bar{\pi} - \underline{\pi})$  and  $r_2^{ED}(N) = \underline{\pi} + 0.58(\bar{\pi} - \underline{\pi})$ . If  $\rho < G(r_1^{ED}(N)) = \underline{\pi} + 0.24(\bar{\pi} - \underline{\pi})$  then either describes a stable equilibrium with debt and equity.<sup>6</sup>

The two stable equilibria have different interest rates on debt,  $r = r_1^{ED}(N)$  and  $r = r_2^{ED}(N)$  and, therefore, different average quality of equity-financed projects. The stock

<sup>6</sup>The equation (5) is essentially a first-order condition. One also needs to check whether  $r_{1,2}^{ED}(N)$  correspond to a global maximum for each investor. The second order conditions are equivalent to  $r - G(r)$  crossing  $(N-1)(1-F(r))/f(r)$  from below. We have also checked whether these local maxima are global. It turns out that in the example above each investor indeed chooses her globally optimal strategy  $D_i, E_i$  in either equilibrium  $r = r_1^{ED}(N), r = r_2^{ED}(N)$ .

returns are also different  $R_1 = G(r_1^{ED}(N)) = \underline{\pi} + 0.24(\bar{\pi} - \underline{\pi})$  and  $R_2 = G(r_2^{ED}(N)) = \underline{\pi} + 0.32(\bar{\pi} - \underline{\pi})$ . An equilibrium without equity also exists whenever  $\rho > \underline{\pi} + 0.21(\bar{\pi} - \underline{\pi})$ .

## 4 Extensions

This Section discusses several extensions of the model.

**Cournot vs. Bertrand competition.** We have assumed above that the investors compete a la Cournot. A model of Bertrand competition with differentiated goods would produce similar results but would be much more complex. One could also redefine our model as Bertrand competition in a two-stage framework along the lines of Kreps and Scheinkman (1983). Suppose that the financial intermediaries first have to precommit capacities (mostly human capital) for delivering services in debt and equity markets; in the second stage they compete a la Bertrand in stock and debt prices. This setup would be equivalent to our model; the choice of capacities is exactly the choice of  $D_i$  and  $E_i$ . In the first stage, the intermediaries may set  $D_i$  and  $E_i$  as high as they wish, but in the second stage, they cannot go beyond these pre-committed capacities (or they can only at a marginal cost of resources being much higher than  $\rho$ ).

**Positive payoff to equity issuers.** The fact that the equity issuing firms obtain trivial payoff and are indifferent between issuing equity and shutting down is an artefact of the simple setup. One could consider a model with an outside option: suppose that if the firm does not invest, its owner-manager can earn a reservation utility  $\Pi > 0$ . Then the equilibrium with equity would involve the payoff of  $\Pi$  to the firm. The capital structure choice would be as follows. If  $P < 1 + \Pi/r$  then there is no equity financing: good firms ( $\pi > r + \Pi$ ) borrow, others do not invest. If  $P > 1 + \Pi/r$ , the choice is even richer: best firms ( $\pi > rP$ ) borrow, intermediate firms ( $\pi \in (\Pi P/(P-1), rP)$ ) issue equity, the least profitable firms ( $\pi < \Pi P/(P-1)$ ) do not invest. Therefore the market demand for debt is  $D = 1 - F(\max\{r + \Pi, rP\})$ , and the market demand for equity is  $F(rP) - F(\Pi P/(P-1))$  if  $P > 1 + \Pi/r$  and zero otherwise. These functions have the same features that drive our results: (i) the better firms issue debt rather than equity, and (ii) the higher the interest rate on debt, the more firms switch from debt to equity.

**Continuous choice of capital structure.** Our model allowed only a binary choice of capital structure: either debt or equity. If the firms can choose any combination of

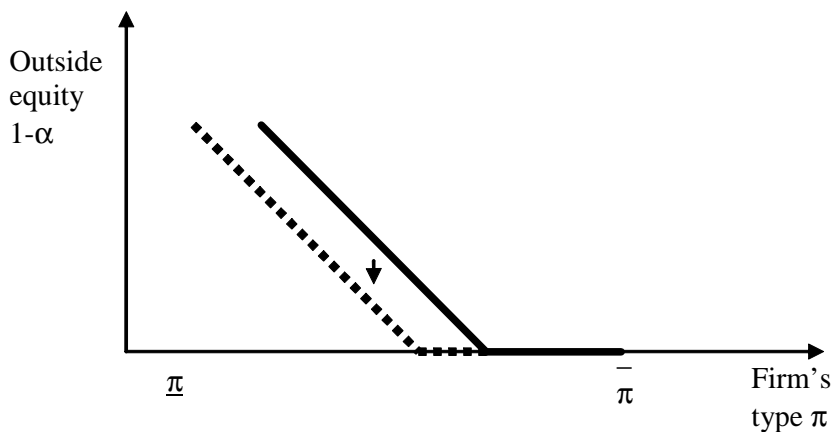


Figure 4: Strategic complementarity in a setting with continuous choice of capital structure. In any equilibrium, better firms issue (weakly) more debt. As interest rate goes down, each firm reduces its reliance on equity finance. Therefore, for any given capital structure  $\alpha$ , investors expect a lower type  $\pi$  and therefore lower returns to equity investment.

debt and equity, capital structure provides investors with a more informative signal of the firm's type. As better firms use more debt, investors will price higher the stock of firms with lesser reliance on outside equity. Yet, the strategic complementarity discussed above is still present. If one investor wants to lend more, the interest rates on debt are driven down, and each firm issues (weakly) less equity. Therefore given any capital structure  $x$ , the return on equity is now lower. As shown in Figure 4, the firm of a type  $\pi$  that used to issue  $x$  outside equity, now wants to issue  $x - dx$  shares only; in the meanwhile  $x$  shares are issued by a less productive firm  $\pi - d\pi$ . Hence, if one investor lends more, it provides other investors with incentives to adjust their portfolios in favor of debt. Appendix B provides a formal treatment of this signalling game.

**Agency costs and incentives.** If the value of the firm depends on the manager's effort chosen after financing, then the firms that issue more outside equity will be priced further down by the stock market due to the agency costs. Now the strategic interaction between investors becomes more complex, yet the strategic complementarity still persists. As one investor purchases less debt, an increased interest rate drives marginal firms from debt to equity financing. While the value of the marginal firm is negatively affected by

the agency costs, the average quality of equity financed project improves. Thus other investors also move away from debt. In Appendix B we formally introduce agency costs in our model.

**Costs of financial distress.** For simplicity, we have assumed away costs of debt financing. If the firm faces the incentive effects of debt overhang, or costs of financial distress and inefficient litigation, or costs of intermediated bank lending (as in Bolton and Freixas, 2000), in any equilibrium some firms will use both debt and equity. Yet, as the structure of sorting does not change (better firms prefer more debt), the main result will remain intact.

**Observed heterogeneity.** The pecking-order theory intuition that equity is suboptimal to debt predicts that better and safer firms use debt while firms that are denied debt financing or those that have already borrowed too much, resort to equity. In real world, there are other factors that determine the choice of capital structure. Given that equity finance involves a fixed cost of issue, larger firms are more likely to opt for stock market. At the same time, the larger firms may also have safer returns, so the sign of correlation between capital structure and source of funding may change. Still, our model would be relevant suggesting that among the firms with the same *observed* characteristics (such as size or sector), the ones that prefer debt are probably the ones with better prospects (this is consistent with empirical evidence surveyed in Myers, 2000).

## 5 Conclusions

This paper studies a model of imperfect competition in financial markets with endogenous capital structure. The model builds on the pecking order theory that assumes that firms are better informed about their growth opportunities than outside investors. An issue of equity sends investors a negative signal about the firm's quality; the cost of equity financing is always higher than that of debt finance. Therefore, in the absence of the costs of financial distress the firms should finance their investment via internal funds or debt. Such conclusion, however, hinges on the assumption that financial markets are perfectly competitive, so that all the imperfections of equity finance are automatically passed back to the firm in the form of a higher cost of capital.

We show that when financial markets are concentrated this does not have to be the case: returns on equity and debt may differ. In the presence of oligopoly in financial

markets some firms issue equity even if there are no costs associated with debt financing. The intuition is straightforward: oligopolistic financial intermediaries set interest rate on debt above their cost of funds. Hence, there are firms that would be financed in perfectly-competitive economy but who cannot afford to borrow under oligopoly. The intermediaries are happy to finance these firms but do not like to lower interest rates for their more profitable debtors. Capital structure emerges as an effective tool for the (second degree) price discrimination: the most profitable firms prefer to be financed via debt rather than switch to equity.

An important implication of our analysis is the multiplicity of equilibria due to strategic interaction between oligopolistic financial intermediaries. The intermediaries' portfolio choices are strategic complements: if one intermediary moves from debt- to equity-holding, others find it profitable to follow. When a large investor reduces lending and invests more in equity, interest rate on debt goes up. Therefore, some firms that used to be financed via debt have to switch to equity financing. As the marginal equity-financed firms are always better than the average equity-financed firms, this improves the expected returns on equity. Therefore investing in equity becomes relatively more attractive to other investors as well. The strategic complementarity results in multiplicity of equilibria. The latter in turn may explain the volatility of stock returns, and stock market crashes. Strictly speaking, there are no bubbles in the model: investors price each stock based on the rationally updated expectations of this stock's returns. However, the returns are endogenous and are not uniquely determined given the multiplicity of equilibria. Our model suggest that stock crashes can occur even if there are no bubbles. Certainly, in order to fully explore the stock price dynamics, one has to build a multi-period setup which is an exciting avenue for further research.

While we develop implications for the volatility in a public stock market, our model if taken literally is a model of an entrepreneur raising capital for a new project. While our intuition is not constrained to this case, a few formal extensions are due to make the argument more convincing: first, consider the case with existing assets, second, consider secondary markets for stocks, third, introduce a conflict between management and initial shareholders (Dybvig and Zender, 1993, showed the implications of the latter for the validity of the pecking order theory).

## Appendix A: Proofs

PROOF OF PROPOSITION 1.

*Equilibria without equity.*

Suppose that the equilibrium price of equity is low,  $P < 1$ . Then, no equity is issued and the equilibrium is a standard equilibrium of a single-product oligopoly. The inverse demand function implies  $dr/dD_i = -1/f(r)$ . The first order condition for investor  $i$  is

$$(r - \rho) - D_i/f(r) = 0$$

Summing up across investors  $i = 1, \dots, N$  and dividing by  $N$ , we obtain (4). A1 implies that the right-hand side of (4) decreases in  $r$ , hence there exists a unique solution denoted by  $r^d(N)$ . Clearly,  $r^d(N)$  decreases with  $N$  and as  $N \rightarrow \infty$ , the solution approaches the perfectly competitive one,  $r^d(N) \rightarrow \rho$ .

This equilibrium exists whenever no investor could benefit from equity investment. Hence,  $E_i$  must be an optimal strategy for every  $i$ . This is the case whenever the average quality of stock of firms that are not issuing debt is below the marginal cost of funds  $R = G(r) \leq \rho$ . Thus, the equilibrium exists whenever  $r^d(N) \leq \pi^*$  which is equivalent to  $N \geq N^D$ .

*Equilibria with equity.*

Suppose that  $P \geq 1$ , so firms with  $\pi \leq rP$  may issue equity. First, we will show that  $P > 1$  cannot hold in equilibrium. Suppose that there is an equilibrium with  $P = \tilde{P} > 1$ , and  $r = \tilde{r}$ . Then the following conditions should hold: (i)  $\sum_{i=1}^N D_i + \sum_{i=1}^N E_i = 1$ , (ii)  $\sum_{i=1}^N D_i = 1 - F(rP)$ ; (iii) there is an investor  $i$  who holds non-trivial equity position  $E_i > 0$ . We will argue that this investor will always have incentives to reduce her investment in equity. Even a small decrease in equity investment results in a discrete drop in stock price from  $\tilde{P}$  to 1. Since the supply of debt funding  $\sum_{i=1}^N D_i$  does not change, the interest rate on debt will adjust accordingly to  $r = \tilde{r}\tilde{P}$  so that  $D_i + D_{-i} = 1 - F(\tilde{r}\tilde{P})$  remains the same. Then the investor  $i$ 's payoff will increase: the first term in (2) will not change, while the second one will certainly increase: the decline in  $E_i$  is infinitesimal, while  $R$  jumps from  $G(\tilde{r}\tilde{P})/\tilde{P}$  to  $G(\tilde{r}\tilde{P})$ . Therefore equilibria with equity can only exist under  $P = 1$ .

There can be two types of equilibria  $P = 1$ : with full investment  $\sum_{i=1}^N D_i + \sum_{i=1}^N E_i = 1$  and rationed investment  $\sum_{i=1}^N D_i + \sum_{i=1}^N E_i < 1$ . Let us first consider the equilibria with full investment. Then investor  $i$  maximizes  $rD_i + G(r)E_i$ . The first-order condition

is

$$0 = r - G(r) - \frac{1}{f(r)} (D_i + G'(r)E_i)$$

Summing up and using  $G'(x) = (x - G(x))f(x)/F(x)$  we obtain (5). Under the assumptions A1 and A2, the left-hand side increases in  $r$  while the right-hand side decreases in  $r$ . Hence the solution  $r^{ED}(N)$  is unique and (as it is easy to show) decreases in  $N$ .

Full investment  $D_i + E_i = 1 - (D_{-i} + E_{-i})$  is an equilibrium strategy if and only if the maximum investment in equity is optimal. In other words, the return on equity should be above the cost of funds:  $R = G(r^{ED}(N)) \geq \rho$ . In other words,  $r^{ED}(N) \geq \pi^*$  which is equivalent to  $N \leq N^{ED}$ .

The last type of equilibria is the one with debt and equity where some firms do not undertake the project. This occurs when  $P = 1$  but  $D_i + E_i < 1 - (D_{-i} + E_{-i})$ . The investors are indifferent about buying more equity. This may happen only if  $G(r) = \rho$ , or  $r = \pi^*$ . In this equilibrium, the first order condition for  $D_i$  is as follows:

$$(r - \rho) - \frac{1}{f(r)} (D_i + G'(r)E_i) = 0$$

Adding up for  $i = 1, \dots, N$  we obtain

$$N(r - \rho) - \frac{1 - F(r)}{f(r)} - (r - G(r)) \frac{\sum_{i=1}^N E_i}{F(r)} = 0$$

After substituting  $r = \pi^*$

$$\sum_{i=1}^N E_i / F(\pi^*) = N - \frac{1}{r - \rho} \frac{1 - F(r)}{f(r)}$$

The equilibrium exists whenever  $0 < \sum_{i=1}^N E_i < F(\pi^*)$ . One can easily check that the left inequality is equivalent to  $N > N^D$ , while the right inequality is equivalent to condition is equivalent to  $N < N^{ED}$ .

## Appendix B: General model

In this section, we add two ingredients to the model: we introduce agency costs and allow for any combinations of debt and equity. We set up the model, introduce the equilibrium concept, and show that there is a strategic complementarity similar to the one in the main model. As one investor buys more debt, the interest rate goes down, better firms switch to debt. Hence quality of equity goes down, and other investors have incentives to sell equity and buy debt.

**Production technology.** The firm's profit  $\pi$  is uncertain; its distribution depends on the manager's effort. There are two outcomes: "low"  $\pi = \pi^L > 0$  and "high"  $\pi = \pi^H = \pi^L + \delta$ , where  $\delta > 0$ . The manager's effort is measured in terms of probability of achieving the high outcome.

The cost of effort depends on the manager's type  $\theta$ ; the cost is  $\delta C(e, \theta)$ , where  $C_e \geq 0, C_e(0, \theta) = 0, C_{ee} > 0, C_\theta < 0, C_{e\theta} < 0$ . The type (productivity)  $\theta$  is distributed on  $[0, \infty]$  with c.d.f.  $F(\theta)$ . We assume an internal maximum; in other words, the parameters are such that even the first best choice of effort (probability  $e$  that solves  $C_e(e, \theta) = 1$ ) is in  $[0, 1]$  for all  $\theta$ .

**Financial contracts.** The firm needs to raise one unit of capital via issuing debt, equity or a combination of the two. Given the price of debt  $p = 1/r$  (dollars raised per dollar to be repaid) and price of equity is  $P$  (in dollars per 100 percent of cash flows), the firm borrows  $D \geq 0$  and issues  $1 - \alpha$  shares. The budget constraint is as follows:

$$(1 - \alpha)P + D \geq 1. \quad (6)$$

Given the profit is  $\pi^i, i = L, H$ , the firm pays  $rD$  to creditors and  $(1 - \alpha)(\pi^i - rD)$  to outside shareholders keeping  $\alpha(\pi^i - rD)$  for itself.

In what follows we assume that  $r < \pi^L$  in equilibrium so there are no bankruptcies. Under limited liability we only need to consider contracts with  $D \leq \pi^L$ . Any contract with  $\alpha \in [0, 1]$  and  $D > \pi^L$  can be replicated by a contract with  $\tilde{D} = \pi^L$  and  $\tilde{\alpha} = \alpha\delta^{-1} [\pi^H - D]_+$ .

**Effort choice.** The firm maximizes

$$\Pi = \alpha(\pi^L - rD)(1 - e) + \alpha(\pi^H - rD)e - \delta C(e, \theta) = \alpha\pi^L - \alpha rD + v(\alpha, \theta)\delta \quad (7)$$

where

$$v(\alpha, \theta) = \max_{e \in [0, 1]} [\alpha e - C(e, \theta)]$$

Using the envelope theorem (or monotone comparative statics), one can easily prove that  $v_\alpha \geq 0, v_\theta \geq 0, v_{\alpha\alpha} \geq 0, v_{\alpha\theta} \geq 0$  (the single crossing property holds).<sup>7</sup> We denote  $e^*(\alpha, \theta)$  the solution to  $\alpha = C(e, \theta)$ . The effort level  $e^*(\alpha, \theta) = v_\alpha(\alpha, \theta)$  (weakly) increases both in type  $\theta$  and in the share of equity  $\alpha$  kept by the manager.

If the firm does not undertake the project, the manager gets her reservation value  $\underline{u}$ .

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<sup>7</sup>If  $C(e, \theta) = e^2/(2\theta)$  then  $v(\alpha, \theta) = \theta\alpha^2/2$ .

Since incentives depend on the capital structure  $\alpha$ , the investors will certainly expect lower returns on equity of firms with higher outside equity  $1 - \alpha$ . Therefore, the stock price  $P$  should depend on the capital structure  $\alpha$  as well. Since there are no bankruptcies, the rate of return on debt will be the same for all firms (a dollar invested in debt always brings  $r$  dollars whoever the borrower is).

**Equilibrium.** The definition of equilibrium extends the one in the basic model. An investor  $i$  chooses a strategy  $\{D_i, E_i(\cdot)\}$ , where  $D_i$  is the amount of money that  $i$  invests in debt, and  $E_i(\alpha)$  is the investment in equity of firms with capital structure  $\alpha$ . Each investor chooses her strategy given strategies of others and the inverse demand functions. The inverse demand functions determine the price of debt  $1/r$  and the price of equity for each capital structure  $P(\alpha)$  as functions of overall investment in debt and in equity of firms with each capital structure.

Hence investor  $i$  solves

$$\max_{D_i, E_i(\cdot)} (r - \rho)D_i + \int_0^1 E_i(\alpha) \left[ \frac{\pi^L + \delta v(\alpha, \theta(\alpha))}{P(\alpha)} - \rho \right] d\alpha$$

where  $\theta(\alpha)$  is the equilibrium correspondence between firms' types and capital structures;  $r$  and  $P(\alpha)$  are inverse demand functions of  $D_i + D_{-i}$  and  $E_i(\alpha) + E_{-i}(\alpha)$ .

**Demand for finance.** Under given  $r$  and  $P(\alpha)$ , a firm of type  $\theta$  chooses  $\alpha \in [0, 1]$  and  $D \geq 0$  to maximize (7) subject to the budget constraint (6). The latter is always binding so we can solve for  $D = 1 - P(\alpha)(1 - \alpha)$ . Now the firm chooses  $\alpha \in [0, 1]$  to maximize

$$u = \alpha\pi^L - r\alpha + r\alpha(1 - \alpha)P(\alpha) + \delta v(\alpha, \theta). \quad (8)$$

subject to

$$[1 - 1/P(\alpha)]_+ \leq \alpha \leq 1,$$

and its participation constraint  $u \geq \underline{u}$ .

For each  $\theta$  this problem has a solution  $\alpha^*(\theta, r, P(\cdot))$ . The single crossing condition  $v_{\alpha\theta} \geq 0$  implies that more productive firms issue less outside equity:  $\partial\alpha^*/\partial\theta \geq 0$ . Let us denote  $\theta_1$  the solution to  $\alpha^*(\theta, r, P(\cdot)) = 1$ . Apparently, all firms with  $\theta > \theta_1$  are financed exclusively through debt.

It is also clear that the higher the interest rate  $r$ , the less debt is issued  $D_r^* \leq 0$ . This creates a strategic complementarity similar to one that drives the multiplicity of equilibrium in the basic model. Suppose that one investor decides to lend more. This

drives interest rate  $r$  down. Therefore the investor's expected return on stock with any given capital structure should decline. For  $\alpha^*(\theta, r, P(\cdot))$  to remain constant an increase in  $r$  must be accompanied with decrease in  $\theta$ . Investors know that under a higher interest  $r$ , a company that issues  $1 - \alpha$  shares must be of a lower type (see Figure 4). The investors' return on each share is  $(1 - \alpha)(\pi^L - rD) + \delta(1 - \alpha) E\{v(\alpha, \theta) | \alpha = \alpha^*(\theta, r, P(\cdot))\}$  which increases in  $\theta$ . Thus, if one investor shifts from equity to debt, the incentives of others to invest in equity may also decline. Yet, unlike in the model of the previous section, we also need to check for change in stock price  $P(\alpha)$  in response to lower interest rate. This is what is done below.

**Solving for inverse demand functions.** We will find  $r$  and  $P(\alpha)$ —price of debt and price of stock of firm with capital structure  $\alpha$ —given total amount borrowed  $D = \sum_i D_i$  and total funds raised via issues of equity by firms with the same capital structure  $E(\alpha) = \sum_i E_i(\alpha) \geq 0$  (we naturally assume  $E(1) = 0$ ). We will also solve for the (weakly monotonic) correspondence between firm's type and capital structure  $\alpha(\theta)$ .

First, we can find the lowest type that is financed  $\underline{\theta}$ . By definition, this type has capital structure  $\underline{\alpha} = \inf\{\alpha : E(\alpha) > 0\}$ . The total amount of debt and equity financing must be equal to investment per firm (one unit) times the number of firms financed  $(1 - F(\underline{\theta}))$ . Therefore

$$1 - F(\underline{\theta}) = D + \int_{\underline{\alpha}}^1 E(\alpha) d\alpha \quad (9)$$

The total number of firms with capital structure  $\alpha$  issuing equity is  $\frac{E(\alpha)d\alpha}{P(\alpha)(1-\alpha)}$ . Therefore we can find the correspondence between types and capital structures  $\alpha(\theta)$  in equilibrium

$$F(\theta) = F(\underline{\theta}) + \int_{\underline{\alpha}}^{\alpha(\theta)} \frac{E(x)dx}{P(x)(1-x)} \text{ for all } \theta \in (\underline{\theta}, \theta_1) \quad (10)$$

The firm  $\theta$  maximizes (8) with regard to  $\alpha$ . For all  $\theta \in (\underline{\theta}, \theta_1)$ , the first order condition is as follows:  $0 = \pi^L - r + \frac{d}{d\alpha} [r\alpha(1 - \alpha)P(\alpha)] + \delta v_\alpha(\alpha, \theta)$ . Integrating the latter with regard to  $\theta$ , we obtain the standard incentive compatibility constraint  $u(\theta) = u(\theta_1) - \delta \int_{\theta}^{\theta_1} v_\theta(\alpha(\vartheta), \vartheta) d\vartheta$ . Substituting (8) into both sides of the equation, we find the price of equity

$$P(\alpha(\theta)) = \frac{(\pi^L - r)(1 - \alpha(\theta)) + \delta \left[ v(1, \theta_1) - v(\alpha(\theta), \theta) - \int_{\theta}^{\theta_1} v_\theta(\alpha(\vartheta), \vartheta) d\vartheta \right]}{r\alpha(\theta)(1 - \alpha(\theta))} \quad (11)$$

for all  $\theta \in (\underline{\theta}, \theta_1)$ .

The remain two conditions. First, the lowest participating type's payoff is equal to her reservation utility:

$$u(\underline{\theta}) = \pi^L - r + \delta v(1, \theta_1) - \delta \int_{\underline{\theta}}^{\theta_1} v_{\theta}(\alpha(\vartheta), \vartheta) d\vartheta = \underline{u}. \quad (12)$$

Second, the lowest participating type's capital structure is the lowest one financed:

$$\alpha(\underline{\theta}) = \underline{\alpha} = \inf\{\alpha : E(\alpha) > 0\} \quad (13)$$

Therefore, given the strategies of the investors  $D$  and  $E(\alpha)$ , conditions (9)-(13) determine  $\alpha(\theta)$ ,  $P(\alpha)$ ,  $r$ ,  $\underline{\theta}$ , and  $\theta_1$ .

**Strategic complementarity.** For the brevity's sake we do not discuss existence or uniqueness of equilibrium. We only establish that the general model has the same strategic complementarity property as the basic model. In particular as aggregate lending  $D$  increases, the return on equity investment  $R(\alpha) = E_{\theta} \left( \frac{\pi^L + \delta v(\alpha, \theta)}{P(\alpha)} \mid \alpha = \alpha(\theta) \right)$  declines for each capital structure  $\alpha$ .

**Proposition 2** *If  $E(\alpha)$  is constant, an increase in  $D$  results in lower  $r$  and lower return on equity investment  $R(\alpha)$  for each  $\alpha \in [0, 1]$*

The proof is intuitive. First, it is easy to show that given equity investment  $E(\alpha)$  an increase in lending  $D$  cannot result in higher interest  $r$ . Therefore, interest rate decreases, and each type borrows more issuing less outside equity. Thus, the curve  $1 - \alpha(\theta)$  shifts (Figure 4) down. Since incentive compatibility implies that  $1 - \alpha(\theta)$  is weakly decreasing, this curve also shifts left (i.e. for a given  $\alpha$  the type  $\theta$  that solves  $\alpha = \alpha(\theta)$  is now lower). Therefore  $\delta v(\alpha, \theta)$  decreases for a given  $\alpha$  and  $\theta$  such that  $\alpha = \alpha(\theta)$ . Straightforward calculations show that as  $r$  decreases, the price of equity (11) must increase. Hence the return on equity decreases.

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