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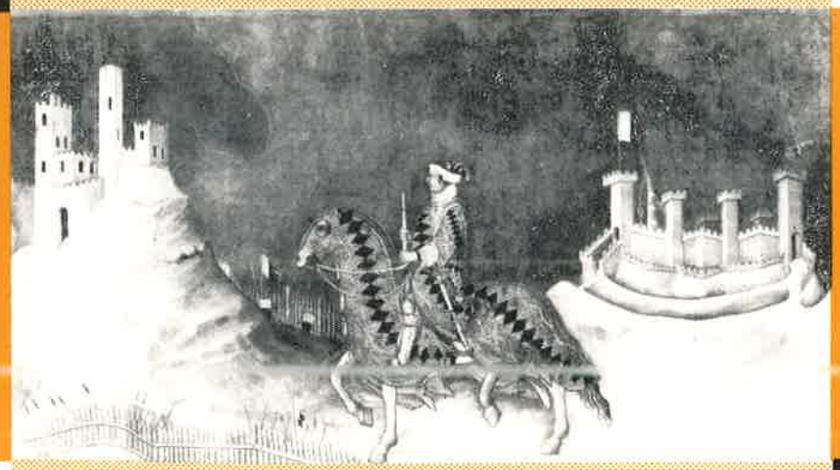
THE EXPECTED COST OF CAPITAL: PRIVATE VS. PUBLIC DEBT PLACEMENTS



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THE EXPECTED COST OF CAPITAL: PRIVATE VS. PUBLIC DEBT PLACEMENTS

Abstract. This paper investigates and compares the cost of capital for a firm that can choose between private, bilateral, borrowing relationships and direct debt issues on the market. We model private debt placements with lenders setting the interest rate and public placements as an auction where firms pre-specify the contractual conditions. The analysis is developed within a framework where potential lenders assess the firm's type through signals which are informative only on average. We find that, while market borrowing eliminates monopolistic profits generated by bilateral relations it is however characterised by interest rates which are increasing in the number of potential bidders. A main conclusion is that firms are more likely to place their debt publicly when the economy is flourishing.

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Siena, dicembre 1994

THE EXPECTED COST OF CAPITAL: PRIVATE VS. PUBLIC DEBT PLACEMENTS

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1. Introduction.

Some recent literature has investigated the advantages and the disadvantages that firms have in raising funds either through bilateral relations, as it is generally the case with banks, or through security issues on the financial market, with the borrower specifying the contract conditions[1].

The present paper offers a motivation for the preference between privately intermediated debt and market issues which hinges on informational problems affecting both the cost of credit (when received) and the likelihood of being financed at all.

In an economy where both "good" and "bad" firms apply for capital, each potential lender formulates an assessment of a certain firm. Such assessments on firm's quality, which we will call for pure convenience *signals*, are costless and informative *only on average* (see Broecker (1990)): the possibility exists that, ex-post, a bad firm is perceived as good and vice-versa. If a lender observes a bad signal, no contract will be offered. However, conditionally to having observed a good signal, an investor *may* be willing to lend. The two main borrowing technologies analysed are: (i) bilateral firm-lender relationships, in which the firm places *privately* its debt and (ii), debt issues at pre-specified contractual conditions, *publicly* auctioned by the firm.

In the first regime, lenders are treated as price-competitors, setting unilaterally the credit cost conditions. When approaching an individual lender, the firm is subject to his monopolistic

power generated by the signal.

On the other side, in the auction regime, the firm may design a debt contract so to induce the potential lenders to bid for it.

One of the main results obtained is that market financing destroys monopolistic profits available to lenders when debt is privately placed. Market financing, however, is subject to costs generated by "excessive" bidding: when many informed bidders take part in an auction, expected gains are reduced. So, the higher the number of potential lenders, the higher the interest rate a firm must promise in order to induce participation.

As a consequence, when bilateral lender-firm relations produce sufficiently low credit costs and the number of potential lenders is high, private debt placements may be preferred to public debt placements. Moreover, "excessive" bidding can produce, for public debt issues, the equivalent of "underpricing" for shares in IPO's[2].

The structure of the paper is the following. In Sects. 2-3, we set up the model, initially considering two lenders competing for a firm. Under bilateral relations, lenders' private information can produce "weak" price competition (Sect.4). In particular, no matter which concept of equilibrium we use (Nash in mixed strategies or leader-follower price setting), the pricing policy is less aggressive when firms' returns are higher. Sect.5 deals with the case of public placements of debt.

In evaluating the firm's net expected profit under the two alternative regimes (Sect.6), we obtain that a high-value firm prefers public to private debt issues when its returns are sufficiently high[3].

We then extend our analysis to the case of $N>2$ lenders (Sect.7). With three or more potential lenders, the cost of credit under bilateral lender-firm relations is drastically reduced, while the negative effect generated by excessive market participation tends to reduce the benefits of public placements.

Finally, in Sect.8, we comment on the analysis of previous sections. This allows us to discuss the firm's preference between borrowing regimes over economic cycles and at inter-sectoral level.

2. Structure of the Model.

Lenders and firms are assumed to be risk-neutral. A firm in the economy can be "high-value" with probability α and "low-value" with probability $1-\alpha$. The return of a high-value firm is $V^H>0$, while the return for a low value firm is V^L. For convenience, we shall take V^L equal to zero.

The firm has no capital. Each lender i ($i=1,2$) has access to an unlimited quantity of capital at zero cost and may decide to lend $I>0$, where I is the cost of the firm's investment project.

Firms know their own type. Each lender has some *private* (and costless) information about a firm's worthiness, which we model as a signal, e_i. The signal suggests that either the firm is a high-value one ($e_i=G$), or that the firm is low-value ($e_i=B$). In particular,

$$Pr(e_i=G \mid V^H) = \beta, \quad Pr(e_i=G \mid V^L) = \theta \qquad (i=1,2) \tag{1}$$

where $\beta \in (1/2;1)$ is the probability of receiving a good signal, conditionally to the firm being actually "good", while $\theta \in (0,1/2)$ is the probability of receiving a good signal when the firm is "bad". Hence, signal e_i is *informative*, namely $\theta < \beta$.

Finally, we define D_i to be the amount of debt repayment required by lender i against a loan of amount I.

DEFINITION 1 *(Contract Feasibility). A contract D is said to be feasible if it satisfies the following condition:*

$$V^H - D \geq I \tag{2}$$

Indeed, the entrepreneur of a firm has always the opportunity of not implementing the project and to "run away" with I. Consequently, each debt contract requiring D as debt repayment must satisfy (2), which can be seen as an incentive constraint.

3. Break-Even Loan Contracts.

In this section we describe the loan contracts yielding zero expected profit, since they represent the basics for the ensuing analysis.

We consider a firm engaging in bilateral relations with each individual lender.

Similarly to Broecker (1990) the timing is the following. Each lender has two options: either he can decide to leave the market and not to provide credit on any condition, or he can stay in the market and announce his credit price policy (D_i, for lender i). Then, every firm applies for a loan only to those lenders who are willing to lend.

After receiving an application, each lender i makes his assessment of the firm, modelled as a *privately* observed signal e_i. Conditionally on e_i, lender i can decide whether to reject the firm's application or not. An offer, as well as a rejection, cannot be observed by the other lender, lender j.

DEFINITION 2 *(Tie-break Rule). When both lenders offer a loan and $D_1=D_2$, the firm will choose lender 1.*

Define $E\Phi^i$ to be the expected profit for lender i. We assume that a lender in the market will lend only if $e_i=G$. When offering a loan, lender i knows that, either:

$$E\Phi^i\big|_{D_i<D_j} = Pr(V^H|e_i=G)[D_i-I] + Pr(V^L|e_i=G)[V^L-I] = \\ = \frac{\alpha\beta}{\alpha\beta+\theta(1-\alpha)} D_i - I \tag{3}$$

holding either when $D_i<D_j$ ($D_i \leq D_j$, if and only if i=1), or whenever bank j *stays out of the market*. Or:

$$E\Phi^i|_{D_i>D_j} = Pr(e_j=B)\left\{Pr(V^H|e_i=G,e_j=B)[D_i-I]+Pr(V^L|e_i=G,e_j=B)[V^L-I]\right\} =$$

$$=(\alpha(1-\beta)+(1-\theta)(1-\alpha))\left\{\frac{\alpha\beta(1-\beta)}{\alpha\beta(1-\beta)+\theta(1-\theta)(1-\alpha)}D_i-I\right\} \quad (4)$$

when $D_i>D_j$ ($D_i\geq D_j$, if i=2).

Some explanation over (4) is in order. Since $D_i>D_j$, lender i is aware that a firm accepting D_i has been denied a loan by j: this entails that e_j=B. In other words, by pursuing a policy of high credit price, i can infer the signal observed by j.

We now characterise the break-even contracts. Consider first $D_i<D_j$. From (3), we obtain the break-even contract Δ^G, which gives i zero expected profit. Hence, Δ^G solves $E\Phi^i|_{Di<Dj}=0$:

$$Pr(V^H|e_i=G)[\Delta^G-I]+Pr(V^L|e_i=G)[V^L-I]=0 \quad (5)$$

Applying the Bayes' rule

$$Pr(V^H|e_i=G)=\frac{Pr(e_i=G|V^H)Pr(V^H)}{Pr(e_i=G)}=\frac{\beta\alpha}{\beta\alpha+\theta(1-\alpha)} \quad (6)$$

$$Pr(V^L|e_i=G)=\frac{Pr(e_i=G|V^L)Pr(V^L)}{Pr(e_i=G)}=\frac{\theta(1-\alpha)}{\beta\alpha+\theta(1-\alpha)} \quad (7)$$

since

$$Pr(e_i=G)=Pr(e_i=G|V^H)Pr(V^H)+Pr(e_i=G|V^L)Pr(V^L)=\beta\alpha+\theta(1-\alpha) \quad (8)$$

Since V^L=0,

$$\Delta^G=\left(1+\frac{\theta(1-\alpha)}{\alpha\beta}\right)I \quad (9)$$

In what follows, Δ^G is always assumed to be feasible, namely $\Delta^G\leq V^H$-I.

Notice that Δ^G is higher (i) the higher θ and the lower is β (the degree of inaccuracy of e_i), (ii) the lower α (the fraction of high-value firms in the economy).

Take now $D_i>D_j$. Lender i knows that an applicant accepting his offer must have been rejected by j, i.e., e_j=B. The break-even contract must then be conditional on the information set $\{e_i=G,e_j=B\}$. Defining Δ^{GB} to be the corresponding break-even contract and using (4), we can obtain it by solving $\Phi^i|_{Di>Dj}=0$, namely:

$$Pr(V^H|e_i=G,e_j=B)[\Delta^{GB}-I]+Pr(V^L|e_i=G,e_j=B)[V^L-I]=0 \quad (10)$$

Assuming *conditional independence*[4] for (e_1,e_2) and using Bayes' rule[5]:

$$Pr(V^H|e_i=G,e_j=B)=\frac{Pr(e_i=G,e_j=B|V^H)Pr(V^H)}{Pr(e_i=G,e_j=B)}=\frac{\beta(1-\beta)\alpha}{\beta(1-\beta)\alpha+\theta(1-\theta)(1-\alpha)} \quad (11)$$

$$Pr(V^L|e_i=G,e_j=B)=\frac{Pr(e_i=G,e_j=B|V^L)Pr(V^L)}{Pr(e_i=G,e_j=B)}=\frac{\theta(1-\theta)(1-\alpha)}{\beta(1-\beta)\alpha+\theta(1-\theta)(1-\alpha)} \quad (12)$$

Then:

$$\Delta^{GB} = \left(1 + \frac{\theta(1-\theta)(1-\alpha)}{\beta(1-\beta)\alpha}\right) I \qquad (13)$$

For completeness, we can define the break-even contract Δ^{GG}, conditional on $(e_1,e_2)=(G,G)$, as:

$$Pr(V^H|e_1=G,e_2=G)[\Delta^{GG}-I] + Pr(V^L|e_1=G,e_2=G)[V^L-I] = 0 \qquad (14)$$

Then (see Appendix A1):

$$\Delta^{GG} = \left(1 + \frac{\theta^2(1-\alpha)}{\beta^2\alpha}\right) I \qquad (15)$$

Analogously, $\Delta^{B}=\{1+(1-\theta)(1-\alpha)/[(1-\beta)\alpha]\}I$ and $\Delta^{BB}=\{1+(1-\theta)^2(1-\alpha)/[(1-\beta)^2\alpha]\}I$.

It follows that:

$$\Delta^{GG} < \Delta^{G} < \Delta^{GB} < \Delta^{B} < \Delta^{BB} \qquad (16)$$

We will assume that Δ^{B} and Δ^{BB} are *never feasible*.

4. Strategic Competition between Lenders When Debt is Privately Placed.

The break-even debt contract analysis abstracts from any strategic consideration about lenders' competition. In what follows, we model competition under two different strategic perspectives.

Consider (3)-(4), and notice that (4) is non-negative if and only if Δ^{GB} is feasible. It is useful to calculate the expected profit in (4) for the maximum level of D_i satisfying the

feasibility constraint, namely for $D_i=V^H-I$. We then obtain:

$$E\Phi^i|_{D_i=V^H-I>D_j} = Pr(e_j=B)\{Pr(V^H|e_i=G,e_j=B)[V^H-2I] + Pr(V^L|e_i=G,e_j=B)[V^L-I]\} = \qquad (17)$$

$$=(\alpha(1-\beta)+(1-\theta)(1-\alpha))\left\{\frac{\alpha\beta(1-\beta)[V^H-I]}{\alpha\beta(1-\beta)+\theta(1-\theta)(1-\alpha)} - I\right\}$$

Notice that $D_i=V^H-I$ is the optimal choice of i, when $D_i>D_j$.

The profit expression (3) is larger than (17) if the following holds:

$$D_i \in [Z, D_j), \qquad with \quad i \neq j, \ (j,i)=1,2 \qquad (18)$$

where Z is defined in Appendix A2. Hence, $D_i=Z$ is the lowest debt contract for which undercutting is preferred to $D_i=V^H-I$. It can also be verified that $Z \geq \Delta^{G}$ if and only if $V^H-\Delta^{GB} \geq I$, i.e. if and only if Δ^{GB} is feasible. Consequently, when $Z<\Delta^{G}$, Δ^{GB} is not feasible and (4) is negative: this implies that lender i would either set D_i below D_j, to make non-negative profits, or leave the market.

Under the tie-break rule assumed, we claim that:

PROPOSITION 1. *A Pure-Strategy Nash Equilibrium in (D_1, D_2) does not exist.*

In order to prove the result, we have to consider two cases: (i) Δ^{GB} feasible, and (ii) Δ^{GB} not feasible. When Δ^{GB} is feasible, the profit expressions of i, corresponding to (3) and (4), are represented in Figure (1a,1b) (according to whether $Z<\Delta^{GB}$ or $Z \geq \Delta^{GB}$).

Proof. (i) Δ^{GB} feasible. Consider Figure 1. If $(D_1,D_2)>Z$, each lender finds it convenient

to undercut the other, until Z is reached. Assume now that 1 sets $D_1=Z$: lender 2's optimal reply is to set $D_2=\max(D_2)=V^H-I$ (this choice dominates $D_2=Z$, since (4) calculated for $D_2=Z$ is smaller than (4) calculated for $D_2=V^H-I$: in fact, our tie-break implies that when $D_1=D_2=Z$ lender 1 is chosen). However, lender 1's optimal reply to $D_2=V^H-I$ is to set $D_1=V^H-I$. Since 2's best reply to $D_1=V^H-I$ is $D_2=D_1-\epsilon$, reciprocal undercutting becomes again the optimal response, until Z is reached again by either bank.

(ii) Δ^{GB} non-feasible. If $D_i>D_j>\Delta^G$ (i,j=1,2), i makes negative profits. Hence, i finds it convenient to undercut bank j by setting $D_i=D_j-\epsilon$. Reciprocal undercutting continues until Δ^G is reached. When $D_2=\Delta^G$, 1 is indifferent between (a) withdrawing from the market and (b) offering $D_1=\Delta^G$ as well. If 1 offers $D_1=\Delta^G$, under the assumed tie-break rule, in order to avoid losses, lender 2 does not offer any contract. When lender j leaves the market, the optimal reply of i is $D_i=V^H-I$: as a consequence, undercutting becomes, again, j's best policy until Δ^G is reached. ■

Remark 1. The result in Proposition 1 continues to hold when the tie-break rule specifies that, if $D_i=D_j$, the contract is allocated with equal probability to either lender. Indeed, with $D_i=D_j$ lender i's expected profit function becomes:

$$E\Phi^i|_{D_i=D_j} = Pr(e_j=B)\left\{Pr(V^H|e_i=G,e_j=B)D_i-I\right\}+\frac{1}{2}Pr(e_j=G)\left\{Pr(V^H|e_i=G,e_j=G)D_i-I\right\} \quad (19)$$

The contract $D_i=D_j=\Delta'$ solving $E\Phi^i|_{Di=Dj}=0$, is always such that $\Delta^G<\Delta'<\Delta^{GB}$. Figure 2 illustrates the position of the three profit functions (3), (4), (19). The proof of the non-existence of a Pure-Strategy Nash Equilibrium, being analogous to the one of Proposition 1, is

straightforward and omitted. □

We tackle the non-existence of a Nash Equilibrium in pure strategies both by constructing the Nash Equilibrium in mixed strategies[6] and by considering a game structure in which lender 1, the "incumbent", moves first than lender 2, the "entrant".

We will show that:

PROPOSITION 2. *Independently of the game structure assumed, the expected cost of credit is monotonically non-decreasing in V^H.*

4.1. The Nash Equilibrium in Mixed Strategies.

(i) Δ^{GB} feasible.

Define the following profit function, Φ^*_i, for bank i, $i\neq j$, (i,j)=1,2:

$$\Phi_i^* = Pr(D_i<D_j)(E\Phi|_{D_i<D_j}) + Pr(D_i>D_j)(E\Phi|_{D_i>D_j}), \quad D_i\in[\delta_0,\delta^0] \quad (20)$$

where $\Pr(D_1=D_2)=0$ and $E\Phi|_{Di<Dj}$ and $E\Phi|_{Di>Dj}$ are defined, respectively, by (3) and (4).

Let $\sigma_j(D_i)$ be the probability that lender j would set $D_j<D_i$. Defining $P(D_i<D_j)=1-\sigma_j(D_i)$, so that $P(D_i>D_j)=\sigma_j(D_i)$ and setting $a\equiv\alpha\beta/(\alpha\beta+\theta(1-\alpha))$, $b\equiv\alpha\beta(1-\beta)(\alpha(1-\beta)+(1-\theta)(1-\alpha))/(\alpha\beta(1-\beta)+\theta(1-\theta)(1-\alpha))$, $c\equiv\alpha(1-\beta)+(1-\theta)(1-\alpha)$, expression (20) can be rewritten as

$$\Phi_i^* = (1-\sigma_j(D_i))(aD_i-I) + \sigma_j(D_i)(bD_i-cI), \quad D_i \in [\delta_0, \delta^0] \tag{21}$$

Since Φ_i^* is constant over $[\delta_0,\delta^0]$, the mixed strategy equilibrium can be fully characterised, once we pin down the values of $(\Phi_i^*,\delta_0,\delta^0)$. Notice that $\delta^0=V^H-I$: setting $D_i=V^H-I$, lender i knows that it will be surely undercut ($\sigma_j(D_i)=1$). When i is undercut, charging something else than V^H-I is sub-optimal. Evaluating the profit expression (4) for $D_i=V^H-I$ gives the profit level in (17), $\Phi_i^*=b\delta^0-cI=b(V^H-I)-cI$. It remains to define δ_0: setting $D_i=\delta_0$, lender i will never be undercut by j and so $\sigma_j(D_i)=0$. Then, δ_0 is the value of D_i solving (21) for $\sigma_j(D_i)=0$, with $\Phi_i^*=b(V^H-I)-cI$. It can be shown that $\delta_0=Z$.

The mixed strategy equilibrium is then fully characterised by the following probability distribution:

$$\sigma_j(D_i) = \frac{b(V^H-I)+(1-c)I-aD_i}{(1-c)I+(b-a)D_i}, \quad D_i \in [Z, V^H-I] \tag{22}$$

which can be rewritten as function of $Z=(b(V^H-I)+(1-c)I)/a$. Notice that $\sigma_j=\sigma_i=\sigma$. Then:

$$E(D_i) = Z + \int_Z^{V^H-I} (1-\sigma(x))dx = Z + \int_Z^{V^H-I} \left(1-\frac{a(Z-x)}{(b-a)x+(1-c)I}\right)dx, \quad i=1,2 \tag{23}$$

In order to evaluate the expected cost of credit, it is necessary to assess the distribution of $d=\min(D_1,D_2)$. It can be shown that such distribution, over the support $[Z,V^H-I]$, takes the form

$$Pr(d>x) = \left[\frac{bx+(1-c)I-aZ}{(b-a)x+(1-c)I}\right]^2 \tag{24}$$

Therefore, E(d) is:

$$E(d) = Z + \int_Z^{V^H-I} \left[\frac{bx+(1-c)I-aZ}{(b-a)x+(1-c)I}\right]^2 dx \tag{25}$$

This defines the expected cost of credit when a firm receives an offer from *both* lenders.

It can be shown that $dE(D_1)/dV^H=dE(D_2)/dV^H>0$ and $dE(d)/dV^H>0$. The higher the ability of a high-value firm to generate (gross) revenues, V^H, the less aggressive the competition between lenders.

(ii) Δ^{GB} non-feasible.

In this case, the lender setting the highest credit cost will always face negative expected profits. This entails that he may not want to make an offer, even when the observed signal is good. We formalise this situation through the introduction of "participation probabilities", (q_1,q_2).

The profit function, Φ^*_i, for lender i ($i\neq j$, $(i,j)=1,2$), is now:

$$\Phi_i^* = (1-q_i)\times 0 + q_i\{[(1-q_j)+q_j Pr(D_i<D_j)](E\Phi^i|_{D_i<D_j}) + q_j Pr(D_i>D_j)(E\Phi^i|_{D_i>D_j})\}, \quad D_i \in [\delta_0, \delta^0] \tag{26}$$

This expression can be rewritten as

$$\Phi_i^* = q_i\{(aD_i-I) + q_j\sigma_j(D_i)[(b-a)D_i+(1-c)I]\} \tag{27}$$

The range of D_i is now given by ($\delta_0=\Delta^G, \delta^0=V^H-I$). If $D_i=\Delta^G$, then $\Phi^*_i=0$. Following the same procedure discussed above, we obtain $\sigma_j(D_i)=(aD_i-I)/[(aD_i-I)-(bD_i-cI)]q_j$.

Imposing $D_i=V^H-I$, so that $\sigma_j(D_i)=1$ the participation probability is:

$$q_j = \frac{a(V^H-I)-I}{(a(V^H-I)-I) - (b(V^H-I)-cI)} \tag{28}$$

which, being Δ^{GB} non-feasible, is strictly less than one[7]. Notice that $q_j=q_i=q$. Hence, even when both lenders observe a good signal about the firm, firm's applications can be rejected with probability $(1-q)^2>0$: this result exhibits similarities with the auction game in Levin and Smith (1994), where the presence of "too many" potential bidders induces a (symmetric) participation equilibrium in mixed strategies.

The values of $E(D_i)$ and $E(d)$ are now given by (i=1,2):

$$E(D_i) = \Delta^G + \int_{\Delta^G}^{V^H-I} (1-\sigma(x))dx = \Delta^G + \int_{\Delta^G}^{V^H-I} \left(\frac{x[a(1-q)+bq]+I[(1-c)q-1]}{[(b-a)x+(1-c)I]q}\right)dx \tag{29}$$

$$E(d) = \Delta^G + \int_{\Delta^G}^{V^H-I} (1-\sigma(x))^2 dx = \Delta^G + \int_{\Delta^G}^{V^H-I} \left(\frac{x[a(1-q)+bq]+I[(1-c)q-1]}{[(b-a)x+(1-c)I]q}\right)^2 dx \tag{30}$$

To compare the average cost of credit when Δ^{GB} is feasible with when is non-feasible, we first evaluate $E(D_i)$ for Δ^{GB} "almost" feasible. As $\Delta^{GB}\to(V^H-I)^+$, $q\to 1$. Moreover, $Z\to\Delta^G$ and $b(V^H-I)-cI\to 0$. Hence (i=1,2):

$$E(D_i) = \Delta^G + \int_{\Delta^G}^{V^H-I} (1-\sigma(x))dx = Z + \int_{Z}^{V^H-I} \left(\frac{(bx-cI)}{(b-a)x+(1-c)I}\right)dx \tag{31}$$

Comparing this expression with (23), we can verify that the average cost of credit is higher when Δ^{GB} feasible. Further, whenever Δ^{GB} is not feasible, it can be verified that $dE(D_1)/dV^H=dE(D_2)/dV^H>0$ and $dE(d)/dV^H>0$.

4.2. The Incumbent-Entrant Game.

In this game lender 1 (the incumbent) sets the contract conditions before lender 2 (the entrant), similarly to Sharpe (1990) and Pagano and Jappelli (1993).

(i) Δ^{GB} feasible.

Since Δ^{GB} is feasible, lender 1, in setting D_1, knows that lender 2's optimal reply, $D_2(D_1)$, is

$$D_2(D_1)=\begin{cases} D_2=V^H-I, & \text{if } D_1\le Z \\ D_2=D_1-\epsilon, & \text{if } D_1>Z \end{cases} \tag{32}$$

where $\epsilon>0$ is arbitrary. Then the following holds:

LEMMA 1. *When Δ^{GB} is feasible, $(D_1=V^H-I,\ D_2=V^H-I-\epsilon)$ is an equilibrium of the game.*[8]

(ii) Δ^{GB} non-feasible.

When Δ^{GB} is not feasible, since $\Delta^G>Z$, the profit expression (4) is negative over the

support $[\Delta^G, V^H\text{-}I]$. A lender can make a non-negative profit only when undercutting the other.

Lender 2's optimal reply to a given D_1 is now:

$$D_2(D_1) = \begin{cases} D_2 \text{ never offered}, & \text{if } D_1 \le \Delta^G \\ D_2 = D_1 - \epsilon, & \text{if } D_1 > \Delta^G \end{cases} \tag{33}$$

(Clearly, a debt contract such that $D_i < \Delta^G$ will never be offered, since bank i would make negative profits). It follows that:

LEMMA 2. *When Δ^{GB} is not feasible, the (unique) equilibrium for the incumbent-entrant game is ($D_1 = \Delta^G, D_2$ never offered).*

Notice that the equilibria in Lemma 1 and Lemma 2 are robust with respect to changes of the tie-break rule considered in Remark 1.

5. Public Placements of Debt.

In this section we model public placements of debt as an auction game where the firm offers a pre-specified debt contract on the market.

The structure of the auction we consider is the following[9]. The firm proposes a contract, D, and the two informed players (lenders) decide whether to bid or not[10]. For both lenders, the observation of a good signal is only a necessary condition for them to bid: indeed, after having observed a good signal, each lender decides his actual participation according to a positive probability, $\rho_i \in [0,1]$ (i=1,2). When both lenders bid for D, the contract is allocated

to either of them with probability 1/2 (or, equivalently, it is equally split between them).

The game is articulated in two stages.

In the first stage the firm proposes a contract D to investors (i,j). In the second stage having observed D and, conditionally on e_i=G, lender i chooses his bidding probability ρ_i obtaining an expected return equal to:

$$\begin{aligned} E\phi^i = \rho_i \{ & Pr(e_j=B)[Pr(V^H|e_i=G,e_j=B)D-I] + \\ & + Pr(e_j=G)[(1-\rho_j)(Pr(V^H|e_i=G,e_j=G)D-I) + \rho_j \frac{1}{2}(Pr(V^H|e_i=G,e_j=G)D-I)] \end{aligned} \tag{34}$$

where ρ_j is the bidding probability of j (conditional to e_j=G).

Defining $A(D) = Pr(e_j = B)\{Pr(V^H \mid e_i = G, e_j = B)D - I\}$ and $B(D) = Pr(e_j=G)\{Pr(V^H|e_i=G,e_j=G)D-I\}$, equation (34) can be rewritten as:

$$E\phi^i = \rho_i \left\{ A(D) + \left(1 - \frac{\rho_j}{2}\right) B(D) \right\} \tag{35}$$

The high-value firm maximises its expected profit

$$E\Pi(D;\rho_i,\rho_j) = (\rho_1\rho_2\beta^2 + (\beta(1-\beta)(\rho_1+\rho_2))[V^H - D] \tag{36}$$

with respect to D. D will be chosen taking into account the following reaction function of lender i, derived from (35):

$$\rho_i^*(\rho_j;D) = \begin{cases} 1, & \text{if } A(D) + \left(1 - \frac{\rho_j}{2}\right) B(D) \ge 0 \\ 0, & \text{if } A(D) + \left(1 - \frac{\rho_j}{2}\right) B(D) < 0 \end{cases} \tag{37}$$

The reaction function of lender j is defined analogously. Finally, (ρ_i^*, ρ_j^*) are determined as the

Nash equilibrium of the second stage of the auction game.

Since from (37) we know that ρ_i^* and ρ_j^* can only be zero or one, we can confine our investigation of equilibria to pure bidding strategies. An equilibrium of the auction game is a triple $(D^*(\rho_i^*,\rho_j^*),\rho_i^*,\rho_j^*)$.

Concentrating exclusively on *symmetric equilibria*, let D^* be the value of D solving $E\phi_i = E\phi_j = 0$ for $\rho_i = \rho_j = 1$, namely $A(D^*) + \frac{1}{2}B(D^*) = 0$. Since $D^* = (1+P(B))I/[2P(B)P(V^H|e_i=G,e_j=B)+P(G)P(V^H|e_i=G,e_j=G)]$, we know that $\Delta^G < D^* < \Delta^{GB}$.

We can now state the following:

PROPOSITION 3. *The unique symmetric equilibrium of this game is* $(D^*,1,1)$.[11]

6. Private vs. Public Debt Placements.

In order to establish what a good firm prefers, we compare the expected profits that it would obtain under different regimes. Notice that *a low-value firm will always mimic the choices of a high-value firm*: in fact, if this were not the case, a low-value firm would be sorted out and not financed.

The analysis is pursued according to the following order: (i) Δ^{GB} feasible, and (ii) Δ^{GB} not feasible. The case of lenders' competition under Nash equilibrium in mixed strategies will be treated through numerical analysis.

(i) Δ^{GB} *feasible.*

When lenders play the incumbent-entrant game (Sect.4.2), the high-value firm's expected profit is:

$$E\pi_{pr} = \beta^2(V^H-(V^H-I)) + \beta(1-\beta)(V^H-(V^H-I)) + (1-\beta)\beta(V^H-(V^H-I-\epsilon)) = \beta(2-\beta)I + \beta(1-\beta)\epsilon \quad (38)$$

where ϵ is close enough to zero.

The expected profit of the high-value firm under the auction game (Sect.5) is

$$E\pi_{AU} = (\beta^2+2\beta(1-\beta))(V^H-D^*) = \beta(2-\beta)(V^H-D^*) \quad (39)$$

It is simple to verify that $E\pi_{pr} < E\pi_{AU}$, whenever $V^H-I > D^*$. Hence:

PROPOSITION 4a. *When* Δ^{GB} *is feasible, and lenders play the incumbent-entrant game, a high-value firm will prefer to place its debt publicly.*

Since the probability of being financed for a high-value firm is $\beta(2-\beta)$ in both (38) and (39), lenders soft competition in the incumbent-entrant game leads to the highest credit cost compatible with the incentive constraint for feasibility (2).

(ii) Δ^{GB} *non-feasible.*

The expected profits of the high-value firm under the incumbent-entrant game are now:

$$E\pi_{pr} = \beta(V^H - \Delta^G) \tag{40}$$

while, under public debt placements, $E\pi_{AU}$ is still defined by (39), provided that D^* is feasible.

PROPOSITION 4b. *When Δ^{GB} is not feasible, and D^* is feasible, $E\pi_{pr} > E\pi_{AU}$ whenever $V^H < D^* + (D^* - \Delta^G)/(1-\beta)$.*

Apart from the trivial case in which, being D^* non-feasible, the auction game is not available to the firm, the preference for either regimes depends crucially upon β. As $\beta \to 1$, the right-hand-side of the inequality tends to $+\infty$, and privacy dominates. Hence, when a high-value firm tends to be revealed as such with probability one, it will go for the regime with the lower credit cost ($\Delta^G < D^*$).

On the other hand, examples in which the auction is preferred can be easily constructed. Take for instance $\beta = 1-\theta$. It can be verified that, the less informative is the signal ($\beta \to 1/2$), the more the contracts (including Δ^G and D^*) tend to coincide. Hence, since the credit cost ceases to be prominent, the emphasis falls on the probability of being financed, which is always greater in the auction.

6.1. Some Numerical Examples with N=2 Lenders.

In this section, we use some simple numerical examples to compare the firm's expected profit under different regimes. By doing this, we can better characterise the high-value firm's preference for those cases which are analytically less manageable (such as. the Auction game

and Nash competition in Mixed-Strategies).

To reduce the number of the parameters, we assume that (i) $\beta = 1-\theta$ (the probability of receiving a good signal when the firm is good is equal to the probability of receiving a bad signal when the firm is bad) and, (ii) I=1. We consider three different values of the gross return from the project (V^H=2.5,3,5). The fraction of good firms in the market ranges from 10% to 90% (α=0.1,0.2,..,0.9) and the accuracy of a good signal, emitted by a high-value firm, goes from a "very low" to a "very high" level (β=0.51,0.6,..,0.99).

We first compare the firm's expected profits under the mixed-strategy N.E. (Table 1(a,b,c)) with the corresponding profits under the Incumbent-Entrant game (Table 2(a,b,c)) (notice that the cost of credit, D, can be deduced from the corresponding profit expressions reported above). Given V^H, competition in mixed-strategies implies a lower expected cost of credit when (α,β) are relatively high (and make Δ^{GB} feasible). On the other hand, the cost of credit under mixed strategies is higher when the fraction of good firms in the market is so low as to make Δ^{GB} *not* feasible. Mixed strategies create a negative externality between the lenders. In fact, losses are to be expected in the event that *both* lenders make an offer (occurring with probability less then one), a case which is ruled out in the incumbent-entrant game.

Considering the Auction game (see Table 3(a,b,c)), it has to be noticed its limited availability: in order to induce lenders to bid (with probability one, in equilibrium), the firm should set a value of D^* which is often too high to be feasible. Hence, private debt placements is the only available option for a firm when α, β and V^H are low. In the remaining cases, since D^* is set as to provide the bidders zero expected profit, the auction dominates mixed-strategies competition for high (V^H,α,β)[12].

In conclusion, with two informed lenders, a high-value firm tends to prefer direct market borrowing to bilateral credit relations ("privacy") for (i) relatively high values of the gross return, V^H (given I=1), (ii) relatively high fraction of high-value firms in the economy, α, and (iii) relatively high accuracy of a good signal, β.

7. The Case with N>2 Lenders.

This section analyses the change in lenders' pricing policy when their number is greater than two. By concentrating on the incumbent-entrant game, we can investigate how the incentives to set up an auction game (analogous to the one treated in Sect.5) can be modified when the regime of private debt placements becomes "more competitive".

In order to analyse the incumbent-entrant game, we first state the following assumptions. There are N lenders: Lender 1, the incumbent, and a competitive fringe of N-1 potential entrants (see Sharpe (1990)). They have the same signal accuracy. The tie-break rule is the following: if a firm is offered a debt contract by lender 1 and by some other, say lender i, and if $D_1=D_i$, then 1 will be chosen. Whenever a firm has to tie-break among S entrants offering credit at the same conditions, it picks one randomly with probability 1/S.

We assume that, given N lenders, a break-even contract is feasible only if at least half of the observed signals are good. Then, the following holds (for a sketch-proof, see Appendix A3):

PROPOSITION 5. *In equilibrium, conditionally to a good signal, lender 1 sets* $D_1=\Delta^G=(\alpha\beta+\theta(1-\alpha))I/\alpha\beta$ *and the remaining N-1 lenders do not offer any contract.*

As a consequence, the expected profit of a high-value firm under *private* debt placements is simply:

$$E\pi_{pr}^{(N)} = \beta[V^H-\Delta^G] \tag{41}$$

We concentrate now on the symmetric equilibrium of the auction game, where all the lenders, conditionally to having observed good signals, bid in equilibrium with probability one (as it can be shown in analogy with Sect.5). Given D, the expected profit of lender i is

$$E\phi^i(N) = \sum_{k=0}^{N-1}\{\alpha\beta^k(1-\beta)^{N-1-k}+(1-\alpha)\theta^k(1-\theta)^{N-1-k}\}\frac{(N-1)!}{(k+1)!(N-1-k)!}\times \times\left[\frac{\alpha\beta^{k+1}(1-\beta)^{N-1-k}}{\alpha\beta^{k+1}(1-\beta)^{N-1-k}+(1-\alpha)\theta^{k+1}(1-\theta)^{N-1-k}}D-I\right] \tag{42}$$

The firm chooses $D=D^*$, so that $E\phi^i(N)=0$. For the case in which $\beta=1-\theta$, then:

$$D^* = \frac{\sum_{k=0}^{N-1}\left\{1+\frac{1-\alpha}{\alpha}\left(\frac{\beta}{1-\beta}\right)^{N-1-2k}\right\}\left(\frac{\beta}{1-\beta}\right)^k\frac{1}{(1+k)!(N-1-k)!}}{\sum_{k=0}^{N-1}\left\{\frac{1+\frac{1-\alpha}{\alpha}\left(\frac{\beta}{1-\beta}\right)^{N-1-2k}}{1+\frac{1-\alpha}{\alpha}\left(\frac{\beta}{1-\beta}\right)^{N-2-2k}}\right\}\left(\frac{\beta}{1-\beta}\right)^k\frac{1}{(1+k)!(N-1-k)!}}I \tag{43}$$

The expected profit of the (high-value) firm in the auction game is:

$$E\Pi(D^*;N) = (1-(1-\beta)^N)[V^H-D^*] \tag{44}$$

To compare (44) with the expected profit of the high-value firm under the incumbent-entrant game, we performed numerical calculations. In Table 4(a,b,c) we report the expected

profit when D^* is issued, for different values of V^H (V^H=2.5,3,5) and N (N=3,10,30). We take I=1, β=1-θ, and let α and β assume three different values. When the number of firms increases, the value of D^* becomes larger and often violates the feasibility constraint (numerical tables of D^* are omitted). The explanation is that, to induce bidding from a larger number of lenders, a higher debt repayment must be promised by the firm in order to (i) compensate for the higher expected loss occurring when financing a firm which has been rejected by "many" other lenders, and (ii) compensate for the lower expected gain occurring when competing with other lenders over a firm which emanated "several" good signals.

Such higher cost of credit, however, can be counterbalanced by a higher probability of being financed, $1-(1-\beta)^N$, which is increasing in N.

We can first notice that profits are monotonically increasing in α since, for given β, $D^* \to 1 = I$ for $\alpha \to 1$: the better the quality of the market, the cheaper the cost of credit and, hence, the higher the expected profit.

On the other hand, for given α, changes in β have a rather ambiguous impact over firm's profit. Surprisingly enough, when the number of lenders is "sufficiently" high (e.g., N=10,30), profits are *decreasing* in β. So, the higher the ability of the signal to communicate that the firm is high-value when this is actually the case, the lower the firm's expected profit in the auction game. The profile of the profit, for different values of β, is the mirror image of the profile of D^*.

The explanation for such behaviour has to do with an *excessive participation externality* arising when β and N increase. Since a higher β increases the expected number of bidders, Nβ, it generates on D^* the same effects of an increase in N that we mentioned above[13].

As a corollary of such an externality, we also find the analogue of the *under-pricing* result in IPO's of shares. Since the break-even *uninformed* contract is $I/\alpha = 1/\alpha$, for large values[14] of N (such as N=10,30) and high values of β (β=0.7,0.9), it holds that $D^* > 1/\alpha$: publicly auctioned debt contracts pay an interest rate greater than the break-even interest rate based on the fraction of high-value firms in the economy.

In conclusion, when the values of N and β are sufficiently high, the expected profit under the incumbent-entrant game (see Table 5(a,b,c)) tends to dominate the one under the auction game. In this case, it is *socially efficient to "waste" information*[15]: in fact, in the incumbent-entrant game, only lender 1 actually makes use of his signal.

8. Conclusions.

The analysis pursued in the preceding sections can be summarised by the following four main results:

(i) Publicly placed debt is an available option only when high-value firms' profitability, V^H, and high-value firms' proportion, α, are sufficiently high.

(ii) For a given β, when public debt placements are feasible, the higher V^H and α, the more market financing becomes attractive.

(iii) As the number of informed potential lenders, N, becomes larger, the cost of privately placed debt tends to be reduced by a harder price competition among lenders, while the cost of publicly placed debt increases because of "excessive participation".

(iv) When the high-value firm's probability of emanating a good signal, β, increases,

the cost of publicly placed debt rises because, again, of "excessive participation".

An immediate implication of (i) is that privately placed debt is the only source of funding even for high-value firms which have, however, relatively low profitability and belong to an environment with high default rate, 1-α, as it is often the case with small businesses. Similarly, according to (ii), good economic conditions (in terms of V^H and α) stimulate public debt placements: hence, capital market financing should be observed more frequently in booming economies (or sectors).

As suggested by (iii), when the number of lenders becomes large, publicly auctioned debt either fails to be available, or it can be "too expensive", due to the strong competition among potential bidders (also, the analogue of underpricing in stock public offerings tends to arise). Hence, a highly competitive environment may damage a firm issuing its debt at pre-specified conditions and make private debt placement more attractive.

According to (iv), an increase in β, as it is for an increase in N, generates a negative externality among potential bidders (which is transferred on the issuing firm in terms of higher interest rates, since lenders make zero expected profit in equilibrium). As a consequence private debt placements, typical of banking relationships, become relatively more convenient for those high-value firms which find it easier to "communicate" their nature. On the other hand, since a low β reduces excessive bidding, market borrowing tends to be preferred by those firms that find it more difficult to communicate their high quality. This can be the case of complex corporations, or of firms which have highly innovative technologies: such conclusion closely matches the one in Allen (1993), even if the latter is based on a very different mechanism[16].

Appendix.

A1. Noticing that $\Pr(e_1=G,e_2=G) = \Pr(e_1=G,e_2=G|V^H)\ \Pr(V^H) + \Pr(e_1=G,e_2=G|V^L)\ \Pr(V^L) = \beta^2\alpha+\theta_1\theta_2(1-\alpha)$:

$$Pr(V^H|e_1=G,e_2=G)=\frac{Pr(e_1=G,e_2=G|V^H)Pr(V^H)}{Pr(e_1=G,e_2=G)}=\frac{\beta^2\alpha}{\beta^2\alpha+\theta^2(1-\alpha)} \qquad (45)$$

$$Pr(V^L|e_1=G,e_2=G)=\frac{Pr(e_1=G,e_2=G|V^L)Pr(V^L)}{Pr(e_1=G,e_2=G)}=\frac{\theta^2(1-\alpha)}{\beta^2\alpha+\theta^2(1-\alpha)} \qquad (46)$$

A2. The expression for Z is:

$$Z \equiv \frac{\alpha\beta+\theta(1-\alpha)}{\alpha\beta[\alpha\beta(1-\beta)+\theta(1-\theta)(1-\alpha)]}\{\alpha\beta(1-\beta)[\alpha(1-\beta)+(1-\theta)(1-\alpha)]\}[V^H-I]+ \qquad (47)$$

$$+\frac{(\alpha\beta+\theta(1-\alpha))^2}{\alpha\beta}I = \frac{1}{a}\{b(V^H-I)+(1-c)I\}$$

A3. *Proof of Proposition 5.*

Assume N=3, with one incumbent and two entrant lenders. We also assume that any contract conditioned on two or three bad signals, or more, is not feasible (in general, we assume that a contract is feasible when at least the half of the signals is good).

According to the tie-break rule adopted, if lender 1 sets a $D_1 \le (D_2,D_3)$, he obtains an expected profit given by (3). If he sets D_1 such that, either $D_2 < D_1 \le D_3$ or $D_3 < D_1 \le D_2$, then he gets an expected profit equal to (4). A $D_1 > (D_2,D_3)$ gives losses, because of our assumption on feasibility. Analogously, if lender 2 sets $D_2 < (D_1,D_3)$, his profit is given by (3), while setting

D_2 such that either $D_1 < D_2 < D_3$ or $D_3 < D_2 < D_1$, imply an expected profit equal to (4). Again $D_2 > (D_1, D_3)$ would gives losses. When $D_2 = D_3 \geq D_1$, 2's expected profit is

$$E\Phi^2|_{D_2=D_3\geq D_1} = Pr(e_1=B,e_2=B)\left[Pr(V^H|e_1=B,e_2=G,e_3=B)D_2 - I\right] + \\ + \frac{1}{2} Pr(e_1=B,e_3=G)\left[Pr(V^H|e_1=B,e_2=G,e_3=G)D_2 - I\right] \tag{48}$$

A similar expression holds for $D_2 = D_3 < D_1$.

The same reasoning adopted for 2 applies to lender 3.

No lender i will ever set D_i at a level strictly greater than the other two, since undercutting avoids losses. Consider now the case where $D_2 = D_3 \geq D_1 > \Delta^G$: lenders 2 and 3 find it convenient to undercut each other, since, by doing this, (4) rather than (48) can be obtained: reciprocal undercutting would continue, unless lender 1 sets $D_1 = \Delta^G$, excluding the entrants from the loan market.

This argument can be immediately extended to more than two (potential) entrants.

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Notes.

1. On the one hand, following Allen (1993), financial markets provide risk-sharing opportunities and information gathering incentives, and may favour the implementation of incentive schemes. On the other hand, the main advantages of "bank" financing (as a close lender-firm relationship) are due to banks' role as delegated monitors and to their ability to set up long-term commitments with their clients. Further, banks can lend more flexibly than capital markets in environments which are informationally unstable (Berlin and Mester (1992)) and help new borrowers to build their reputation over time, before issuing debt directly (Diamond (1991)). However, banks can develop and exploit some monopoly power over firms, so to reduce investment incentives (e.g., Rajan (1992)).

2. For some theoretical references about underpricing in IPO's, see, e.g., Chemmanur (1993).

3. This conclusion is reached without assuming exogenous costs of any kind.

4. Two random variables (x,y) are *conditionally independent* with respect to z when: $Pr(x,y|z)=Pr(x|z)\ Pr(y|z)$. Conditional independence does not imply independence.

5. Notice that $Pr(e_i=G,e_j=B) = Pr(e_i=G,e_j=B|V^H)\ Pr(V^H) + Pr(e_i=G,e_j=G|V^L)\ Pr(V^L) = \beta(1-\beta)\alpha+\theta_i(1-\theta_j)(1-\alpha)$

6. See, e.g., Levitan and Shubik (1972).

7. Notice in fact that, when $\Delta^{GB}\leq V^H-I$, $-(b(V^H-I)-cI)\geq 0$. Moreover, when $\Delta^G=V^H-I$, $q_1=q_2=0$.

8. There is actually a second equilibrium, namely $(D_1=Z,\ D_2=V^H-I)$, which we disregard since it is not robust to slight modifications in the assumptions: this is, e.g., the case when $\theta_1<\theta_2$.

9. For related models of public offerings, see, e.g., Benveniste and Spindt (1989) and Chemmanur (1993).

10. We assume, without modelling it explicitly, that an "uninformed" lender (a lender who does not have access to a signal) never takes part in the auction: indeed, if this were the case, he would over-subscribe issues that were left over by informed investors.

11. The assumption of symmetry is discussed in Levin and Smith (p.586,1994). Asymmetric equilibria also exist: let $D=D_A^*$ solve $E\phi_i=0$ for $\rho_j=0$ (or, $E\phi_j=0$ for $\rho_i=0$), namely $A(D_A^*)+B(D_A^*)=0$ (it can be verified that $D^*>D_A^*$). It can be shown that: if $V^H\geq(2-\beta)D^*-(1-\beta)D_A^*$, the unique (symmetric) equilibrium of the game is $(D^*,1,1)$; otherwise, the game has the two following asymmetric equilibria, $(D_A^*,1,0)$ and $(D_A^*,0,1)$ (*Proof.* The expected profit of the firm in (36) is equal to: (i) $\beta(2-\beta)[V^H-D]$, when $\rho_i=\rho_j=1$, which is maximised

for $D=D^*$, and (ii) $\beta(1-\beta)[V^H-D]$ when $\rho_i=1$ and $\rho_j=0$, or $\rho_i=0$ and $\rho_j=1$, which is maximised for $D=D_A^*$. When $\beta(2-\beta)[V^H-D^*]\geq\beta(1-\beta)[V^H-D_A^*]$, $V^H\geq(2-\beta)D^*-(1-\beta)D_A^*$ holds and the proposition follows.■)

12. An interesting case occurs when Δ^{GB} is "almost" or "just" feasible: in this case, (mixed-strategy) price competition between lenders is able to drive the expected cost of credit to a lower level than D^*, even if lenders' expected profits may be strictly positive. (Notice that the probabilities to be financed, for a high-value firm, either coincide or tend to coincide "around" Δ^{GB}'s feasibility.)

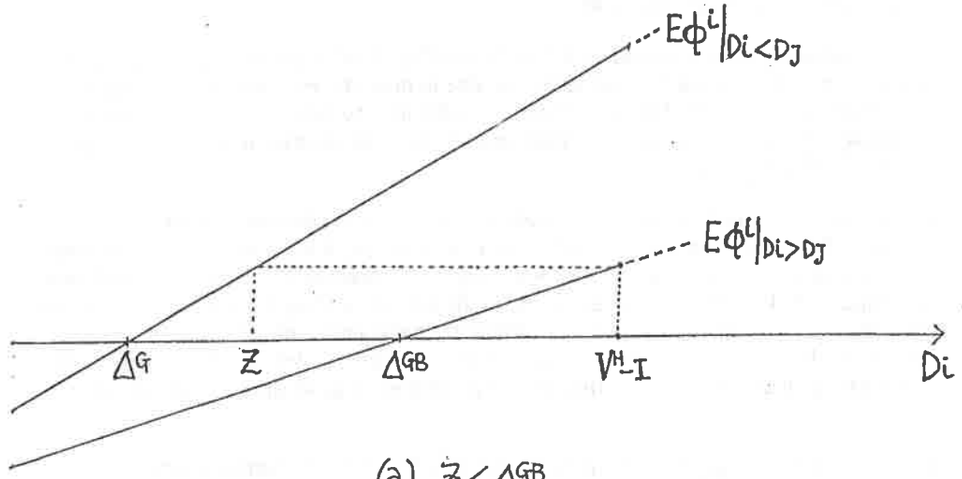
13. We can also express D^* as a linear convex combination of conditional break-even contracts. The break-even contract, conditioned on N signals, k of which are good, is equal to $[1+((1-\alpha)/\alpha)((1-\beta)/\beta)^{2k-N}]I$ and it is decreasing in β whenever $2k\geq N$, i.e., $k\geq N/2$, and increasing when $k<N/2$. When β increases, in the convex combination the weight associated to break-even contracts conditioned on a sufficiently high number of bad signals increases, so that, for the bidder's expected profit to remain zero, the distance between D^* and the break-even contract conditioned on a "sufficiently" high number of good signals has to increase as well.

14. Notice that, with $N=2$, it always holds that $D^*<1/\alpha$, i.e., the correspondent of "over-pricing" in share issues.

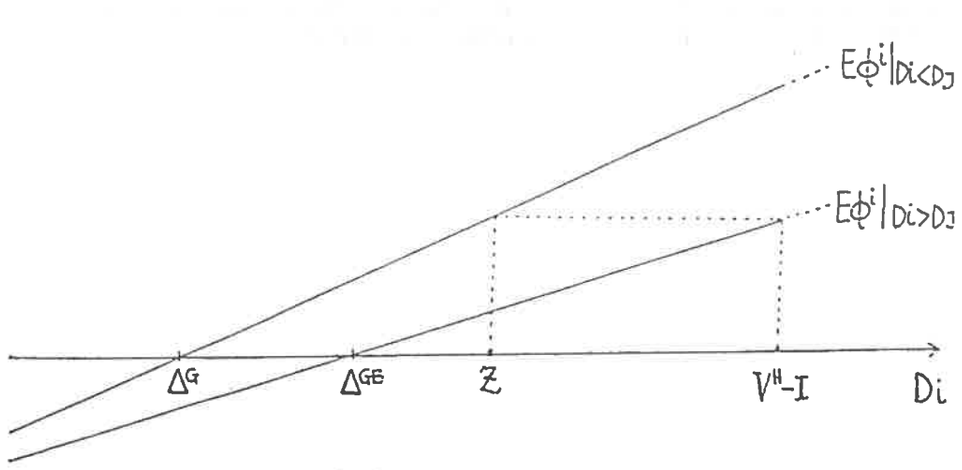
15. Recall that, under both the incumbent-entrant game and the auction game with $N>2$, the lenders' expected profit is zero.

16. Allen (1993) argues that complex organisations and non-standard technologies generate little consensus over managerial actions: in these cases, then, by aggregating private information, the stock market stimulates "multiple checking", producing a more accurate and efficient evaluation of firms than a bilateral banking relation. Even if in our model β can be interpreted as a measure of the consensus over the firm's quality, what drives our result is excessive bidding, with a flavour similar to Levin and Smith (1994).

FIGURE 1



(a) $\bar{Z} < \Delta^{GB}$



(b) $\bar{Z} \geq \Delta^{GB}$

FIGURE 2

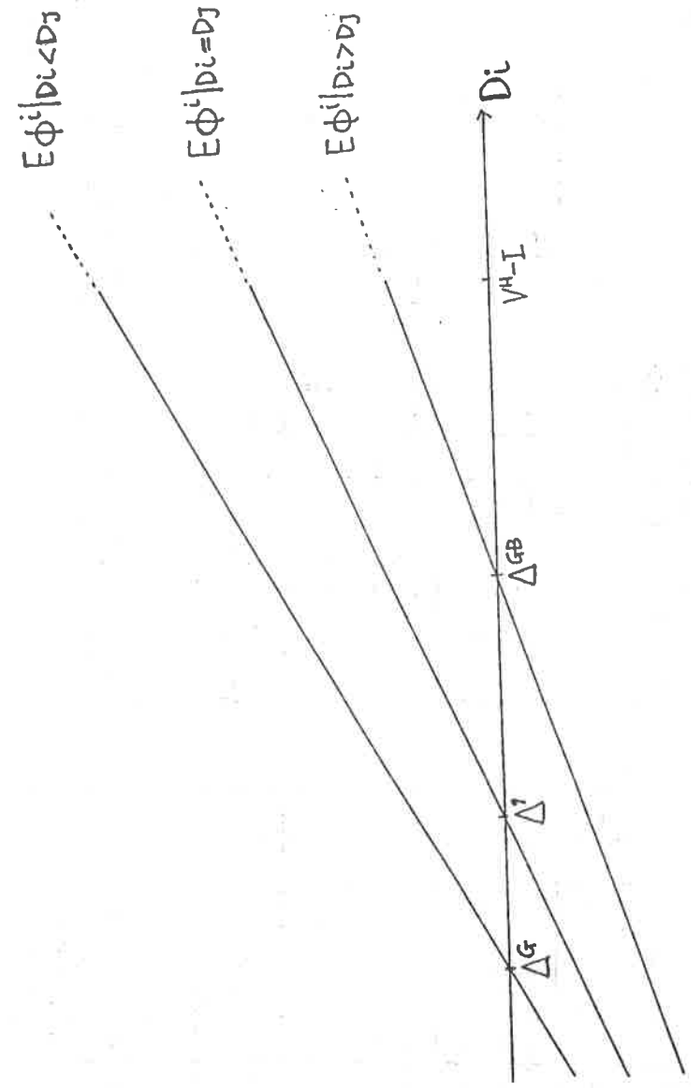


TABLE 1

The Nash-Equilibrium in Mixed Strategies (2 lenders): Firm's Expected Profit

Table 1a. $V^H=2.5$

ß\α	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
0.51	*	*	*	*	*	*	0.78	0.84	0.87
0.6	*	*	*	*	*	*0.30*	0.96	0.98	1.02
0.7	*	*	*	*	*0.16*	*0.72*	1.10	1.13	1.15
0.8	*	*	*	*0.16*	*0.51*	*0.95*	1.25	1.25	1.26
0.9	*	*0.02*	*0.18*	*0.42*	*0.74*	*1.09*	1.36	1.35	1.34
0.99	*0.17*	*0.26*	*0.42*	*0.62*	*0.87*	*1.19*	1.42	1.41	1.43

Table 1b. $V^H=3$

ß\α	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
0.51	*	*	*	*	*0.78*	0.87	0.92	0.96	0.98
0.6	*	*	*	*0*	*1.04*	1.08	1.13	1.16	1.21
0.7	*	*	*	*0.62*	*1.30*	1.34	1.32	1.35	1.38
0.8	*	*0*	*0.42*	*0.97*	*1.52*	1.53	1.53	1.52	1.55
0.9	*0*	*0.35*	*0.79*	*1.24*	*1.71*	1.67	1.66	1.67	1.71
0.99	*0.50*	*0.77*	*1.06*	*1.44*	*1.85*	1.78	1.75	1.78	1.84

Table 1c. $V^H=5$

ß\α	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
0.51	*	*	0.97	1.17	1.30	1.39	1.44	1.49	1.52
0.6	*	*0.37*	1.53	1.67	1.73	1.80	1.83	1.86	1.93
0.7	*	*1.20*	2.10	2.17	2.19	2.22	2.20	2.26	2.33
0.8	*0.27*	*1.97*	2.63	2.57	2.56	2.59	2.60	2.65	2.75
0.9	*1.21*	*2.63*	3.09	2.97	2.88	2.86	2.88	3.00	3.15
0.99	*2.41*	*3.23*	3.45	3.24	3.12	3.08	3.12	3.26	3.52

NOTE: When the sign * appears, the contract considered is not feasible.
Italics denotes the combinations for which the contract Δ^{BG} is not feasible.

TABLE 2

The Incumbent-Entrant Game (2 lenders): Firm's Expected Profit

Table 2a. $V^H=2.5$

ß\α	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
0.51	*	*	*	*	*	*	0.78	0.84	0.87
0.6	*	*	*	*	*	*0.64*	0.84	0.84	0.84
0.7	*	*	*	*	*0.75*	*0.85*	0.91	0.91	0.91
0.8	*	*	*	*0.90*	*1*	*1.06*	0.96	0.96	0.96
0.9	*	*0.95*	*1.12*	*1.20*	*1.25*	*1.29*	0.99	0.99	0.99
0.99	*1.40*	*1.44*	*1.46*	*1.47*	*1.47*	*1.47*	1	1	1

Table 2b. $V^H=3$

ß\α	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
0.51	*	*	*	*	*0.53*	0.76	0.76	0.76	0.76
0.6	*	*	*	*0.60*	*0.80*	0.84	0.84	0.84	0.84
0.7	*	*	*	*0.95*	*1.10*	0.91	0.91	0.91	0.91
0.8	*	*0.80*	*1.14*	*1.30*	*1.40*	0.96	0.96	0.96	0.96
0.9	*0.90*	*1.40*	*1.57*	*1.65*	*1.70*	0.99	0.99	0.99	0.99
0.99	*1.89*	*1.94*	*1.96*	*1.97*	*1.97*	1	1	1	1

Table 2c. $V^H=5$

ß\α	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
0.51	*	*	0.76	0.76	0.76	0.76	0.76	0.76	0.76
0.6	*	*0.80*	0.84	0.84	0.84	0.84	0.84	0.84	0.84
0.7	*	*1.60*	0.91	0.91	0.91	0.91	0.91	0.91	0.91
0.8	*1.40*	*2.40*	0.96	0.96	0.96	0.96	0.96	0.96	0.96
0.9	*2.70*	*3.20*	0.99	0.99	0.99	0.99	0.99	0.99	0.99
0.99	*3.87*	*3.92*	1	1	1	1	1	1	1

NOTE: When the sign * appears, the contract considered is not feasible.
Italics denotes the combinations for which the contract Δ^{BG} is not feasible.

TABLE 3

Public Placements of Debt (2 lenders): Firm's Expected Profit

Table 3a. $V^H=2.5$

ß\α	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
0.51	*	*	*	*	*	*	0.82	0.96	1.06
0.6	*	*	*	*	*	*	0.98	1.10	1.19
0.7	*	*	*	*	*	*0.99*	1.13	1.23	1.31
0.8	*	*	*	*	*	*1.10*	1.24	1.32	1.39
0.9	*	*	*	*	*	*1.17*	1.31	1.40	1.45
0.99	*	*	*	*	*	*1.20*	1.34	1.43	1.48

Table 3b. $V^H=3$

ß\α	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
0.51	*	*	*	*	*0.78*	1.03	1.20	1.34	1.44
0.6	*	*	*	*	*1.03*	1.25	1.40	1.52	1.61
0.7	*	*	*	*0.96*	*1.25*	1.45	1.58	1.68	1.76
0.8	*	*	*	*1.12*	*1.40*	1.58	1.72	1.75	1.87
0.9	*	*	*	*1.19*	*1.47*	1.67	1.80	1.89	1.95
0.99	*	*	*	*1.19*	*1.50*	1.70	1.84	1.93	1.88

Table 3c. $V^H=5$

ß\α	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
0.51	*	*	1.31	1.93	2.30	2.55	2.72	2.86	2.96
0.6	*	*	1.85	2.39	2.71	2.93	3.08	3.20	3.29
0.7	*	*1.39*	2.31	2.78	3.07	3.27	3.40	3.50	3.58
0.8	*	*1.75*	2.59	3.04	3.32	3.50	3.64	3.67	3.79
0.9	*	*1.78*	2.69	3.17	3.45	3.64	3.78	3.87	3.93
0.99	*	*1.57*	2.65	3.19	3.50	3.70	3.84	3.93	3.98

NOTE: When the sign * appears, the contract considered is not feasible.
Italics denotes the combinations for which the contract Δ^{BG} is not feasible.

TABLE 4

Public Placements of Debt with *N=(3, 10, 30)* lenders: Firm's Expected Profit.

Table 4a. $V^H=2.5$

ß\α	0.2	0.5	0.8
0.51	(* , * , *)	(* , * , *)	(1.11, 1.25, 1.25)
0.7	(* , * , *)	(* , * , *)	(1.26, 1.05, *)
0.9	(* , * , *)	(* , * , *)	(1.16, * , *)

Table 4b. $V^H=3$

ß\α	0.2	0.5	0.8
0.51	(* , * , *)	(0.90, 1, 1)	(1.55, 1.75, 1.75)
0.7	(* , * , *)	(1.13, * , *)	(1.75, 1.55, 1.43)
0.9	(* , * , *)	(* , * , *)	(1.66, * , *)

Table 4c. $V^H=5$

ß\α	0.2	0.5	0.8
0.51	(* , * , *)	(2.66, 3, 3)	(3.32, 3.75, 3.75)
0.7	(* , * , *)	(3.07, 2.23, 1.74)	(3.70, 3.55, 3.43)
0.9	(* , * , *)	(2.54, * , *)	(3.66, 2.54, 1.85)

NOTE: The triples in parentheses represent the (high-value) firm's expected profit when there are, respectively, 3, 10 and 30 lenders. When the sign * appears, the contract D* is not available.

TABLE 5

The Incumbent-Entrant Game with N≥3 lenders: Firm's Expected Profit.

Table 5a. $V^H=2.5$

ß\α	0.2	0.5	0.8
0.51	*	*	0.64
0.7	*	0.75	0.97
0.9	0.95	1.25	1.35

Table 5b. $V^H=3$

ß\α	0.2	0.5	0.8
0.51	*	0.53	0.90
0.7	*	1.10	1.32
0.9	1.40	1.70	1.77

Table 5c. $V^H=5$

ß\α	0.2	0.5	0.8
0.51	*	1.55	1.92
0.7	1.60	2.50	2.72
0.9	3.20	3.50	3.57

NOTE: When the sign * appears, the contract Δ^G is not feasible.

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