Anti-Competitive Financial Contracting: The Design of Financial Claims*

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Abstract

This paper presents the first model where entry deterrence takes place through *financial* rather than *product-market* channels. In standard models of the interaction between product and financial markets, a firm's use of financial instruments deters entry by affecting *product market* behavior, whereas in our model entry deterrence occurs by affecting the *credit market* behavior of investors towards entrant firms. We find that in order to deter entry, the claims held on incumbent firms should be sufficiently risky, i.e. equity, in contrast to the standard Brander-Lewis (1986) result that debt deters entry. The model sheds light on the policy debate on the separation of banking as to whether banks should be permitted to hold equity in firms. It also provides an explanation for why venture capitalists hold *automatically* convertible securities in start-up firms.

Keywords: Coase Problem, Over-funding, Venture Capital, Convertible Debt

JEL Classification: G3

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Este artículo presenta el primer modelo donde la disuasión de entrada se obtiene a través de vías *financieras* y no a través del *mercado de los productos.* En los modelos estandard de interacción entre los mercados financieros y reales, la utilización de los instrumentos financieros por parte de una empresa disuade la entrada afectando el comportamiento en el mercado de los productos, mientras que en nuestro modelo la disuasión de entrada se obtiene afectando el comportamiento, en el mercado de capitales, de los inversores hacia las empresas *entrantes.* Encontramos que para disuadir la entrada, los títulos poseidos en la empresa ya presente en el mercato, deben de ser suficientemente arriesgados (acciones, por ejemplo) al contrario del resultado estandard de Brander y Lewis (1986) que la deuda disuade la entrada. El modelo contribuye al debate sobre el problema de si los bancos deben estar autorizados o no a poseer acciones de empresas. Además, proporciona una explicación de la razón por la cual los *venture capitalists* poseen títulos *automáticamente* convertibles en las empresas jovenes.

“ The difficulties inherent in acquiring external finance in the United States in the nineteenth century provide an explanation for the basis of the fortunes of certain American entrepreneurs and suggest at least one reason why the economy was characterized by increasing concentration in the growth sectors” Lance Davis (1966).

1 Introduction

This paper presents the first model where entry deterrence takes place through *financial* rather than *product-market* channels. This is a new form of entry deterrence which has not previously been considered, but which is nonetheless potentially important in countries and industries where funding opportunities are relatively scarce. In standard models of the interaction between product and financial markets, the focus has always been on how a firm’s use of financial instruments affects *its own product market behavior*, and thus its rival’s optimal response. By contrast, in this paper we show that even if financial contracts are completely neutral in their impact on product market behavior, they have an impact on *the behavior of investors*, and thus affect the funding opportunities of potential entrants in this way.

One might think that with imperfectly competitive financial markets, the problem of financial entry deterrence would be trivial: investors (who share in the surplus generated by investment) should deny funding to entrants to limit industrial competition. In fact, matters are not so simple, as the following simple example demonstrates. Suppose a monopoly investor signs a contract in which he agrees to supply the monopoly amount of capital to a single firm, in return for safe debt in that firm. (Holding safe debt is of course desirable since it maximizes the entrepreneur’s incentives to exert effort). A problem arises because the investor is well-informed about the industry and his return in the funded firm is safe and unaffected by changes in profitability - so the investor will be tempted to fund *another* firm to enter the industry. Of course, knowing that the investor will be tempted to supply a second firm ex-post, the first firm will not accept the same terms ex-ante, so the investor’s profits are reduced by his lack of commitment. This commitment problem is known as the “Coase problem” in direct analogy to the problem of durable goods monopoly (see Rey and Tirole, forthcoming).

The logic of our result is very straightforward. The *form* of the financial contract between the incumbent firm and its investor will affect the investor’s willingness to provide funds to entrant firms, by making his returns more or less sensitive to the effect of product market competition. The solution to the Coase problem is to make the investor’s claim sufficiently sensitive to the profits of the incumbent firm that he has a *financial* incentive not to fund the second firm. In effect, recognizing the possibility that a knowledgeable investor could fund several firms in an industry changes financial contract design from a one-sided to a two-sided moral hazard problem, where the entrepreneur's incentives must be traded off against those of the investor.

We show that the entry-deterring claim is in fact *equity* (or, equivalently, risky debt), in contrast to the Brander-Lewis result that *debt* induces tougher behavior in the product market, and so deters entry. The difference in results comes from the different channels through which entry deterrence occurs. Brander and Lewis (1986) - and the literature on the interaction between product and financial markets which has followed them[1] - abstract from any financial market effects of the design of claims, and concentrate on product market effects. We do the reverse. Our model is in some ways a new formulation of the "deep pocket" argument. An incumbent can shorten an entrant's pocket by borrowing money which would otherwise be invested in his rival. Which approach is the most relevant in practice is largely an empirical question. We believe that there are some situations where difficulty in obtaining funding *per se*, rather than fear of aggressive behavior by an incumbent, is the factor which prevents firms from entering the market. This is certainly the case in some Eastern European countries, and countries such as in Italy, where competition in financial markets is very limited and has never been encouraged. Moreover, historical evidence suggests that our model can be readily applied to the nineteenth century United States.[2]

The model also sheds light on the debate as to whether banks should be permitted to hold equity in firms. In situations where there are ample alter-

[1]The literature on the interaction between product and financial markets is becoming extensive, here we just mention a few papers. The impact of capital structure on incumbent product market behavior has been analyzed by Showalter (1995), who extends the Brander-Lewis model to price competition, Maskimovic (1988) who looks at the impact of debt on collusive outcomes; and Aghion, Dewatripont and Rey (1998) who show how the extent of outside finance can affect whether firms compete in strategic substitutes or complements. Fudenberg and Tirole (1986), Poitevin (1989a) and Bolton and Scharfstein (1990) are instead mainly concerned with the design of claims on the entrant; they show how agency problems in financial markets can leave entrant firms vulnerable to predation. Gertner, Gibbons and Scharfstein (1988) analyze the conflicts that arise when capital structure is used to signal to more than one receiver. Poitevin (1989b) and Battacharya-Chiesa (1995) depart from the norm in considering lenders' rather than product market incentives. They show that coordination on a common lender can help coordinate on mutually desirable outcomes for the industry, but do not consider the design of claims. Empirical evidence of financial market effects on product markets is provided by Chevalier (1995), Chevalier-Scharfstein (1996) and Zingales (1998).

[2]For a theoretical discussion of why financial markets are often uncompetitive, and a review of anti-trust cases in financial markets, see Bruzzone and Polo (1998). In section 6.1 we present a more detailed discussion of case studies.

native sources of funding for entrants, equity-holding by banks is likely to do little damage. But where funding sources are imperfectly competitive, an incumbent firm will generally disadvantage its rivals by selling equity to a bank with a comparative advantage (e.g. specialized knowledge leading to lower cost of funds) in funding its industry. Thus one may wonder about the wisdom of the prescription of a universal banking system for Eastern European countries (see Frydman et al 1993 for further discussion).

In a second application of the model, we provide an explanation for why venture capitalists hold automatically convertible securities in start-up firms. Until now, the reason why conversion occurs *automatically* has been something of a puzzle. Existing models motivate convertibility as a means of providing *entrepreneurs* with the correct incentives, so conversion is always in the venture capitalist's interest ex post, making the *compulsion* to convert redundant. We show that convertibility can also be used to motivate *venture capitalists* (in particular, not to fund competing firms); conversion is not necessarily in the venture capitalist's interest ex post, so compulsion is necessary.

The plan of the paper is as follows. Section 2 sets out the basic model. Section 3 examines the second-best financial contract between the incumbent firm and the investor, and explains why financial entry deterrence will not generally be possible under such a contract. The entry deterring (third best) contract is set out in section 4. Section 5 discusses some extensions of the basic model, and section 6 presents the applications to banking regulation and venture capital. Section 7 concludes.

2 The Model

2.1 Basic Structure

Two entrepreneurs have the opportunity to enter a new and profitable industry; each of them has to make an investment I_i in order to enter the industry and produce. The entrepreneurs have no internal funds: thus, they must borrow I_i from an external investor.[3]

For ease of exposition, we assume that only one investor can finance this industry. This assumption is not essential to our results, which would hold provided there is some form of imperfect competition between investors.[4] However-

[3] For evidence that entrepreneurs are indeed constrained in setting up and running firms by their ability to borrow, see Holz-Eakin et al (1994) and Evans and Jovanovic (1989).

[4] The simplification from imperfect competition to monopoly is standard in the foreclosure literature (see Rey and Tirole, forthcoming). The incentive to exclude clearly depends on the idea that there is imperfect competition between investors, since otherwise an entrant denied funding will simply accept an identical offer from another investor. For evidence that some financial markets are indeed uncompetitive, we refer the reader to the later discussion

ever, it greatly simplifies the analysis and the drawing of parallels to the Coase problem in input supply markets. No important insights are lost in simplifying from imperfect competition to monopoly in the market for funds, apart from the impact of the level of financial competition on the design of claims. We address this briefly in section 5.3.

We assume that the single investor has cost of funds r=1 and makes take-it-or-leave-it offers to the firm(s).[5]

Project:

Once started, each firm's project is subject to moral hazard. After the project is financed, entrepreneur i chooses a level of effort $e_i \in [\Delta, 1]$, which is not observed by the investor. We assume $\Delta \leq 1/2$. Entrepreneurial effort raises the probability of success, which also depends on whether the firm enjoys a monopoly position or it competes with the other firm.

Under monopoly, if effort e_i is exerted then the project yields R^H (success) with probability e_i and R^L (failure) with probability $(1-e_i)$, where $R^H > I > R^L > 0$.[6]

Competition reduces the probability of success by Δ.[7] That is, under duopoly, effort e_i induces a probability of success of just $(e_i - \Delta)$ for firm i. Moreover, firm j's effort does not affect i's probability of success and vice versa.[8] This is the simplest possible way of capturing the idea that competition

in section 6.

[5]The results would be even stronger if we instead allowed firms to make take-it-or-leave-it offers to the investor. But given the investor's monopoly position, it seems reasonable to give him the bargaining power.

[6]In a sample of 49 venture capitalists, Gorman and Sahlman (1989) report that most venture-backed companies that have failed to meet expectations still manage to "squeeze out a stable, independent existence", which supports our assumption that $R^L > 0$. The interest of the assumption $R^L > 0$ is that it becomes possible to distinguish between debt and equity, which are equivalent if there are no returns to divide in the failure state.

[7]In Gorman and Sahlman (1989), 34% of the venture capitalist respondents cited competition as a factor contributing to financed companies' failure. For more general evidence that competition reduces the probability of survival, see Hannan and Freeman (1989), or Carroll and Hannan (1989). See also the next footnote. Similar results can be obtained when competition reduces revenues in case of success; but the analysis is considerably more cumbersome, so we use this simpler set-up.

[8]See Cestone and White (2000) for some stylized examples as to when such an assumption might be taken literally. Here we make it mainly for modelling purposes. It has several advantages, including allowing us to be agnostic on whether competition increases or reduces optimal effort by managers (on which the literature is inconclusive - see Hart (1983), Martin (1993)). A probably more realistic alternative would be to assume that firm i's probability of success is reduced by firm j's effort (although this is not obvious since some efforts, such as advertising, may be mutually beneficial). In this case, a different type of entry deterrence becomes possible. If Firm 1 commits to a high effort, Firm 2's entry becomes more and more unprofitable *per se*. This is the standard form of entry deterrence, just like accumulation of capital à la Spence (1977) and Dixit (1979, 1980). Rather than repeating

shifts probability mass from high revenue to low revenue outcomes.

Preferences:

All agents are risk-neutral. Firms 1 and 2 are identical. Entrepreneur i's von Neumann-Morgernstern utility function is

$$U(R_{bi}, e_i) = R_{bi} - \Psi(e_i)$$

where R_{bi} is the expected monetary payment borrowing firm i receives after revenues are realized. Effort e_i costs $\Psi(e_i)$ to the entrepreneur. Thus, were he to receive a flat payment, he would exert the lowest possible effort. The function $\Psi(\,\cdot\,)$ is strictly increasing, twice continuously differentiable and convex. Entrepreneurs have reservation wage W_i. The simplest way to think of this parameter is in terms of the entrepreneur's outside wage: how much he could earn if he did not borrow from the investor to start his own firm. A related idea is that the entrepreneur has some bargaining power in dealing with the investor, and so is able to extract rents of value W_i. However, one could also think of W_i as the best offer that the entrepreneur i has received from competing investors. In this case a higher W_i would correspond to more competition between investors. A third interpretation for W_i is in terms of assets provided by the entrepreneur. This third interpretation would result in the investor solving somewhat different optimization programs, but the basic insights would be similar. For concreteness we will proceed in terms of the first interpretation because it yields the most straightforward analysis.

For notational simplicity, we will omit the subscript 1 when referring to Firm 1: therefore Firm 1's return, effort and reservation wage will be R_b , e and W throughout.

Timing:

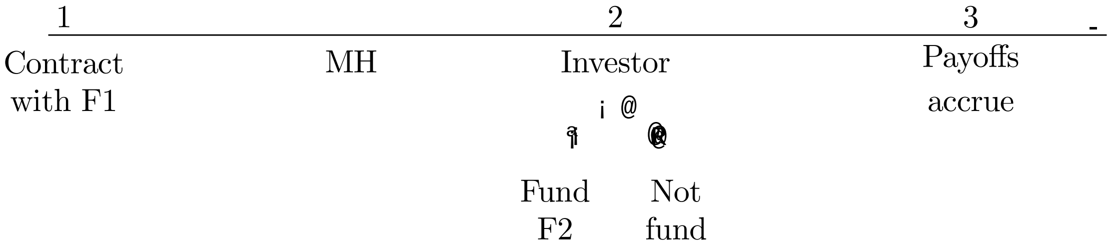
t=1 The investor offers a contract to firm 1. Firm 1 accepts or rejects. If Firm 1 accepts, then it picks a level of effort $e \in [\Delta, 1]$. The effort decision is pure moral hazard, not observed by the investor.

t=2 The investor decides whether to fund Firm 2 or not; if it decides to do so, it offers a contract to Firm 2, which then accepts or rejects. Firm 2 observes whether firm 1 has been funded when considering the investor's offer. If Firm 2 accepts the contract, then it picks an effort level $e_2 \in [\Delta, 1]$.

t=3 Payoffs are realized according to the manager's level of effort and to whether the investor has funded one or both firms

The timing of the model is summarized in the following figure:

standard arguments, we work with the simpler case where efforts are neither complements nor substitutes in order to focus attention on the new form of entry deterrence.



Contracts:

Financial contracts simply state a rule for splitting the cash-flow. More precisely, a contract is a pair of real numbers R_b^L, R_b^H specifying the entrepreneur's payoff in case of failure and success. Any borrower is protected by limited liability; therefore $R_b^L \geq 0$ and $R_b^H \geq 0$. We assume that it is impossible to write an *exclusive dealing* contract, imposing some form of punishment for the investor contingent on whether he funds the new entrant Firm 2. Very likely, such a contract would be illegal and thus not enforceable.[9] Moreover, since Firm 1's success or failure are both consistent with either competition or monopoly, the parties cannot circumvent this legal constraint by contracting on revenues.

2.2 Entry Deterrence and the Coase problem

The industry has the same structure as in the foreclosure literature. The investor plays the role of an upstream monopolist, providing downstream firms with an essential input to the production process (money); there is potential competition in the downstream industry, but it can develop only if both firms have access to funding.

The investor can offer a contract to one or both firms. If only one firm

[9] An alternative reason why a contract which is directly contingent on firm 2's existence is not used lies in the difficulty of verifying whether firm 2 is indeed competing with firm 1. An exclusive dealing clause would then be inefficient in that it might discourage funding of valuable, non-competing firms. More generally, we believe that because the legal process is time-consuming and costly, parties may prefer to use financial rather than legal incentives to prevent competition emerging.

is funded, it then enjoys a monopoly position; otherwise, the two firms compete in the product market, which makes expected industry-wide profits lower. Defining V^M and V_i^C as monopoly profit and duopoly profits net of agency costs,[10] the interesting case clearly arises when:

$$V^M > V_1^C + V_2^C$$

that is, when the investor (who captures the surplus from lending) should optimally let just one firm enter the industry and deny funding to other firms. From the point of view of the investor, this is clearly a matter of *financial entry deterrence*: if he does not offer funding to the second firm, the latter cannot enter. But in fact, matters are not so simple. Readers familiar with the foreclosure literature will guess that the investor faces a commitment problem in not funding Firm 2. After having funded Firm 1, the investor may have an incentive to behave opportunistically and also let Firm 2 enter the industry. To be more specific, assume Firm 1 is naive and signs the financial contract expecting to enjoy a monopoly position; it may then be ex-post optimal for the investor to expropriate firm 1 by funding Firm 2 as well. In equilibrium Firm 1 will anticipate this opportunistic behavior, so the investor would like to commit not to fund firm 2. This commitment problem is what - by analogy to the new foreclosure doctrine - we call *the investor's Coase problem.*[11] Thus in what follows we will refer to successful financial entry deterrence as having solved the investor's Coase problem.[12]

Two features of our model are crucial for the Coase problem to arise: first, when Firm 1 signs the financial contract with the investor, it does not observe whether Firm 2 is being funded or not (note that contracting need not be sequential; the Coase problem would also arise with simultaneous *and secret* contracts). Second, the contract with Firm 1 cannot be made contingent on whether Firm 2 is funded.

[10] A formal definition for V^{M} and $\mathsf{V}_{\mathsf{i}}^{\mathsf{C}}$ will be given later.

[11] The Coase problem is so-named because of the further analogy with Ronald Coase's (1972) discussion of the commitment problem faced by a durable good monopolist.

[12] Notice that although economists are accustomed to thinking in terms of credit-rationing, from the industry point of view what the investor faces here is a problem of *over-funding.* As in the foreclosure literature, the investor always has incentives to supply more than the ex-ante optimal amount of credit to the downstream firms.

3 The optimal contract without potential entrants

3.1 The commitment case

Before dealing with the investor's Coase problem, we solve the benchmark (monopoly) case where Firm 1 faces no threat of entry by potential competitors. This is equivalent to assuming that the investor can credibly commit not to fund any other firm in the industry. In this case the optimal financial contract for the investor solves:

$$\begin{array}{ll} Max_{R_b^H, R_b^L, e} & \left[e(R^H - R_b^H) + (1-e)(R^L - R_b^L) - I_1 \right] \\ (IR) & eR_b^H + (1-e)R_b^L - \Psi(e) \geq W \\ (IC) & R_b^H - R_b^L = \Psi'(e) \\ (LL) & R_b^L \geq 0,\ R_b^H \geq 0 \end{array}$$

We will refer to the solution to this program as the *second best* optimum, and denote the associated effort level by e^M (M for monopoly).[13] R_b^L and R_b^H are the borrowing firm's payoffs in case of failure and success. (IR) is the firm's participation constraint and (IC) is the firm's incentive constraint. (LL) is the limited liability constraint. The solution to this program depends on the level of W. We state this result in the following:

Lemma 1 *In the absence of potential competitors, the investor's optimal claim is debt: $R_b^L = 0$ and $R_b^H = \Psi'(e^M)$, where e^M is the second best effort. Also, there exists a threshold level $W_1 = e^M\Psi'(e^M) - \Psi(e^M)$ for the firm's reservation wage such that:*

(i) for $W \leq W_1$ optimal effort e^M solves $R^H - R^L = \Psi'(e) + e\Psi''(e)$.

(ii) for $W_1 < W \leq \bar{W}$ optimal effort e^M solves $e\Psi'(e) - \Psi(e) = W$ and therefore increases with W.

Effort levels satisfy: $e^M < e^*$ (the first best effort) for any W.

Proof. See Appendix ■

The interpretation of this result is straightforward: as the security design literature has pointed out, the optimal financial contract minimizes agency costs by paying the entrepreneur only in case of success, which boils down to

[13] If effort was observable then the optimal financial contract would solve:

$$Max_{R_b^L, R_b^H, e} \left[e(R^H - R_b^H) + (1-e)(R^L - R_b^L) - I_1 \right]$$

$$e R_b^H + (1-e)R_b^L - \Psi(e) \geq W \qquad (IR)$$

$$R_b^L \geq 0,\ R_b^H \geq 0$$

The first best level of effort e^* is thus defined by the first order condition:

$R^H - R^L = \Psi'(e^*)$.

taking a debt claim in the firm.[14] Also, when W is low, inducing the second best effort e^M requires leaving the entrepreneur with an extra rent; therefore, the first order condition in (i) trades off the cost of this rent with the benefit from higher effort. When W is higher than W_1 the contract in (i) does not satisfy the entrepreneur's IR. Clearly, for this constraint to hold, only the payment in the high state $R_b^H = \Psi'(e)$ is increased, which is equivalent to increasing effort.

The entrepreneur's shares of returns in the cases of failure and success are, respectively, 0 and $\Psi'(e^M)$. This can be interpreted as a debt contract specifying a reimbursement $D^M = R^H - \Psi'(e^M)$. Note that debt is always risky, as $e^M < e^*$ implies $D^M = R^H - \Psi'(e^M) > R^L$. Not surprisingly, the investor's debt claim is relatively risky for low levels of W and becomes safer as W increases: higher levels of W imply more high-powered entrepreneur's incentives, which correspond to a safer claim for the investor.

3.2 Why lack of commitment yields a Coase Problem

When the investor cannot commit to deny funding to subsequent new-entrant firms, it can be shown that the first entrepreneur does not accept the terms of the second-best contract derived in lemma 1 above, unless his reservation wage is very low.

Suppose the above debt contract is signed at stage 1. At stage 2 a second entrepreneur wants to copy Firm 1's entrepreneurial idea and produce a competing product. However, Firm 2 has no funds: to enter the market it must obtain financing from the only investor who is sufficiently informed about the industry - that is, Firm 1's financier.

The second entrepreneur is as good as the first one in implementing projects. However, he is not an innovator (i.e., has no talent at discovering new projects), which suggests his reservation wage is lower than the first entrepreneur's one. For simplicity, we will assume throughout that $W_2 = 0$.[15]

The gross return from funding Firm 2 is:

$$\begin{aligned} \mathsf{V}_2 = Max_{e_2, R_{b2}^{\mathsf{L}}, R_{b2}^{\mathsf{H}}} \; & (e_2 - \Delta)(R^H - R_{b2}^H) + (1 - e_2 + \Delta)(R^L - R_{b2}^L) - I_2 \\ s.t. : \; & (e_2 - \Delta)R_{b2}^H + (1 - e_2 + \Delta)R_{b2}^L - \Psi(e_2) \geq 0 \end{aligned}$$

[14] For a detailed derivation of this result, see Innes (1990).

[15] This assumption is inessential, but one needs to make some assumption about the correlation between the two entrepreneurs' reservation wages and this is the simplest. We can interpret $\mathsf{W}_2 = 0$ in terms of the two alternative motivations for reservation wages given in section 2.1 above. For instance, competition to fund the second firm may be less intense than competition to fund the first firm, e.g. because the investor learns something about the second firm from funding the first firm, so outside banks are worried about winners' curse problems in competing to fund Firm 2.

$$R_{b2}^H - R_{b2}^L = \Psi'(e_2)$$
$$R_{b2}^L \geq 0,\ R_{b2}^H \geq 0$$

Now, will the investor want to strike a deal with Firm 2 ? In other words, will an investor's "Coase problem" arise, whereby the investor (ex-post) optimally floods the industry with financial funds? The answer is "yes" if the following condition holds:

$$e^M(R^H - \Psi'(e^M)) + (1 - e^M)R^L <$$
$$(e^M - \Delta)(R^H - \Psi'(e^M)) + (1 - e^M + \Delta)R^L + \mathsf{V}_2$$

The left-hand side of this inequality is the value of the investor's claim in Firm 1 when the contract $R_b^L = 0, R_b^H = \Psi'(e^M)$ is in force and Firm 2 is *not* funded. The right-hand side is the value of the investor's claim in F1 when the same contract holds and Firm 2 is funded, *plus* the return from funding Firm 2.

This can be rearranged as condition (1):

$$\Delta(R^H - R^L - \Psi'(e^M)) < \mathsf{V}_2 \tag{1}$$

When deciding whether to fund Firm 2, the investor trades off the additional payoff V_2 with the reduced value of his claim in Firm 1 induced by market competition. As competition reduces the probability of success of both firms, the investor's claim is affected by Firm 2's entry only if it is risky, that is, if $R^H - \Psi'(e^M) > R^L$. Also, the riskier the investor's claim, the less will he be tempted to fund Firm 2.

The above reasoning underlines the first important result of our paper: *an investor holding sufficiently safe debt in a firm will always find it optimal to fund the firm's rivals.*

Knowing that the investor will be tempted to supply a second firm ex-post, the first entrepreneur will accept the contract $R_b^L = 0,\ R_b^H = \Psi'(e^M)$ if and only if: $W \leq W_0 = (e^M - \Delta)\Psi'(e^M) - \Psi(e^M)$, that is, whenever his reservation wage is very low. When W is larger than W_0 the entrepreneur will not accept this contract and the investor will bear ex-ante all the cost of his future lack of commitment, obtaining just the duopoly profits (net of agency rents) from the industry. It is in this case that the investor will look for a contractual solution to eliminate the temptation of opportunism. As we are interested in analyzing this contractual response to the Coase problem, in what follows we will assume $W > W_0$.

4 Excluding Firm 2

We have seen that an investor's Coase problem arises whenever his claim satisfies condition (1). If he wants to preserve the innovating firm's monopolistic rent, the investor must take into account his future opportunistic behavior when solving for the optimal contract. This boils down to making the investor's claim more sensitive to the effect of competition on firm 1's profit.

More formally, the optimal contract offered to F1 is the solution to the following program:

$$Max_{R_b^H, R_b^L, e} \left[e(R^H - R_b^H) + (1-e)(R^L - R_b^L) - I_1 \right]$$
$$(IR) eR_b^H + (1-e)R_b^L - \Psi(e) \geq W$$
$$(IC) R_b^H - R_b^L = \Psi'(e)$$
$$(IC_I)\ e(R^H - R_b^H) + (1-e)(R^L - R_b^L) \geq$$
$$(e-\Delta)(R^H - R_b^H) + (1-e+\Delta)(R^L - R_b^L) + \mathsf{V}_2$$
$$(LL)\ R_b^H \geq 0,\ R_b^L \geq 0$$

This program may be referred to as the *third best* optimum: when a potential entrant exists, the optimal contract must also satisfy the investor's incentive compatibility constraint (IC_I). The third best solution is described in the following:

Lemma 2 *Assume that at t=2 firm 2 will ask for funding to compete with firm 1. Assume also that condition (1) holds. Then the optimal financial contract induces a level of effort* $e^{CP} < e^M$*. Also, there exists a threshold level* $\hat{W} = e^{CP}\Psi'(e^{CP}) - \Psi(e^{CP})$ *for firm 1's reservation wage such that:*

(i) for $W \leq \hat{W}$ *the optimal contract is:* $R_b^L = 0$, $R_b^H = \Psi'(e^{CP})$

(ii) for $W > \hat{W}$ *the optimal contract is:* $R_b^L = b = W - \hat{W}$, $R_b^H = b + \Psi'(e^{CP})$

Proof. If condition (1) holds for $e = e^M$, then any contract specified in Lemma 1 fails to satisfy $(IC)_I$, and thus cannot be a solution to the above program. In order to solve his Coase problem the investor must make his claim riskier, i.e. reduce $\Psi'(e) = R_b^H - R_b^L$. This requires inducing an effort level e^{CP} lower than e^M. Clearly, effort is reduced only until the incentive constraint holds strictly. Therefore e^{CP} is uniquely determined by:

$$\Delta(R^H - R^L - \Psi'(e^{CP})) = \mathsf{V}_2$$

From the firm's (IC) constraint it then follows that $R_b^H = R_b^L + \Psi'(e^{CP})$. Therefore, we are left with choosing the optimal level of R_b^L.

If $W \leq \hat{W}$ effort e^{CP} is induced by paying the entrepreneur $R_b^L = 0$ and $R_b^H = \Psi'(e^{CP})$, which satisfy as an inequality the entrepreneur's (IR) constraint. This contract is uniquely optimal for the investor, in that raising R_b^L would only raise agency costs.

If $W > \hat{W}$ then the previous contract fails to satisfy the entrepreneur's (IR). Therefore R_b^L must be increased up to $b > 0$ to satisfy: $e^{CP}\Psi'(e^{CP}) + b - \Psi(e^{CP}) = W$. Accordingly, $R_b^H = b + \Psi'(e^{CP})$. ■

We provide the following interpretation for the above result. When the Coase problem arises, the financial contract must solve a double-sided moral hazard problem. The investor is faced with the following trade-off. To induce high levels of effort he would like to have the entrepreneur bear most of the risk. But on the other hand, the investor has to bear sufficient risk to prevent himself from funding the second firm. In other words, he must internalize the uncertainty induced by increased competition, which pushes towards a less high-powered incentive scheme for the entrepreneur. The Coase problem can be solved only at the expense of less entrepreneurial effort.

The optimal contract for which we have just solved is simply a profit-sharing rule. We now ask ourselves how this rule can be implemented through existing financial instruments. It turns out that the third best contract is more equity-like than the second best contract defined in the previous section. The features of the "anti-competitive" financial contract are described in the following:

Proposition 3 *An investor wanting to supply only the monopoly amount of capital to the industry designs his financial claim in order to solve his "Coase problem":*

(i) if $W \leq \hat{W}$ then he holds risky debt. The entrepreneur owes him $D_r = R^H - \Psi'(e^{CP})$; in the case of failure the entrepreneur defaults and the investor seizes the firm's cash R^L. This claim is riskier than debt D^M.

(ii) if $W > \hat{W}$ then the investor holds a combination of safe debt and equity. He is entitled to the debt reimbursement $D_s = R^L - \frac{b(R^H-R^L)}{\Psi'(e^{CP})}$, and also owns an equity share $s = 1 - \frac{\Psi'(e^{CP})}{R^H-R^L}$ in Firm 1.

Proof. (i) From Lemma 2 (i), the investor's shares of returns are R^L and $R^H - \Psi'(e^{CP})$. It is straightforward to interpret this as holding debt D_r. From $e^{CP} < e^M$ and $\Psi'' > 0$ it follows that $D_r > D^M$: reimbursement is larger and default more likely. (ii) Suppose the investor holds debt D_s and an equity share s. Then his payoff in case of failure is:

$$D_s + s\left(R^L - D_s\right) \equiv R^L - \frac{b(R^H-R^L)}{\Psi'(e^{CP})} + \left(1 - \frac{\Psi'(e^{CP})}{R^H-R^L}\right)\left(R^L - R^L + \frac{b(R^H-R^L)}{\Psi'(e^{CP})}\right)$$

$\equiv R^L - b$. Analogously, his payoff in case of success is:

$$D_s + s(R^H - D_s) \equiv R^L - \frac{b(R^H-R^L)}{\Psi'(e^{CP})} + \left(1 - \frac{\Psi'(e^{CP})}{R^H-R^L}\right)\left(R^H - R^L + \frac{b(R^H-R^L)}{\Psi'(e^{CP})}\right)$$

$\equiv R^H - b - \Psi'(e^{CP})$.

Therefore, the optimal return-splitting rule is being implemented ■

This result is quite intuitive: an investor holding fairly safe debt in firm 1 will always want to fund Firm 2, as his claim is insensitive to the effects of competition. Also, the temptation to expropriate Firm 1 by funding Firm 2 will be stronger the higher is W, the entrepreneur's stake in the project. To solve this commitment problem the investor will make his claim riskier.

This may turn out to be simply riskier debt as in case (i), or, when the Coase problem is very serious, a combination of debt and equity as in case (ii). Note that risky debt can always be reinterpreted as a combination of safe debt and equity. Therefore, we can reinterpret Proposition 3 in the following way. For any level of W, the investor holds a combination of safe debt and an equity share $s = 1 - \frac{\Psi^{\theta}}{R^{\mathsf{H}} - R^{\mathsf{L}}}$; (i) if $W < \hat{W}$, then safe debt is equal to R^L; (ii) if $W \geq \hat{W}$, then safe debt is $R^L - \frac{b(R^{\mathsf{H}} - R^{\mathsf{L}})}{\Psi^{\theta}}$. In both cases, the investor holds the same kind of claim, except that the riskless component is reduced as W grows larger: for large values of W the safe debt component becomes smaller and the investor gets most of his return from his equity-holding. This is because a larger entrepreneurial stake implies a more serious commitment problem for the investor.

There is a close analogy between our financial contracting result and the remedies for the upstream monopolist's Coase problem envisioned by the foreclosure doctrine. As Rey and Tirole (2000) suggest, the upstream monopolist may want to integrate downwards with one of the downstream firms, in order to eliminate the temptation of opportunism and credibly commit itself to reduce supplies to downstream firms. Equity-holding plays the role of vertical integration in our context.

Our result provides an explanation for why equity financing is widely used even in environments characterized by strong informational asymmetries, such as the financing of new firms and emerging industries. Agency theory suggests that an investor concerned by the asymmetry of information associated with start-ups, should hold *low information intensity* securities, such as debt (see, e.g. Myers-Majluf 1984). That such firms are often financed by equity issues is therefore something of a puzzle. Existing explanations for the use of equity have pointed to the need to reduce excessive risk-taking by the entrepreneur. However, we argue that the use of equity in such industries can often be seen as a response to the Coase problem. Two features of new industries make them particularly vulnerable to the Coase problem. Firstly, successful entry into an emerging industry is often easier than entry into a mature industry comprising firms with established reputations, so the temptation to fund competitors is greater. Secondly, the riskiness of start-ups means that few investors are willing to provide capital to such firms, so investors in such industries have a degree of monopoly power over entrepreneurs. An important class of investors in start-ups and new industries are venture capitalists. Therefore, in section 7 we extend our model to perform a more specific analysis of the venture capital industry.

5 Some Extensions and Generalizations

5.1 Remarks on Welfare Analysis

It would be desirable to perform some welfare analysis on the above model. However, much depends on the *social desirability* of introducing competition to an industry, which has not so far been specified. In general, competition will improve consumer welfare ex-post through higher output and lower prices, so that one might suppose that it would be desirable for financial regulators to try to prevent investors from solving the Coase problem. But if the entrepreneur has a high reservation wage, he might be deterred from entering the industry at all if the Coase problem cannot be solved. For example, if:

$$V^M > W > V_1^C$$

then the entrepreneur can be persuaded to enter the industry only if he can be guaranteed a monopoly position. In this case regulation making the solution of the Coase problem more difficult would prevent the emergence of this new industry. Thus one might suppose that the social optimum would be achieved by a policy of allowing investors to hold equity in situations where it is important to allow monopoly rents, e.g. as a reward to innovation, but to prevent them from doing so otherwise. This is simply another guise of the familiar Schumpeterian trade-off. Using this scheme and the results of our model, it may be interesting to speculate about the regulation governing investments by banks in different countries. We pursue this issue more fully and provide more evidence in section 6.1. However, we feel that any welfare analysis of the effects of using different types of financial claims is incomplete if it does not take into account the fact that if deprived of one potential instrument for solving the Coase problem, investors may use other, more costly means to do so. In the following subsection, we briefly mention one alternative solution to the over-funding problem.

5.2 Lack of Monitoring by Investors

Let us assume that Firm 2's project may be of two types. With probability α the project is "good", in which case funding Firm 2 yields V_2 to the investor. With probability $(1-\alpha)$ the project is "bad", and it yields to the investor $\underline{\mathsf{V}}_2 < 0$. Assume that in the process of funding firm 1, the investor may observe a signal about Firm 2's profitability, i.e. he may find out whether Firm 2 is good or bad. Now suppose we make the additional assumption that:

$$\alpha \mathsf{V}_2 + (1-\alpha)\underline{\mathsf{V}}_2 < 0$$

Then on average the investor makes negative profits with the second firm, so if he did not receive any signal about the second firm, then he would not want to fund it. The Coase problem arises only if the investor receives a good signal about the second firm. Therefore an obvious way for the investor to solve his Coase problem is to avoid learning the value of the signal. If Firm 1 knows that the investor simply does not have the infra-structure or expertise to interpret the signal, for example, then he knows he is safe from investor expropriation. Thus the firm and the investor can benefit from the investor failing to set up such means of monitoring, since it enables them to write a more high-powered (debt-like) contract for the firm, inducing more effort. We interpret this variation of the model as one of commercial bank lending. Venture capitalists (and universal banks) monitor the firms in which they invest very closely, whereas in the UK and US, commercial banks do notoriously little monitoring. This is a simple demonstration of the fact that ill-informed investors will generally face fewer over-funding problems, and that manipulation of the information available to the investor provides a second means of solving the Coase problem. Of course, in this simple model lack of monitoring is costless for the investor, whereas it will generally be associated with adverse selection and moral hazard problems. Then investors must trade-off the costs of deliberately inducing such problems with their benefits (in the form of reduced temptation to fund Firm 2). As we saw above, solving the Coase problem through the design of financial claims is also costly in terms of managerial effort, so in general there will be a further trade-off to be made between the two types of solution. In addition, there is also a well-known feedback mechanism between the type of claim held and the incentive of the investor to engage in monitoring (see e.g. Holmström and Tirole 1993). We hope to investigate some of these issues in more detail in future work.

5.3 Imperfect Capital Markets and Industrial Concentration

So far in this paper we have assumed that there is one investor who is the unique source of funds for the industry. In this case, if the investor has appropriate financial incentives to deny funding to Firm 2, the latter will not be able to enter the industry and compete. To what extent is our analysis robust to the introduction of competition in the credit market?

We address this issue at greater length elsewhere (Cestone-White 2000), where we show that the main insights from the monopoly case continue to hold as long as competition in the credit market is *imperfect*. The new feature is that, when the first investor can be *bypassed*, *some* competitors may enter the product market in equilibrium.[16] The optimal anti-competitive contract commits the investor to fund *only* the entrants that the second investor would also fund. As in the present paper, this commitment can only be achieved by taking a riskier claim in the incumbent firm.

These points can easily be understood with the aid of the following simple example.[17] First notice that if Firm 2 could turn to a *perfectly* competing source of funds, it would always enter the market; therefore, the first investor would never bother to take (costly) equity in Firm 1, as this would not prevent competition in the product market. Therefore suppose that the second investor competes imperfectly with the first investor, because he has a higher cost of funds: $r_2 > r_1 = 1$. Once Firm 1 has been funded by Investor 1, the second investor will fund Firm 2 if and only if $\mathsf{V}_2 - (r_2 - r_1)I_2 \geq 0$. Then two possible cases may arise. If $0 < V_2 < (r_2 - r_1)I_2$ there is no competition to fund Firm 2, and the first investor can prevent competition in the product market by simply committing himself not to fund Firm 2. In this first case the Coase problem is an issue and anti-competitive *equity* financing arises as in Proposition 3 above. If instead $V_2 \geq (r_2 - r_1)I_2$, then Firm 2 can always turn to the second investor if denied funding by the first investor. Anticipating this, the first investor will itself fund Firm 2 and take a *debt* claim in Firm 1.

The above example, though incomplete, illustrates two important points. First, when the credit market is imperfectly competitive, anti-competitive goals have the same *qualitative* impact on financial contracts as in the monopoly case: investors take high-powered claims when they aim to deter entry (i.e. when V_2 is low enough for this to be feasible). Second, *more competition in the credit market spurs more intense competition in the product market* (as r_2 becomes smaller, it is more likely that Firm 2 is funded in equilibrium). This is because when competition in the credit market becomes more intense, the efficient investor has less leeway in restraining entry in the downstream industry.[18]

[16] For an analysis of *bypass* in a foreclosure setting, see Rey and Tirole (2000).

[17] The following example is a simplification of our extended model. In the latter we assume a continuum of potential entrants with different values V_2. Only those entrants with higher values can afford to approach a less efficient investor, and thus are not subject to financial entry deterrence.

[18] The question of how increased credit market competition should affect the design of financial contracts is more complex. Two conflicting effects are at work. On the one hand, when the credit market becomes more competitive (r_2 becomes smaller relative to r_1), the Coase problem arises 'less frequently', making the investor's claim more low-powered or debt-like. On the other hand, in the presence of competition, the reservation wages of the firms become endogenous. A more efficient competing investor will also offer a better deal to Firm 1, which has then a higher reservation utility W_1. This second effect means that the first entrepreneur gets more rent and results in an increased payment for the entrepreneur in the low state. As pointed out in section 4, a larger entrepreneurial stake then feeds back

This point is intuitively clear, and is confirmed by historical evidence on the joint evolution of capital market institutions and industry structure. Davis (1966) provides several case studies of emerging industries in 19th century U.S. and U.K to argue that in the U.S. "some firms were more successful than others in their search for 'informal finance', and the successful firms grew at the expense of their less fortunate competitors. As a result, industrial concentration increased in the affected industries." Conversely, in England, "because the capital markets were better", industries "did not become unduly concentrated". It is surprising therefore, that the idea has not received more attention in the literature. In fact, previous theoretical work assessing the impact of credit market competition has instead taken a *partial equilibrium* approach, abstracting from any interaction with other markets.[19] This may have led to policy prescriptions biased in favor of credit market concentration. Our paper is among the first to show that countries with poorly competitive financial markets may risk the emergence of industrial concentration. In light of this new theory, we argue that the anti-trust monitoring of financial and product markets should be better coordinated.

6 Two Applications

6.1 Banking Regulation

In some countries, and at some times in the past, the banking industry has not been perfectly competitive. These settings provide an application for our theory. For example, De Long (1990) argues persuasively that there were severe barriers to entry (mainly in the form of reputational capital) in the investment banking industry in the US in the early twentieth century. He argues that although the investment bankers performed a useful monitoring and certification role, "some share of the increase in value almost surely arose because investment banker[s]...aided the formation of oligopoly." Later he remarks that "Often 'Morganization' meant the creation of value for shareholders by the extraction of monopoly rents from consumers". Our theory explains how this was possible, and also why the Glass-Steagall Act (1933) (which prohibits equity-holding by commercial banks) put an end to so-called financial capital-

into a more serious commitment problem for the investor, implying a more high-powered claim if the Coase problem is to be solved.

[19]See for instance Petersen and Rajan (1995) or Matutes and Vives (1996). A notable exception is Gonzalez-Maestre and Granero (1999) who allow industry and credit-market structure to be determined endogenously and simultaneously as firms need bank loans to enter the market. However, in that model, the terms of the bank-firm repayments are made contingent on the number of competitors that are funded to enter the market, so the Coase problem does not arise.

ism in the United States (Segliman 1982). The extension of monopoly power by banks into industry requires the double coincidence of imperfect competition in the banking industry and bank equity-holding.[20]

A major policy debate is now in course as to whether this restrictive legislation should be relaxed. In his overview of the costs and benefits of such a reform, Saunders (1994, pp.239-40) expresses concern that, "*A bank may restrict the supply of credit to the competitors of its commercial firm affiliate...while showing preferential credit treatment towards its affiliated firm... This issue is important given the widely held public policy view that banks are 'special' in their provision of loans or credit finance to corporations.*" *The Economist* (Feb 1st 1997) also asks whether pressure to reform the Glass-Steagall Act "might not ...recreate the cartels of [J.P.] Morgan's day?" Our model suggests that these fears would indeed be rationally grounded, if US financial markets were today as uncompetitive as 70 years ago.[21] But given the competitiveness of sources for funding in the US, a relaxation of the rules will probably have little impact.

In countries where funding opportunities are more scarce, however, equity holding by banks may give more cause for concern. For example, entrant firms in Eastern Europe face severe funding shortages because there is little competition in the banking industry, and little opportunity for outside funding (Pissarides 1998). Moreover, existing banks tend to be biased towards funding only incumbent firms (Gordon 1994, p59, Frydman et al 1993). In these circumstances it might be advisable for these countries to avoid bank equity holding, rather than encouraging bank debt-equity swaps in the old state industries, as has sometimes been the case (for a description of events in Poland, Hungary and Slovenia, see for example van Wijnbergen 1998).

This analysis assumes of course that competition is beneficial (see section 5.1 above). However, there may be instances where it is desirable to hold off competition in order to stimulate growth. The situation in Eastern Europe probably does not correspond to such an instance, since it is the new entrant firms - currently starved of funding - which are most likely to generate new growth, rather than the larger former state-owned incumbent enterprises (Pissarides 1998). But economists such as Schumpeter and Gershenkron have

[20] For an alternative view of the impact of bank equity-holding, see Arping (1999). In the context of a perfectly competitive financial market he shows that if entrant firms face a soft budget constraint, limited ownership of established firms by banks can make it easier for young firms to obtain debt financing. As in our model, he shows that equity-holding makes banks act toughly towards entrants. But when the latter cannot otherwise commit to repay, bank toughness improves their ex post incentives, and thus their ex ante prospects of finance.

[21] De Long (1990) raises the interesting possibility that financial capitalism and lack of concentration in investment banking may be intimately linked, since it is difficult for banks with small market shares to maintain reputations.

argued that such a trade-off was indeed at the centre of the industrial revolution in Germany and elsewhere. A concise description of the role of large equity holding banks in Belgian, German and Italian industrialization can be found in Da Rin and Hellman (1998). It is clear that by holding equity, these banks (in contrast to the debt-holding British banks of the time, for example), had a very active interest in the profitability of the firms they funded. They limited product-market competition, but the monopoly profits made thus available were ploughed back into the business to produce very fast expansion. But as growth has slowed down in Germany in the last three decades, there has been more concern about the large stakes controlled by the banking system, and the banks have been the subject of several competitive investigations.[22] A more recent concern is that the German economy has not developed the small dynamic firms in information and bio-technology that have developed in the US and UK; to the extent that these industries exist in Germany, it is only as divisions of incumbent firms. Thus one might well worry that the universal banking system is beginning to stifle growth.

6.2 Convertible debt and the Venture Capitalist's Coase problem

6.2.1 Introduction

As mentioned above, the Coase problem may be particularly acute in emerging industries. In the US, such new industries are often financed by venture capital. Recent evidence (Gompers and Lerner 2000) suggests that, at least at times when the supply of funds to venture capital is tight, venture capitalists do have a degree of market power in financing entrepreneurs.[23] This is not surprising since the number of venture capitalists that an entrepreneur might approach for funding is often fairly limited: he must choose one which is locally-based and has specialized knowledge of the industry in which he will operate. The fact that venture capitalists invariably club together to form syndicates in financing firms further increases their monopoly power. Indeed, reading descriptions of the bargaining process between venture capitalist and entrepreneur, one has the impression that a substantial amount of bargaining power lies with the

[22] Note that the current German situation differs somewhat from our model in that the proxy voting system allows the banks to control a much larger fraction of shares than they actually own.

[23] Gompers and Lerner (2000) show that the price which venture capitalists pay entrepreneurs for shares in their firms rises when the supply of venture capital increases, and that this is not due to changes in firm characteristics, but rather to "money chasing deals" and venture capitalists competing to fund projects. The converse of this, of course, is that at times when the supply of funds is tight, then competition to fund projects is limited, and venture capitalists can exploit monopoly power in bargaining with entrepreneurs.

former. The entrepreneur's "outside option" lies not in competing offers from other venture capitalists (who, if interested, will very likely join the same syndicate once the deal is struck), but in finding other sources of funds (see e.g. Silver 1984, p.87).

A second feature of the venture capital environment makes them worthy of separate consideration. The venture capitalist is typically involved in close monitoring of the entrepreneur. As the relationship continues, the venture capitalist has access to marketing studies, the results of product testing and other short term performance measures, and so learns more about how to avoid pitfalls and problems in the industry. It is almost inevitable that through financing an innovating firm, the venture capitalist learns something about the likely profitability of the whole industry. He is then in a much better position to fund potential entrants, and is naturally tempted to make further use of his knowledge and exploit his comparative advantage in choosing and monitoring projects in this industry by funding a competing firm. Indeed, other venture capital partnerships will often try to persuade him to do so by offering very attractive deals to join their syndicate in order that they can benefit from his expertise.

Therefore, it is not very surprising that venture capitalists do sometimes succumb to the temptation to fund competing firms.[24] For example, amongst the syndicate funding Osborne Computer Corporation were Sevin, Rosen Partners, and First Century Partnership. Sevin, Rosen Partners was the lead investor in Compaq Computer Corporation, a competitor to Osborne. First Century Partnership was an investor in Gavilan Computer Corporation, a portable computer manufacturer (Silver, 1984 p.58). In a particularly severe case of over-funding (probably from a social as well as an industry point of view), Sahlman and Stevenson (1985) document "the six year long parade of venture capital investors into an emerging segment of the computer data storage industry. In all, 43 start-ups were funded in an industry segment that could be expected in the long run to support perhaps four."

Given the practical importance of the Coase problem for the venture capital industry, one might expect from the simple model of section 4 that they would hold common equity claims in their investments. This is indeed the case for late stage investments. For early stage investments, venture capitalists prefer to use convertible debt or convertible preferred stock (Sahlman 1990, Gompers 1996). In addition, the conversion often occurs *automatically* upon the attainment of

[24] As mentioned in section 5.3 above, it is simple to extend the model of section 4 to allow for cases where over-funding occurs probabilistically in equilibrium. If the investor does not know the value of V2 in advance of contracting with Firm 1, he trades off the certain reduction in Firm 1's incentives, against the chance that Firm 2 will be sufficiently profitable that he will be tempted to fund Firm 2 ex post. The optimal probability of entry will generally be strictly positive (see Cestone-White 2000 for more detail).

certain profits, sales, or performance milestones. We now extend our previous model to explain these facts. In this we bring a new insight to the study of venture capital finance. Previous models have focussed on the concave-convex shape of the return stream giving the entrepreneur desirable incentives not to engage in excessive risk taking (Gompers 1996, Biais and Casamatta 1999) or signal manipulation (Cornelli and Yosha 1997).[25] But in these models, the conversion of debt into equity is done to improve entrepreneurial incentives. It is in the venture capitalist's interest to convert when the good signal arrives (because he wants to constrain the entrepreneur), so it is not at all obvious why he should write an agreement constraining himself to do something which he will anyway find optimal ex post. Automatic conversion does not add anything to standard voluntary conversion agreements. Our model is the first which explains automatic conversion. As will become clear in the following analysis, the time-inconsistency feature of the Coase problem means that conversion must be agreed ex ante, because it may no longer be optimal ex post. Our explanation draws upon the feature of venture capital funding outlined above - that through early stage investments, the venture capitalist learns about the prospects for profitable entry into the industry.[26]

6.2.2 A Model of Convertible Debt

We use the same basic model as in section 4 above, but assume in addition that further information about *Firm 2's* profitability is revealed to all parties after the first stage of *Firm 1's* financing.[27] We show that even if there is no new information about firm 1 itself, it is optimal to make Firm 1's contract contingent on this information because of the need to solve the Coase problem. Our assumptions are specified in what follows.

Project

Firm 1's payoff structure is the same as in the basic model. Firm 2's project may be of two types. With probability α the project is "good", in which case it yields the payoffs R^H and R^L with the probabilities specified in the basic

[25] We focus here only on those papers which study the cash flow allocation created by convertible debt contracts, since this is also our approach. A second set of papers stresses the allocation of control rights induced by convertible securities. An earlier literature looks at how one might design claims to motivate venture capitalists (in particular, to ensure adequate monitoring). But this early literature does not explain the use of convertible debt.

[26] It is arguable that late stage investments do not involve much learning about industry prospects, because (a) usually by this late stage, the success of the industry is already assured and (b) late stage investments are usually undertaken by venture capitalists without specialized knowledge of the industry, with little monitoring. Thus the model of section 4 fits this situation without modification.

[27] More generally, one might suppose that new information about *Firm 1*'s profitability is also revealed as Firm 1's business plan proceeds, but we ignore this additional complication.

model. With probability $(1-\alpha)$ the project is "bad": it yields a zero payoff with some positive probability x. The stochastic structure of the payoffs for a bad project is summarized in the following matrix:

$$\begin{array}{cc} R^H & e_2-\Delta-x \\ R^L & 1-e_2+\Delta \\ 0 & x \end{array}$$

where e_2 is effort exerted by the second entrepreneur.

At the contracting stage neither the venture capitalist nor firm 1 knows firm 2's type.

Timing

The timing of events is as follows:

t=1 (Contracting stage) The investor offers a contract to Firm 1. Firm 1 accepts or rejects. At this stage neither the firm nor the investor knows Firm 2 's type.

t=2 (Start-up stage) In the process of starting Firm 1's project, the entrepreneur and the venture capitalist observe a signal about Firm 2's profitability: as a result, they find out whether Firm 2 is good or bad. The signal is verifiable.[28] At the end of this stage both parties have an exit option: they can abandon the project if their continuation payoff is negative.

t=3 (Production stage) Firm 1 picks a level of effort $e \in [\Delta, 1]$. This decision is not observed by the investor.

t=4 The investor decides whether to fund Firm 2 or not; if he decides to do so, he offers a contract to Firm 2, which then accepts or rejects. Firm 2 observes whether Firm 1 has been funded *and* knows its type when considering the investor's offer. If Firm 2 accepts the contract, it then picks an effort level $e_2 \in [\Delta + x, 1]$.

t=5 Payoffs are realized according to each manager's level of effort and whether the investor has funded one or both firms. The first entrepreneur and the venture capitalist share returns according to the contract signed at t=1. If Firm 2 was funded at t=4, then the second entrepreneur and the venture capitalist share Firm 2's profits according to the contract they signed then.

Firm 2's credit-worthiness

We define:

$$\underline{V}_2 = Max_{e_2, R^L_{b2}, R^H_{b2}} \, (e_2-\Delta-x)(R \;- R^H_{b2}) + (1-e_2+\Delta)(R^L - R^L_{b2}) - I_2$$
$$s.t.: (e_2-\Delta-x)R^H_{b2} + (1-e_2+\Delta)R^L_{b2} - \Psi(e_2) \geq 0$$
$$R^H_{b2} - R^L_{b2} = \Psi'(e_2)$$

[28] If the signal is not verifiable, the analysis would proceed in much the same way. There would be an additional incentive compatibility constraint on the investor's program (given below) to ensure that the investor indeed converts his debt when he would otherwise face the Coase problem.

$$R_{b2}^L \geq 0,\ R_{b2}^H \geq 0$$

$\underline{V}_2$ is the net present value of Firm 2's project, net of agency costs, when Firm 2 is "bad". Let us assume:

$$\underline{V}_2 < 0$$

A bad-type Firm 2 is never worth funding. This means that the Coase problem will not arise if, in the process of funding Firm 1, the venture capitalist receives a bad signal about Firm 2.

Funding a good-type Firm 2 yields V_2 to the venture capitalist, where V_2 is as defined in section 3.2. We assume that condition (1) holds, i.e. the venture capitalist is tempted to fund firm 1's rival whenever he receives good signals about its profitability (and holds the "second best claim" in Firm 1).

Contracts

The financial contract with Firm 1 can be made contingent on the signal observed at stage 2. Therefore, a contract specifies the firm's payoffs in each possible state of nature: $\left(\underline{R}_b^L, \underline{R}_b^H, \overline{R}_b^L, \overline{R}_b^H\right)$. $\underline{R}_b^L$ ($\underline{R}_b^H$) is the entrepreneur's reward in case of failure (success), contingent on a bad signal being observed at stage 2, and $\overline{R}_b^L$ ($\overline{R}_b^H$) is the entrepreneur's reward in case of failure (success) contingent on a good signal being observed at stage 2.

The optimal contract to be offered to Firm 1 will solve the following program:

$$\begin{array}{ll}
Max_{\underline{R}_b^H, \underline{R}_b^L, \overline{R}_b^H, \overline{R}_b^L, \underline{e}, \overline{e}} & \alpha\left[\overline{e}(R^H - \overline{R}_b^H) + (1-\overline{e})(R^L - \overline{R}_b^L)\right] + \\
& (1-\alpha)\left[\underline{e}(R^H - \underline{R}_b^H) + (1-\underline{e})(R^L - \underline{R}_b^L)\right] - I_1 \\
(\underline{IR}) & \underline{e}\,\underline{R}_b^H + (1-\underline{e})\,\underline{R}_b^L - \Psi(\underline{e}) \geq W \\
(\overline{IR}) & \overline{e}\overline{R}_b^H + (1-\overline{e})\overline{R}_b^L - \Psi(\overline{e}) \geq W \\
(IC) & \underline{R}_b^H - \underline{R}_b^L = \Psi'(\underline{e}),\ \overline{R}_b^H - \overline{R}_b^L = \Psi'(\overline{e}) \\
(IC_I) & \overline{e}(R^H - \overline{R}_b^H) + (1-\overline{e})(R^L - \overline{R}_b^L) \geq \\
& (\overline{e}-\Delta)(R^H - \overline{R}_b^H) + (1-\overline{e}+\Delta)(R^L - \overline{R}_b^L) + V_2 \\
(LL) & \underline{R}_b^L \geq 0,\ \underline{R}_b^H \geq 0,\ \overline{R}_b^L \geq 0,\ \overline{R}_b^H \geq 0
\end{array}$$

We will refer to this as the venture capitalist's program. According to whether a good or a bad signal is observed at stage 2, effort $\bar{e}$ or $\underline{e}$ is implemented. As the entrepreneur may abandon the project after the signal is observed, the contract must satisfy his *ex-post* participation constraints $\underline{IR}$ and $\overline{IR}$: not only must the entrepreneur be willing to accept the contract at date 1, but he also must continue the project after receiving a bad or a good signal about his potential rival. (IC), the firm's incentive constraint, gives the first order conditions for the entrepreneurial effort choice after a bad and a good signal. The investor's incentive compatibility constraint just states that, *after receiving a good signal on Firm 2*, the venture capitalist must prefer not to fund Firm 2. Since if a bad signal is observed, the venture capitalist will never want to fund firm 2, the contract does not need to prevent any over-funding behavior in this case. The last constraint ensures limited liability for the entrepreneur.

The solution to this program is stated in the following:

Lemma 4 *The optimal financial contract for the venture capitalist will be contingent on the signal received at date 2.*

If a bad signal is observed at date 2, then the entrepreneur is paid $\underline{R}_b^L = 0$ *in case of failure and* $\underline{R}_b^H = \Psi'(e^M)$ *in case of success, where* e^M *is the second best effort defined in Lemma 1. Entrepreneurial effort is* $\underline{e} = e^M$*.*

If a good signal is observed at date 2, then the entrepreneur's payoffs are the same as in Lemma 2:

(i) for $W \leq \hat{W}$*, the entrepreneur's payoffs are* $\overline{R}_b^L = 0$ *and* $\overline{R}_b^H = \Psi'(e^{CP})$

(ii) for $W > \hat{W}$*, the entrepreneur's payoffs are* $\overline{R}_b^L = b$ *and* $\overline{R}_b^H = b + \Psi'(e^{CP})$

Entrepreneurial effort is $\overline{e} = e^{CP}$*, i.e. the third best level of effort.*

Proof. This result is immediate since the venture capitalist's program can be split in two separate programs: the optimal levels of $\underline{R}_b^L$, $\underline{R}_b^H, \underline{e}$ are found by solving a program which is formally identical to the second best optimum, whereas the optimal levels of $\overline{R}_b^L, \overline{R}_b^H$ and $\overline{e}$ are the solution to a program which is identical to the third best optimum. ■

We provide an interpretation for the optimal financial contract that is consistent with the evidence on the modes of financing observed in venture capital deals.

Proposition 5 *There exists a convertible debt contract,* $\{D_0, D_1, s\}$ *, that implements the optimal financial contract of Lemma 4. The venture capitalist initially takes debt* $D_0 = R^H - \Psi'(e^M)$ *in Firm 1. If and only if a good signal occurs then part of the debt is automatically converted into an equity stake* $s = 1 - \frac{\Psi'(e^{CP})}{R^H - R^L}$*, so that the venture capitalist is left with a debt position* D_1*. The post-conversion debt position is decreasing in W:*

(i) if $W \leq \hat{W}$*, then* $D_1 = R^L$

(ii) if $W > \hat{W}$*, then* $D_1 = R^L - \frac{b(R^H - R^L)}{\Psi'(e^{CP})}$ *where* $b = W - \hat{W}$*.*

Proof. If a bad signal occurs, then the venture capitalist is left with a debt claim $D_0 = R^H - \Psi'(e^M)$. But, according to Lemma 1, this financial claim implements the contract $\underline{R}_b^L = 0$, $\underline{R}_b^H = \Psi'(e^M)$. If a good signal occurs, part of the debt is converted into equity, so that the venture capitalist's claim becomes a combination of debt D_1 and an equity stake s in Firm 1. From Proposition 3 it follows that this is equivalent to paying the entrepreneur $\overline{R}_b^L$ in case of failure and $\overline{R}_b^H$ in case of success, with $\overline{R}_b^L$ and $\overline{R}_b^H$ defined as in Lemma 4. ■

In the basic model of section 4, we showed that holding debt plus an equity stake in Firm 1 makes the investor less eager to fund Firm 2. Using a standard debt contract would have instead provided maximal incentives to Firm 1's entrepreneur, but left room for the venture capitalist's Coase problem. So, the Coase problem had to be solved through equity at the cost of a lower managerial effort.

When there is a verifiable signal about the likelihood of the Coase problem arising, debt converting automatically on realization of the signal does better than a simple equity claim or straight debt in dealing with this trade-off.[29] It gives the venture capitalist an equity claim and thus prevents him from funding Firm 2 *only when this temptation arises*, that is, only after a good signal about Firm 2's profitability is observed. After a bad signal is observed, the Coase problem is not an issue. Therefore, in that contingency it is preferable for the venture capitalist to hold a debt claim to maximize entrepreneurial incentives.

Notice, however, that conditional on having observed the good signal, the venture capitalist may not want to convert his debt into equity. It may be more profitable for him to keep his relatively safe debt in the first firm, and instead make a profit from funding the second firm. Of course, ex ante, the venture capitalist would like to commit himself to solving the Coase problem when it arises in order to extract better terms from Firm 1; but ex post, having signed the contract with Firm 1, this consideration is no longer important. This is why it must be agreed *in advance* that conversion will take place *automatically* upon observation of the signal. If conversion is left to the venture capitalist's discretion ex post, this entails an extra incentive compatibility constraint for the venture capitalist, which may not be met, so that voluntarily convertible debt will not solve the overfunding problem. In this result, we make a significant advance over the previous literature, which has seen convertible debt as designed to motivate entrepreneurs, and has thus been unable to differentiate between automatic and voluntary conversion agreements.

[29] In this we differ from Gompers (1996) and Biais-Casamatta (1999). Because these papers take an essentially static approach, convertible debt is equivalent to debt plus equity, and it is not clear why the former should be preferred to the latter.

7 Conclusion

In this paper we have drawn attention to a new channel through which entry deterrence can operate. Previous work has focused firstly on the product market moves a firm can make to discourage entry (Spence (1977) and Dixit(1980)) and then on how financial commitments can be used to induce such product market behavior (Brander and Lewis (1986)). We show that when capital markets are imperfectly competitive, there is an alternative way to prevent entry which has nothing to do with altering product market behavior. Instead it relies on altering investors' incentives in order that they are unwilling to fund entrant firms.

To simplify matters, we have considered the case of a monopoly investor. We showed that even in the monopoly case, when financial entry deterrence should in principle be easiest, ensuring that the investor does not fund competing firms is not a trivial matter. Although the investor would like to commit ex ante to avoiding competition (since this reduces industry surplus), ex post he will face a commitment problem in doing so. Once the contract with the first firm is signed, the investor can appropriate some of that firm's returns by funding a second entrant to the industry. Of course, anticipating this, the first firm will not agree to the same terms, so the investor must find a way to commit to deterring entry. The solution is to make sure that the investor's stake in the first firm is sufficiently sensitive to the first firm's ex post performance that he no longer gains from introducing competition. In other words, to deter entry, the first firm must be funded by equity, even at the cost of reducing the entrepreneur's incentives to exert effort. The whole problem of financial entry deterrence is analogous to that of foreclosure in the vertical integration literature; the investor's commitment problem is a variant of the well known Coase problem of oversupply of inputs, with the input in this case being money. Equity finance plays the role of vertical integration in our context.

Applying the logic of foreclosure to financial markets provides several new insights. Firstly, previous generalities are shown to no longer hold true. In particular, it is *equity* that is the entry deterring claim, whereas in previous analyses relying on product market incentives, it was always *debt* finance that constituted aggressive behavior.[30]

[30] This was true no matter whether competition was in strategic substitutes (Brander and Lewis, 1986), or complements (Showalter 1995), or potential collusion (Maskimovic 1988). The exception is Poitevin (1989), where an equity-financed incumbent has an advantage over the debt-financed entrant in predatory price wars. But there the focus is on the design of the entrant's claim, which (because of asymmetric information) gives him "short pockets"; the incumbent deters entry by threatening a price war. Here instead, we emphasize how the design of the incumbent's claim deters entry by making it difficult for entrant to get finance. The design of the entrant's claim and the behavior of the incumbent in the event of entry - central to the Poitevin result - are largely irrelevant here.

Secondly, we showed that lack of competition in financial markets can translate into lack of competition in product markets. It is surprising that, such an important implication has previously received so little attention in the literature. The result confirms economists' previous intuition as to the centrality of the efficient operation of financial markets to a well-functioning economy.

Thirdly our model suggests that this vertical extension of market power is hampered by a Coasian commitment problem if investors cannot hold equity finance, yielding strong implications for the regulation of banks in imperfectly competitive financial markets. Equity-holding by banks in such markets should be limited - except where considerations of competition are to be subordinated to goals of faster growth which may come from monopoly power.

Fourthly, we extend the basic model to allow us to better understand venture capital finance. We present evidence that venture capitalists have market power in the provision of finance to entrepreneurs. We argue that they are particularly vulnerable to the Coase problem, since in the process of funding incumbent firms they *learn* about the prospects for new entrants to the industry. This makes them more tempted to fund new entrants than they otherwise would be (since they avoid much downside risk). We use these two features of venture capital finance to explain why venture capital claims are frequently in the form of automatically convertible debt. The reasons for *automatic* conversion were previously something of a puzzle. In existing models, conversion was always optimal for the venture capitalist on attainment of the signal, so it was not obvious why he should need to commit himself to this strategy. The time-inconsistency inherent in the Coase problem provides a clue to the reason. Ex ante, the venture capitalist would like to commit not to fund future entrants in order to give sufficient reward to the first firm it funds. But ex post, once the venture capitalist has learned that funding new entrants will be profitable, he may prefer to retain debt in the first firm and fund entrant firms. Therefore he needs to commit himself to instead holding equity when the good signal arrives, and thus having little incentive to introduce competition. When the signal is bad, however, he retains debt in order to maximize entrepreneurial incentives. Thus the optimal claim is debt converting to equity automatically on attainment of signals of high profitability.

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Appendix: Proof of Lemma 1

Substitute $R_b^H = R_b^L + \Psi'(e)$ throughout and write the first order conditions for e and R_b^L:

(1) $\frac{\partial L}{\partial e} = R^H - R^L - \Psi'(e) - e\Psi''(e) + \lambda\left[e\Psi''(e)\right] = 0$

(2) $\frac{\partial L}{\partial R_b^L} = -1 + \lambda \leq 0$ and $(-1+\lambda)R_b^L = 0$

where λ is the Lagrange multiplier for the (IR) constraint.

(i) If (IR) does not bind at the optimum, then $\lambda = 0$ and e^M is determined by $R^H - R^L = \Psi'(e^M) + e^M\Psi''(e^M)$. From $\Psi''(e)>0$ and the definition of the first best effort e^*, it follows $e < e^*$. As (IR) is slack, $\lambda = 0$ and thus $R_b^L = 0$. For this to be the case, the level of effort must satisfy: $e^M\Psi'(e^M) - \Psi(e^M) \geq W$, i.e. it must be $W \leq W_1$.

(ii) Suppose instead that $W > W_1$. Then the contract in (i) cannot be the solution to the program, as it fails to satisfy (IR). Then, either R_b^H or R_b^L must be raised. As $e^M < e^*$, it is optimal to raise only the entrepreneur's payment in the high state, so as to raise his effort. Therefore, $R_b^H = \Psi'(e^M(W))$, where $e^M(W)$ satisfies (IR) as an equality: $e^M(W)\Psi'(e^M(W)) - \Psi(e^M(W)) = W$.