Financing Entrepreneurs:

Optimal Contracts and the

Role of Intermediaries

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FINANCING ENTREPRENEURS: OPTIMAL CONTRACTS AND THE ROLE OF INTERMEDIARIES

Abstract: I study an economy in which entrepreneurs seek financing for long-term projects from capital-constrained intermediaries, who specialise in monitoring, and uninformed investors. Monitoring enables an intermediary to affect investment decisions, and may confer an informational advantage at the interim stage. Optimal financial contracts are designed to induce both ex ante (choice of investment project) and ex post (decision to continue or liquidate at the interim stage) efficiency, while economising on the use of scarce intermediary capital.

Under certain assumptions, a degree of asymmetric information at the interim stage (between informed insiders and uninformed outside investors) makes it possible to improve on contracting possibilities for the symmetric information case. The paper identifies circumstances in which "venture capital" contracts are optimal.

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New, innovative entrepreneurial businesses are often seen as crucial to an economy's growth and prosperity. Indeed, the financing of such entrepreneurial activity has become an important policy as well as theoretical issue. Part of the reason for this has been the development of a flourishing venture capital industry in the US: well-publicised success stories such as those of Apple Computer, Intel, Federal Express, Lotus Development, Microsoft, Compaq Computer and Genentech, have stimulated considerable interest in the link between financing and entrepreneurial success[1].

To explore this link, I study an economy in which entrepreneurs seek financing for long-term projects from two possible sources: capital-constrained intermediaries, who specialise in monitoring (such as venture capitalists, for example), and investors, who are assumed to be too small to monitor. The emphasis on long-term projects is motivated by an interest in the way the optimal financing mix varies over the firm's life cycle, in relation to the need for monitoring and the availability of information to different agents. It turns out that considerable insight can be gained into optimal financial contracts for different types of project by analysing a simple two-period model.

The model, presented in section 1, extends the basic version of the one introduced by Holmstrom and Tirole (1997) to a two-period setting. During the first period an entrepreneur makes a project investment decision; at the end of the period either a "good" state or a "bad" state is realised, where the state represents the probability of success in the second period. Efficiency at this stage requires continuation of the project in the good state and liquidation in the bad state. There are two potential sources of moral hazard in the presence of external financing: ex ante, the entrepreneur may choose an inefficient project, which has a lower probability of the good state occurring, but allows the entrepreneur to enjoy a private benefit, instead of an efficient project, which has a higher probability of the good state occurring, but no private benefits. Ex post, the entrepreneur (or whichever party has control) may choose to continue the project in the bad state, or liquidate in the good state. Optimal contracts should deal with the two possible sources of moral hazard, so as to achieve both ex ante (project choice) and ex post (decision to continue or liquidate) efficiency.

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[1] On the US venture capital industry, see Barry et al. (1990), Black and Gilson (1998), Brav and Gompers (1997), Gompers (1995,1996,1997), Gompers and Lerner (1996, 1999), Gorman and Sahlman (1989), Hellmann (1997,1998), Kortum and Lerner (1998), Lerner (1994, 1995), Megginson and Weiss (1991), and Sahlman (1990).

External finance for capital-constrained entrepreneurs can come either from intermediaries or directly from investors. The crucial function of intermediaries in the model, as in Holmstrom and Tirole, is monitoring: this enables an intermediary to reduce the entrepreneur's opportunity cost of choosing the efficient project, thereby alleviating the ex ante moral hazard problem. The main difference with Holmstrom and Tirole is the addition of the ex post moral hazard problem, associated with the decision to continue (which requires further financing) or liquidate the project. This is one of the key decisions over which a venture capitalist typically has considerable influence (see Gompers and Lerner (1999)).

I consider three possible information structures. In section 2, as a benchmark case, I assume that the realisation of the state is observable by all agents in the model. In this case ex post moral hazard is not a problem, and the results are simply the two-period analogue of those obtained by Holmstrom and Tirole. Specifically, there are three types of outcome. If the entrepreneur has sufficient own capital, he can raise all the required additional finance directly from investors. When the entrepreneur's capital falls short of a critical threshold level, as will often be the case for start-up companies, the ex ante moral hazard problem is too severe, and the project cannot be undertaken relying only on direct finance. It may then be possible to finance the project by turning to an intermediary, who can alleviate the ex ante moral hazard problem through monitoring, provided the monitoring technology is not too costly. If the entrepreneur's capital is too low, even this possibility is not feasible, and the project cannot be financed at all.

In section 3, I examine the implications of a different informational assumption: the realisation of the state at the end of the first period is observed by the entrepreneur, but not by outside investors. However, it may also be observed by an intermediary who has been closely involved with the firm (a close financier, such as a venture capitalist). I distinguish between two possibilities. In section 3.1, I assume that the intermediary will be able to observe the state only if he monitors during the first period: that is, the monitoring effort required to affect the entrepreneur's investment decisions is also necessary to become informed about the firm's probability of success. In this case, providing the intermediary with monitoring incentives becomes *easier* than in the symmetric information case analysed in section 2. The intuition is the following: if the intermediary does not monitor ex ante, he will not be informed ex post, and he can be "found out", by giving the entrepreneur appropriate incentives to challenge any attempt to "bluff". Since it is possible to find out in this way whether the intermediary has monitored, it is also possible to punish him for failing to monitor: monitoring becomes de facto contractible. In the symmetric information case studied in section 2, on the other hand, it is not possible to find out ex post whether the intermediary has monitored, because no mechanism can be designed that distinguishes between the case where the intermediary is informed as a result of his monitoring effort, and the case where he is informed simply because the state has become public information. This means

that it will be more costly, in general, to provide monitoring incentives, which in turn leads to fewer good projects being undertaken.

Thus a degree of asymmetric information at the interim stage may make it possible to improve on contracting possibilities for the symmetric information case. However, this result depends crucially on the assumption that the intermediary can only gain an informational advantage over outside investors by monitoring during the first period. Section 3.2 assumes instead that the intermediary always observes the state. This assumption is intended to capture the idea that low-intensity monitoring (for simplicity, zero cost) is sufficient to learn the firm's probability of success, whereas high-intensity monitoring (higher cost, $c>0$) is required to affect investment choices; for example, because the latter entails intervention costs. Thus the intermediary will always have an informational advantage over outside investors at the interim stage. In this case it is no longer possible to elicit information about the intermediary's monitoring effort; moreover, efficiency is (slightly) reduced relative to the symmetric information case, because there is a cost (albeit very small) to eliciting information about the state.

Optimal contracts for this case can take a relatively simple form, which resembles venture capital contracts in several respects. In particular, it is consistent with the following common characteristics of venture capital financing: (a) the fact that venture capitalists are typically given significant control rights, allowing them to ensure liquidation if necessary (Gompers (1997)); (b) the use of convertible securities (Gompers (1997), Sahlman (1990)), and (c) the fact that continuation finance is often raised through an Initial Public Offering with "lock-up provisions that prohibit corporate insiders and private equity investors from selling at the time of an offering...(and) require that all insiders, including the venture capitalists, do not sell any of their equity after the offering for a pre-specified period (usually six months)" (Gompers and Lerner (1999)).

The first of these characteristics, the allocation of substantial control rights to venture capitalists, has been analysed formally by Hellmann (1998)[2]: his model focuses on venture capitalists' right to replace the founding CEO, and their incentives to engage in a search for a new CEO when they perceive problems with the existing one. In the present paper the allocation of control rights enables venture capitalists to reduce entrepreneurial moral hazard concerning investment decisions, and to make the efficient continuation/liquidation decision ex post; the allocation of cash flows provides them with the correct incentives to exercise these control rights. The use of convertible securities in venture capital financing has already received considerable attention in the literature. Marx (1994) finds that a risk-averse venture capitalist can be given the right incentives to intervene through

[2] See also the discussion in Black and Gilson (1998).

the use of convertible preferred equity. Berglof (1994), in an incomplete contracting framework, examines the role of convertible securities in providing appropriate incentives to an entrepreneur and a venture capitalist while allowing them to extract maximum surplus from a future sale of the firm. Also in an incomplete contracting framework, Repullo and Suarez (1998(a)) find that the venture capitalist should bear the downside risk while receiving protection against dilution; this motivates the use of convertible preferred stock. Bergemann and Hege (1997) study a moral hazard model in which convertible debt ensures that the entrepreneur is only rewarded if the project succeeds, while avoiding premature liquidation. Finally, in Cornelli and Yosha (1997) convertible debt is used to deter the entrepreneur from engaging in "window-dressing" or short-termism, in a model where the entrepreneur can manipulate short-term signals. None of these models, however, account for all three of the observed characteristics mentioned above.

This paper is also clearly related to the literature on optimal long-term financial contracts in the presence of asymmetric information. Rajan (1992), focusing on debt contracts, has investigated the trade-off between bank and arm's length financing. In his model a bank obtains (costlessly, as in section 3.2 of the present paper) an informational advantage at the interim stage, which allows it to make more efficient continuation/liquidation decisions; however, its informational monopoly also allows it to extract some of the surplus, thereby distorting the entrepreneur's ex ante effort incentives. Von Thadden (1995) has shown that the intermediary's ex post opportunism could be controlled through an optimal long-term contract; this is also the case in the present paper. In Von Thadden's model, and also in Repullo and Suarez (1998(b)), the purpose of (costly) monitoring is to acquire information about the firm's probability of success, which will enable the intermediary to take the efficient continuation/liquidation decision. Holmstrom and Tirole focus instead on a different interpretation of monitoring: through monitoring, the intermediary is able to influence the entrepreneur's investment choices, reducing entrepreneurial moral hazard. The present paper combines these two interpretations of monitoring: monitoring enables the intermediary to influence the entrepreneur's investment choices, and may also be needed to become informed about the firm's probability of success.

The plan of the paper is as follows. Section 1 presents the model; section 2 examines the benchmark case of symmetric information, while section 3 analyses optimal contracts under asymmetric information and discusses their relation to venture capital contracts; section 4 concludes.

1. The model

The model has two periods, three dates: t=0,1,2. There are three types of agent: entrepreneurs, monitors (intermediaries) and investors. At the beginning of the first

period, t=0, each entrepreneur decides whether to invest in a project, requiring an initial expenditure equal to C_0. At the end of the first period, t=1, the state *s* is realised. If the project is continued, requiring further financing equal to C_1, it will yield returns $R>0$ at t=2 with probability *s*, and zero otherwise. Alternatively, the project can be liquidated at t=1, yielding liquidation proceeds of value $L>0$[3]. The entrepreneur can raise finance from monitors (intermediaries) and/or investors. All agents in the model are assumed to be risk-neutral; entrepreneurs and intermediaries are protected by limited liability.

Entrepreneurs

There is a continuum of entrepreneurs. At t=0, each entrepreneur (henceforth also called a firm) is endowed with own capital $A_f<C_0$, and an investment opportunity, or idea. Entrepreneurs differ only by having different amounts of own capital at t=0. Entrepreneurial capital is distributed according to the cumulative distribution function $G(A)$, which denotes the fraction of entrepreneurs with capital less than *A*. The aggregate amount of entrepreneurial capital is $K_f = \int A dG(A)$.

Each entrepreneur faces considerable uncertainty about his project's returns at t=0: some of the uncertainty is resolved at t=1, when the state *s* is realised. For simplicity, *s* is assumed to take one of two values: s_G ("good" state) or s_B ("bad" state), with $s_G>s_B$. If the project is continued, it will yield returns *R* at t=2 with probability *s*, and zero otherwise. Thus *s* represents the probability of success in the second period. Returns are assumed to be verifiable. The state *s* is observed by the entrepreneur; different assumptions will be made about its observability by other agents as the analysis proceeds.

The entrepreneur can affect the probability of the good ($s=s_G$) or bad ($s=s_B$) state occurring. Specifically, he can undertake some action(s) yielding an additional, private benefit *B* in the first period; the cost of this is to reduce the probability of the good state. A moral hazard problem may then arise when the project requires external finance. We can formalise the entrepreneur's decision as a choice between two projects: the "good" project, in which the good state will occur with probability p_H, and the "bad" project, in which the good state occurs with a lower probability p_L, but the entrepreneur receives the private benefit $B>0$ during the first period. Denote by $dp=p_H-p_L>0$ the increase in the probability of the good state occurring associated with choosing the good project.

[3] If liquidation proceeds were equal to zero the results would not be qualitatively different, but more finance would have to be raised from uninformed investors at t=0 in some cases, to provide appropriate incentives at t=1. I assume for simplicity that $L>0$, which is often the case in practice in the venture capital context (for example, software programs can be resold to another company).

Intermediaries (Monitors)

The crucial function of intermediaries in this model is monitoring, which can alleviate the moral hazard problem associated with the entrepreneur's project choice. Monitoring enables an intermediary to become informed, and use the information to impose greater discipline on the entrepreneur. I model this formally by assuming that, through monitoring, the intermediary can reduce the entrepreneur's private benefit from undertaking the bad project to b, where $B>b>0$. This effectively reduces the entrepreneur's opportunity cost of "good behaviour".

There is plenty of evidence of intensive monitoring by intermediaries such as venture capitalists: according to Gorman and Sahlman (1989), lead venture investors visit each portfolio company an average of 19 times per year, and spend 100 hours in direct contact (on site or by phone) with the company. Close involvement by venture capitalists also entails, in many cases, the provision of valuable services to the portfolio company: Sahlman (1990) notes that venture capitalists help recruit and compensate key individuals, work with suppliers and customers, and help establish tactics and strategy. This too can be interpreted as another way of reducing the entrepreneur's opportunity cost of good behaviour.

The intermediary has to incur a private cost $c>0$ in order to monitor a project. This cost is assumed to be non-contractible; monitoring will therefore only take place if the intermediary is given appropriate incentives to monitor. I shall follow Holmstrom and Tirole in assuming that the projects funded by an intermediary are perfectly correlated. As they argue, perfect correlation is an unrealistic but convenient simplifying assumption. The key point is that without any correlation, and without diseconomies of scale in monitoring (i.e. every project costs c to monitor, regardless of the number of projects the intermediary invests in), an intermediary could, through diversification, commit to monitoring without needing to inject own capital into the projects (Diamond (1984)). I rule out this possibility because I am interested in studying how financial contract design is affected when intermediary capital is in scarce supply (implying that intermediaries specialise in monitoring): I therefore need a model in which the amount of intermediary capital available in the economy matters.

Some degree of project correlation is in fact a more plausible assumption than no project correlation, for a number of reasons, including the possibility of macroeconomic shocks, and also industry- or sector-specific shocks, particularly for intermediaries whose monitoring skills lead to specialisation in dealing with certain industries or sectors (e.g. venture capitalists). The assumption of perfect correlation is extreme, but it simplifies the analysis. In particular, it means that we can focus on studying individual contracts between the entrepreneur and an intermediary, without modelling explicitly the intermediary's other investments, since there are no gains from cross-pledging the returns from different projects.

I shall denote by *m* the gross expected rate of return (per period), net of monitoring costs, demanded by intermediaries at t=0. The equilibrium value of *m* will be determined by the interaction between supply and demand for intermediary capital. K_m will represent the aggregate amount of intermediary capital.

Investors

In contrast to intermediaries (monitors), other investors are assumed to be too small to monitor. For this reason, they shall generally be referred to as "uninformed investors". Investors demand a gross expected rate of return per period equal to *r*, which is normalised to one. There are many uninformed investors in each period, so that it is always feasible for the entrepreneur to raise finance from uninformed investors as long as he can credibly promise them the required rate of return, *r=1*.

The projects

The following assumptions will be made about the projects. Firstly, continuation is efficient at t=1 in the good state:

(A1) $$s_G R - C_1 > L$$

Secondly, liquidation is efficient at t=1 in the bad state:

(A2) $$s_B R - C_1 < L$$

Thirdly, it is efficient to invest in the good project ex ante, even if it requires monitoring:

(A3) $$p_H (s_G R - C_1) + (1 - p_H) L \geq C_0 + c$$

Finally, it is never efficient to invest in the bad project:

(A4) $$B + p_L (s_G R - C_1) + (1 - p_L) L < C_0$$

These assumptions mean that, if the entrepreneur could finance the project entirely out of own capital, he would choose the good project at t=0, continue it at t=1 if $s=s_G$, and liquidate at t=1 if $s=s_B$. In what follows, the analysis will focus on how these "first-best" choices may be induced even when the entrepreneur is capital-constrained.

Information

I shall consider three different informational assumptions concerning the state, *s*, at t=1. In section 2, I assume that the realisation of *s* is observed by all agents at

t=1; this assumption applies to businesses whose activities are easily observable, and whose value depends mainly on tangible assets. In many cases, however, firm insiders are likely to have an informational advantage, particularly when the firm is engaged in research and development, and when a substantial proportion of its assets are in the form of intangibles. This possibility will be captured in two ways. In section 3.1, I assume that *s* is privately observed by the entrepreneur, and can be observed by an intermediary only through monitoring. Thus the monitoring effort required to affect investment decisions is also needed to become informed about the firm's probability of success. In section 3.2, I relax this assumption somewhat by assuming that the level of monitoring effort needed by the intermediary to observe *s* is considerably lower (for simplicity, zero cost) than the level of monitoring effort required to affect investment decisions (cost $c>0$).

Both possibilities are a priori plausible: for some businesses it may be relatively easy for the intermediary to obtain an informational advantage relative to small investors (this assumption underlies, for example, the work of Rajan (1992)), while much more effort is required to become actively involved so as to affect investment choices. On the other hand, some businesses may require very intensive monitoring, particularly at the start-up and early development stages, to be able to assess the firm's chances of success (this assumption underlies the work of Repullo and Suarez (1998), among others).

Figure 1

t = 0	t = 1	t = 2
Financial contracts signed. Investment decision, costing C_0. Entrepreneur chooses good or bad project. Monitor can affect the choice at cost *c*.	Realisation of *s*. Continuation costs C_1. Liquidation yields *L*.	If project succeeds, with probability *s*, returns *R*; otherwise zero. All claims settled.

Timing

The timing of events is summarised in Figure 1.

2. Symmetric information: firm prospects observed by financial markets

This section examines the benchmark case in which all agents in the model, including uninformed investors, can observe the realisation of *s* at t=1. I assume that contracts signed at t=0 cannot be made directly contingent on *s* (because it would be too costly to describe it with sufficient precision in a legally enforceable contract); this is not a problem, however, because contracts can condition on *s* indirectly. Specifically, they can condition on market price information at t=1 which fully reveals *s*.

Direct finance

I examine first financial contracts in the absence of monitoring. Given that monitoring is costly, the entrepreneur would prefer to raise the external finance he needs directly from uninformed investors (henceforth treated for simplicity as a single party). In what follows, I derive the conditions under which this can be achieved with reference to a simple contract, Contract 1.

Contract 1

- at t=0, the required initial investment C_0 is financed with entrepreneurial capital A_f and investor capital A_0;
- at t=1, the entrepreneur decides whether to liquidate the project;
- if he does not liquidate the project, the entrepreneur tries to raise continuation finance C_1 by offering potential new investors[4] a claim to returns R_1 at t=2;
- if potential new investors accept the offer, the project is continued, otherwise it is liquidated;
- if the project is liquidated, the entrepreneur receives L_f and the investors L_u;
- if the project is continued and fails, noone receives anything at t=2; if the project succeeds, the entrepreneur receives R_f, the "old" investors R_0, and the new investors R_1.

The following conditions must be satisfied:

$$A_f + A_0 = C_0 \qquad \textbf{(1)}$$

[4] Potential new investors may include the existing investors. The point is that the contract should not require continuation finance to be raised *only* from existing investors, otherwise conditions (4) and (5) below may not suffice to achieve ex post efficiency.

$$L_f + L_u = L \quad \textbf{(2)}$$

$$R_f + R_0 + R_1 = R \quad \textbf{(3)}$$

$$s_G R_1 = C_1 \quad \textbf{(4)}$$

The first three are feasibility conditions. The last ensures that continuation finance can be obtained in the good state but not in the bad state. To obtain ex post efficiency, it must also be the case that the entrepreneur prefers continuation to liquidation in the good state:

$$s_G R_f \geq L_f \quad \textbf{(5)}$$

Ex ante efficiency, on the other hand, requires that the entrepreneur choose the good project. The entrepreneur's ex ante incentive compatibility constraint (ICC) is given by:

$$p_H s_G R_f + (1-p_H)L_f \geq B + p_L s_G R_f + (1-p_L)L_f \quad \textbf{(6)}$$

which simplifies to

$$dps_G R_f \geq B + dpL_f \quad \textbf{(7)}$$

The contract is feasible, subject to the relevant incentive constraints, only if it can guarantee uninformed investors their required expected rate of return:

$$A_0 \leq p_H s_G R_0 + (1-p_H)L_u \quad \textbf{(8)}$$

We can obtain expressions for the maximum values of R_0 and L_u that can be promised to uninformed investors without violating the entrepreneur's incentive constraints. To do this we need lower bounds on R_f and L_f. Clearly the lower bound on L_f is simply zero, due to limited liability. Using this, the lower bound for R_f can be obtained from the entrepreneur's ex ante ICC:

$$R_f \geq \frac{B}{dps_G} \quad \textbf{(9)}$$

Hence:

$$L_u \leq L \quad \textbf{(10)}$$

$$R_0 \leq R - \frac{B}{dps_G} - \frac{C_1}{s_G} \quad \textbf{(11)}$$

Thus uninformed investors can be induced to provide at most A^{max} at t=0, where A^{max} is defined by:

$$A^{\max} = p_H \left[s_G R - \frac{B}{dp} - C_1 - L\right] + L \quad \textbf{(12)}$$

This means that the entrepreneur will be able to undertake the project without requiring any monitoring only if his own capital, A_f, is at least equal to A^*, where A^* is equal to C_0-A^{max}. Notice that this result does not depend on the specific form assumed for Contract 1: the result follows from the entrepreneur's ex ante ICC, together with limited liability. Thus it would not be possible to design a different contract allowing the good project to be undertaken when $A_f<A^*$. Contract 1, subject to conditions (1)-(6) being satisfied, is not only simple but optimal, where optimality is defined as the achievement of both ex ante (project choice) and ex post (continuation/liquidation decision) efficiency.

Monitoring

When $A_f<A^*$, the entrepreneur may still be able to finance the project by turning to an intermediary: monitoring reduces the entrepreneur's opportunity cost of choosing the good project, and hence reduces the share of project income that has to be pledged to the entrepreneur to satisfy his ex ante ICC. Obviously this will improve financing possibilities relative to the no-monitoring case only if the cost of monitoring is sufficiently low.

Consider then the following three-party contract agreed at t=0 between the entrepreneur, an intermediary and uninformed investors:

Contract 2

- at t=0, the required initial investment C_0 is financed with entrepreneurial capital A_f, intermediary capital A_m and investor capital A_0;
- at t=1, the entrepreneur decides whether to liquidate the project;
- if he does not liquidate the project, the entrepreneur tries to raise continuation finance C_1 by offering potential new investors a claim to returns R_1 at t=2;
- if potential new investors accept the offer, the project is continued, otherwise it is liquidated;
- if the project is liquidated, the entrepreneur receives L_f, the intermediary L_m and the investors L_u;
- if the project is continued and fails, noone receives anything at t=2; if the project succeeds, the entrepreneur receives R_f, the intermediary R_m, the "old" investors R_0, and the new investors R_1.

The contract needs to satisfy the following conditions:

$$A_f + A_m + A_0 = C_0 \qquad \textbf{(13)}$$

$$L_f + L_m + L_u = L \qquad \textbf{(14)}$$

$$R_f + R_m + R_0 + R_1 = R \qquad \textbf{(15)}$$

$$s_G R_1 = C_1 \qquad \textbf{(16)}$$

which are analogous to the ones required for the two-party contract examined earlier. As before, the entrepreneur needs to be given an incentive to choose continuation over liquidation in the good state:

$$s_G R_f \geq L_f \qquad \textbf{(17)}$$

He also needs to be given an incentive to choose the good project ex ante. Assuming the intermediary monitors, this incentive constraint becomes:

$$dps_G R_f \geq b + dpL_f \qquad \textbf{(18)}$$

which is of course weaker than in the absence of monitoring (condition (7)), since $b<B$. Now consider the intermediary's incentives. The intermediary has an incentive to monitor only if the following condition holds:

$$p_H s_G R_m + (1 - p_H)L_m \geq c + p_L s_G R_m + (1 - p_L)L_m \qquad \textbf{(19)}$$

where I assume that the entrepreneur would choose the bad project in the absence of monitoring. Expression (19) implies:

$$dps_G R_m \geq c + dpL_m \qquad \textbf{(20)}$$

Since $L_m \geq 0$, this gives a lower bound for R_m, equal to:

$$R_m \geq \frac{c}{dps_G} \qquad \textbf{(21)}$$

Thus to induce monitoring by the intermediary, the entrepreneur has to offer him at least $R_m=c/(dps_G)$, $L_m=0$. The corresponding level of capital investment by the intermediary, A_m, is defined implicitly by:

$$m^2 A_m = p_H s_G \left(\frac{c}{dps_G}\right) - c \qquad \textbf{(22)}$$

which gives:

$$A_m = \frac{c}{m^2}\left(\frac{p_H}{dp} - 1\right) \qquad \textbf{(23)}$$

If intermediary capital is scarce and invested entirely in the monitoring of projects, the entrepreneur will not ask for a higher level of intermediary capital than the minimum consistent with monitoring incentives, given by (23). As long as the intermediary can be induced to monitor, the entrepreneur can raise additional capital, if necessary, from uninformed investors, provided he can guarantee them their required expected rate of return ($r=1$).

The maximum amount of capital that can be raised from uninformed investors at t=0 without violating either the entrepreneur's or the intermediary's incentive constraints is given by:

$$A^{+} = p_H[s_G R - \frac{b}{dp} - \frac{c}{dp} - C_1] + (1 - p_H)L \qquad \textbf{(24)}$$

implying that the entrepreneur will be able to undertake the project at t=0, financing it with a mixture of own, intermediary and uninformed capital, only if own capital A_f is at least equal to $A^{**}=C_0-A_m-A^{+}$.

Contract 2, subject to conditions (13)-(19) being satisfied, is optimal, in the sense of achieving both ex ante (project choice) and ex post (continuation/liquidation decision) efficiency. The main difference with Contract 1 is of course the fact that Contract 2 induces monitoring: since monitoring is costly, this will be valuable if and only if monitoring allows the good project to be undertaken in circumstances in which this would not be feasible without monitoring; that is, if $A^{**}(m^*) < A^*$. Notice also that a contract in which the intermediary decides whether to continue or liquidate at t=1 could do just as well: in particular, the minimum level of entrepreneurial capital required for the project to be feasible would still be $A^{**}(m^*)$. This is because ex post efficiency is achieved very easily under symmetric information: it is sufficient to set R_1 so that investors are only willing to provide the required continuation finance in the good state. The party in control, whether it is the entrepreneur or the intermediary, will always wish to continue in the good state since they receive nothing in the event of liquidation (so as to provide appropriate ex ante incentives), while their expected returns from continuation are strictly positive.

As in Holmstrom and Tirole, mixed financing can be interpreted in two ways: firstly, in terms of "certification", where the uninformed investors are independent investors who invest directly in the firm, but only when the involvement of the intermediary (for example, a venture capitalist) assures them that monitoring will take place and induce the efficient choice of project. Secondly, mixed financing can also be interpreted as "intermediation", where an intermediary, such as a bank,

raises funds from the uninformed investors (e.g. depositors) and invests them along with its own funds in the firms that it monitors.

Equilibrium

The aggregate demand for intermediary capital, $D_m(m)$, is equal to $A_m(m)[G(A^*)-G(A^{**}(m))]$. Assuming that there is no excess supply of intermediary capital at the minimum acceptable rate of return (equal to one), equilibrium in the monitoring market will be characterised by equality between supply and demand:

$$K_m = D_m(m^*) = A_m(m^*)[G(A^*)-G(A^{**}(m^*))]$$

where m^* represents the expected rate of return earned by intermediaries in equilibrium.

Results for the symmetric information case can be summarised as follows.

Proposition 1: (i) When $A_f \geq A^*$, the entrepreneur can undertake the good project, raising all the required external finance from uninformed investors.
(ii) When $A^* > A_f \geq A^{**}(m^*)$, the entrepreneur can still finance the project by turning to an intermediary, who will engage in (costly) monitoring.
(iii) When $A_f < A^{**}(m^*)$, the entrepreneur will not be able to undertake the project.

3. Asymmetric information: financial markets do not observe firm prospects

This section assumes that the entrepreneur observes the realisation of *s* at t=1, but outside investors do not. I focus on the more interesting case of mixed finance: that is, finance is provided partly by uninformed investors and partly by an intermediary, who must be given appropriate incentives to monitor[5]. Section 3.1 assumes that the intermediary can observe *s*, unlike uninformed investors, but only if he monitors during the first period. Section 3.2 considers the case where the intermediary can observe *s* even without monitoring during the first period: this case captures the the idea that the intermediary can obtain an informational advantage over small investors at low cost, while the effort cost required to affect investment decisions is significantly greater.

[5] Results for the direct finance case are available from the author upon request. The main finding is that the minimum level of entrepreneurial capital required to undertake the project is strictly greater than under symmetric information. This is because the entrepreneur, who has private information about the state, must be given incentives to liquidate in the bad state, which requires a greater share of the project's returns to be pledged to him.

3.1 The intermediary observes the state *s* only if he monitors

In this section I first give the intuition for the result, which is then stated formally in Proposition 2; finally I discuss its implications. When the realisation of *s* is not observed by outside agents and can only be observed by the intermediary through monitoring, it becomes *easier* to provide the intermediary with monitoring incentives ex ante. This is because the entrepreneur is always informed: he observes whether the intermediary monitors, and he observes the realisation of *s* at t=1. Since both parties (the entrepreneur and the intermediary) know at t=1 whether the intermediary has been monitoring, and, conditional on monitoring, they both know the state *s*, this information can be elicited, making it possible not only to implement the efficient continuation/liquidation decision, but also to reduce the intermediary's returns if he does not monitor to almost zero[6]. Monitoring therefore becomes de facto contractible.

The intuition for this is simple: when the intermediary does not monitor, he expects the state *s* to be good with probability p_L, and bad with probability $1 - p_L$. This makes it possible for the informed party, the entrepreneur, to "catch out" the intermediary, by inducing a choice that reveals the intermediary's expectation, and hence his lack of knowledge about the state. This is in contrast to the symmetric information case: when *s* is publicly observable at t=1, it is not possible to elicit information about the intermediary's monitoring effort, because no mechanism can be designed that distinguishes between the case where the intermediary knows *s* as a result of his monitoring effort, and the case where he knows *s* simply because it has become public information. With symmetric information, therefore, the intermediary has to be given incentives to monitor by making his expected returns in the good state ($s_G R_m$) sufficiently large, while keeping his returns in the bad state (L_m) equal to zero. This means that he can always secure an expected return equal to $p_L s_G R_m$ even without monitoring. With asymmetric information, on the other hand, the intermediary can be punished for not monitoring by reducing his returns almost to zero; his expected returns from monitoring can thus be set just greater than the monitoring cost *c*, implying almost no need for intermediary capital.

Under these conditions, competition among intermediaries ensures that in equilibrium the expected rates of return demanded by intermediaries and investors are equal: $m^* = 1$. The following Proposition summarises the results for this case:

Proposition 2: Assume *s* is observed by the entrepreneur, by the intermediary if and only if he monitors, and never by outside agents. Then the entrepreneur can undertake the good project if, and only if, $A_f > A^{**}(m^*)$, where $m^* = 1$.

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[6] Specifically, as shown in the Appendix, his returns from no monitoring have to be strictly positive, but can be very small.

Proof: see Appendix.

Proposition 2 shows that a degree of asymmetric information at the interim stage need not reduce efficiency relative to the symmetric information case; on the contrary, efficiency may be increased, in the sense that a greater number of good projects can be financed. This will be the case when the expected rate of return demanded by intermediaries in the symmetric information equilibrium is sufficiently greater than one. The reason is that any expected rents earned by intermediaries in the symmetric information equilibrium are eliminated in the asymmetric information equilibrium. However, this result depends crucially on the assumption that the intermediary can only observe s if he monitors during the first period, as will be shown below.

3.2 The intermediary always observes the state *s*

This section assumes that the intermediary will be able to observe the realisation of *s* at t=1 even if he does not incur the monitoring cost *c*. This is a simplifying assumption, intended to capture the idea that different intensities of monitoring are required for different purposes, and in particular that the effort level needed to have a beneficial impact on the firm's investment decisions is significantly greater than the effort level needed to assess the firm's progress and prospects.

In this case it is no longer possible to elicit information about the intermediary's monitoring effort, since he observes *s* even when he does not incur the monitoring cost *c*. Monitoring incentives must therefore be provided, as in the symmetric information case, by making expected returns in the good state sufficiently high and expected returns in the bad state as low as possible. Since there are two informed parties at t=1, it is still possible to elicit information about the state *s*, and use this information to implement the efficient continuation/liquidation decision. The following result can be obtained:

Proposition 3: Assume *s* is observed by the entrepreneur and the intermediary, but not by outside agents. Then the entrepreneur can undertake the good project if, and only if, $A_f \geq A^{**}(m^*)$, where the inequality holds strictly for $m^*>1$.

Proof: see Appendix.

The key difference between this result and Proposition 2 is that the expected rate of return demanded by intermediaries in equilibrium, m^*, can, and generally will, exceed one (the expected rate of return demanded by uninformed investors). As a consequence, the minimum level of entrepreneurial capital required for a project to be feasible will be strictly greater than in Proposition 2. Optimal contracts in these circumstances are designed to economise on the use of intermediary capital, subject

to achieving both ex ante (project choice) and ex post (continuation/liquidation) efficiency. They do this almost as effectively as under symmetric information (Proposition 1(ii)); the difference is that they require the intermediary to receive a strictly positive share of liquidation proceeds, but this can be very small (hence the strict inequality for $m^*>1$ in Proposition 3).

One such contract (Contract 4) is described in the Appendix. It has the following properties:

- the intermediary can force liquidation immediately when he observes s at t=1; in this case he receives liquidation proceeds $L_m>0$, where L_m is very small, while the entrepreneur receives nothing;
- alternatively, the intermediary can decide not to liquidate, and propose continuation (which requires further financing). If the entrepreneur agrees, the required finance is raised from investors and the project is continued. The intermediary 's and the entrepreneur 's claims to success returns are equal to R_m and R_f, respectively;
- if the intermediary proposes continuation and the entrepreneur disagrees, the project is liquidated; in this case the entrepreneur receives strictly positive liquidation proceeds (see below), while the intermediary receives nothing.

One possible interpretation of this contract is the following: the intermediary holds an option to liquidate the project; this option is worth exercising only if the state is bad, but in this case it should be exercised immediately when the state is realised, because the entrepreneur can take advantage of any delay to undertake some action which increases his returns while reducing the value of the option for the intermediary[7].

How does this compare with venture capital contracts ? Contract 4 resembles a venture capital contract in several respects. Firstly, the intermediary can force liquidation if he wishes when he observes *s*. This is consistent with observed practice in venture capital agreements: according to Gompers (1997) "Many contracts...contain mandatory redemption rights...Essentially, the venture capitalists can force the firm to repay the face value of the investment at any time. This mechanism can often be used to force liquidation". Moreover, "the contracts usually contain some provision for restricting the issuance of new securities. Almost all documents contain a provision that restricts the issuance of senior securities without the approval of previous investors. Many documents alter the restriction to include securities on the preferred equity level or any security issuance".

[7] The interpretation of the contract in terms of options is close in spirit to the work of Nöldeke and Schmidt (1995, 1997).

Secondly, the intermediary's expected returns in equilibrium satisfy the following inequality:

$$s_G R_m > L_m > 0$$

where the first term of the inequality represents expected returns in the good state and the second expected returns in the bad state. This can be interpreted as the payoff from a convertible security: for example, convertible debt, with face value L_m, and the option to convert at t=1 to an equity share of value R_m if the project succeeds. The intermediary clearly has an incentive to exercise the conversion option in the good state, but not in the bad state. Again, the use of convertible securities is a very common feature of venture capital agreements (Gompers (1997), Sahlman (1990)).

Thirdly, since the decision to continue the project must act as a credible signal to investors that the probability of success is high (s_G), it should not be the case that the intermediary and the entrepreneur can, when continuation finance is raised, simultaneously sell all or part of their claims to success returns, R_m and R_f, at the same price as the claim to R_1 (i.e. at price s_G). This too is consistent with observed practice in the US venture capital industry: continuation finance is very often raised through Initial Public Offerings (IPOs) (that is, from new uninformed investors), and, as noted in the introduction, there are "lock-up provisions that prohibit corporate insiders and private equity investors from selling at the time of an offering...Most investment banks require that all insiders, including the venture capitalists, do not sell any of their equity after the offering for a pre-specified period (usually six months)".

In one respect, however, Contract 4 differs significantly from typical venture capital agreements. Specifically, it gives the entrepreneur an incentive to disagree with the intermediary in the bad state, if the latter proposes continuation. Moreover, the payoffs contingent on this event are more favourable to the entrepreneur, and less favourable to the intermediary, than if the intermediary decides to liquidate immediately upon observing *s*. The reason is that the contract needs to deter the intermediary and the entrepreneur from agreeing to continue in the bad state (at the expense of uninformed investors), since this yields greater expected returns than liquidation when *s*

intermediary for failing to liquidate promptly in the bad state. For example, one problem often emphasized in the literature on venture capital is the possibility that, when the firm's prospects are poor, the owner-manager may transfer value away from the firm, obtaining a private gain at the expense of other investors ("asset stripping"). Indeed, the need to protect the venture capitalist against such dilution underlies Berglof's (1994) analysis of venture capital financing. In the context of the present paper, however, it may be that the possibility of asset stripping plays a useful role, by providing the required punishment threat for the intermediary, thereby inducing him to liquidate promptly once he learns that $s = s_B$.

4. Conclusions

Optimal financing arrangements for entrepreneurial businesses vary significantly, depending on the risks involved and their evolution over time, the nature of information flows, the efficiency of monitoring technologies, and also prevailing market conditions and other determinants of the relative cost of intermediated versus direct, market-based finance. This paper has shed some light on the role played by each of these factors.

When some of the relevant information cannot be contracted upon ex ante, but can be observed by all agents ex post, it is often possible to implement efficient outcomes relying simply on direct, market-based finance. When the entrepreneur's initial capital is too low, however, monitoring is needed, implying some form of relationship financing: this will often be the case for start-up companies. Once we allow for asymmetric information about the firm's prospects at the interim stage, financial contracts must also elicit this information from the firm's "insiders"; this can explain the use of convertible securities and restrictive covenants in venture capital agreements, as well as the dominant role of IPOs as a way of obtaining continuation finance for venture-backed companies.

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Appendix

Proof of Proposition 2

For ease of exposition, I adopt the following notation:

- *continuation, claims i,f* means: potential new investors are offered a claim to returns R_1 at t=2 in return for finance C_1. If the offer is accepted, the project is continued; at t=2 in the event of success the intermediary receives *i*, the entrepreneur *f*, new investors R_1, and old investors the remainder. If the offer is rejected, the project is liquidated and all the proceeds go to the investors.
- *liquidation, payoffs i,f* means: the project is liquidated, the intermediary receives *i*, the entrepreneur *f*, and investors the remainder.

Consider the following contract:

Contract 3

- at t=0, the required initial investment C_0 is financed with entrepreneurial capital A_f, intermediary capital A_m, and investor capital A_0.
- at t=1, the intermediary announces either "the state is good", i.e. $s = s_G$, or "the state is bad", i.e. $s = s_B$; the subsequent game in each case is described below:

$s = s_G$

Stage 1: the entrepreneur can either agree → continuation, claims R_m, R_f; or challenge.
Stage 2: if the entrepreneur challenges, the intermediary can either choose continuation, claims x_m, 0; or abstain.
Stage 3: if the intermediary abstains, the entrepreneur has to choose between:
(a) liquidation, payoffs $s_B\, x_m + e$, $s_B(R_f + e) + e$, and
(b) continuation, claims x_m, $R_f + e$.

$s = s_B$

Stage 1: the entrepreneur can either agree → liquidation, payoffs L_m, L_f; or challenge.
Stage 2: if the entrepreneur challenges, the intermediary can either choose liquidation, payoffs $s_B\, z_m + e$, 0; or abstain.
Stage 3: if the intermediary abstains, the entrepreneur has to choose between:
(a) liquidation, payoffs $s_B\, z_m$, $s_G\, z_f - e$, and
(b) continuation, claims z_m, z_f.

The contract has to satisfy the following conditions:

$$s_G R_1 = C_1 \quad \textbf{(26)}$$

$$p_L s_G z_m + (1 - p_L) s_B z_m > s_B z_m + e \quad \textbf{(27)}$$

$$s_G z_f - e > L_f > 0 \quad \textbf{(28)}$$

$$R_m > z_m \quad \textbf{(29)}$$

$$L_m > s_B x_m + e \quad \textbf{(30)}$$

$$p_H s_G R_f + (1 - p_H) L_f \geq b + p_L s_G R_f + (1 - p_L) L_f \quad \textbf{(31)}$$

$$p_H s_G R_m + (1 - p_H) L_m - c \geq p_L s_G z_m + (1 - p_L) s_B z_m \quad \textbf{(32)}$$

$$p_H s_G R_m + (1 - p_H) L_m - c \geq p_L s_G x_m + (1 - p_L)(s_B x_m + e) \quad \textbf{(33)}$$

The first condition ensures that potential new investors at t=1 will be willing to provide continuation finance C_1 if, and only if, they believe the probability of success is high ($s = s_G$). Since they cannot observe s themselves, we are considering a Perfect Bayesian Equilibrium in which the decision to continue the project signals that $s = s_G$. Condition (27) ensures that, if the game reaches stage 2 ($s = s_B$), the intermediary chooses liquidation if he has monitored and knows that the state is s_B, and abstains if either he has not monitored, or he has monitored and knows that the state is s_G. Condition (28) ensures that the entrepreneur has an incentive to challenge when the game reaches stage 1 ($s = s_B$) if, and only if, either the state is s_G, or the state is s_B but the entrepreneur knows the intermediary has not monitored. Conditions (29) and (30) imply that the intermediary has an incentive to announce the true state when he is informed. The entrepreneur's ex ante (project choice) ICC is given by (31), while the intermediary's ex ante (monitoring) ICC is given by (32) and (33).

It is possible to set z_m, x_m and e very small, thus reducing the intermediary's expected returns if he does not monitor (given by the right-hand side of (32) or (33), whichever is the greater), to almost zero. As for the entrepreneur, (31) yields the following lower bound for R_f:

$$R_f \geq \frac{b}{dps_G} + \frac{L_f}{s_G} \qquad \textbf{(34)}$$

But since L_f can be very small (the only constraint is that it should be strictly positive, from (28)), this is equivalent to:

$$R_f > \frac{b}{dps_G} \qquad \textbf{(35)}$$

Using this, it is straightforward to verify that the minimum level of entrepreneurial capital required for the good project to be feasible under Contract 3 is just greater than $A^{**}(m^*)$ evaluated at $m^*=1$.

Proof of Proposition 3

Consider the following contract:

Contract 4

- at t=0, the required initial investment C_0 is financed with entrepreneurial capital A_f, intermediary capital A_m, and investor capital A_0.
- at t=1, the intermediary decides whether to liquidate the project; if he does, he receives L_m, the entrepreneur receives $L_{f,}$ and investors $L_{u.}$
- if the intermediary decides not to liquidate the project, the entrepreneur can

constraints; condition (16) ensures that potential new investors at t=1 will be willing to provide continuation finance C_1 if, and only if, they believe the probability of success is high ($s = s_G$). Since they cannot observe s themselves, we are considering a Perfect Bayesian Equilibrium in which the decision to continue the project signals that $s = s_G$. The last two conditions are the entrepreneur's ex ante (project choice) ICC and the intermediary's ex ante (monitoring) ICC.

The above conditions are the same as under symmetric information; in particular, they yield the same lower bounds for the returns that need to be pledged to the entrepreneur and to the intermediary, equal to:

$$R_f = \frac{b}{dps_G}; \qquad L_f = 0 \tag{36}$$

$$R_m = \frac{c}{dps_G}; \qquad L_m = 0 \tag{37}$$

The difference with the symmetric information case is that we need to elicit information about s at t=1. To see under what conditions Contract 4 achieves this, it is helpful to consider the game played at t=1 between the intermediary and the entrepreneur, illustrated below. To make the exposition easier to follow, I focus on the payoffs of the two informed parties, under the assumption that new investors believe $s = s_G$ when the intermediary tries to raise continuation finance.

Stage 1: the intermediary chooses either liquidation → payoffs L_m, L_f; or continuation.
Stage 2: if the intermediary chose continuation in stage 1, the entrepreneur can either agree → project continued, claims R_m, R_f ; or disagree → project liquidated, payoffs 0, $s_B R_f + e$.

To ensure that the project is continued in the good state and liquidated in the bad state, it must be the case that: $e>0$, $(s_G - s_B)R_f > e$, $s_G R_m > L_m > 0$. Since e can be small, it is almost possible to implement the lower bounds in (36) and (37); the only difference being that we require L_m to be strictly positive. Thus the minimum level of entrepreneurial capital required for the good project to be feasible under Contract 4 is just greater than $A^{**}(m^*)$ for $m^*>1$, and exactly the same for $m^*=1$.