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ABSTRACT

Learning and Syndication in Venture Capital Investments*

The objective of this Paper is to understand: i) why venture capital investments are often syndicated; and ii) what are the effects of syndication on the post-investment involvement of venture capitalists. We analyse a model where a venture capitalist's efficiency to screen an uncertain project depends both on experience and on the signal they can obtain from another specialized investor. Disclosing the existence of the investment project to this second investor is harmful since the latter becomes *de facto* a potential competitor. We show that this potential competition can only be avoided through syndication, which affects the learning process. We further explore the cost of syndication in terms of investment decisions or post-investment involvement of venture capitalists.

JEL Classification: D80, G20 and G30
Keywords: competition, learning, syndication and venture capital

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1 Introduction

The venture capital industry has grown dramatically over the last decade even if we take into account the slowdown of the past few years. In the US, venture capital investments grew from $ 3.3 billion in 1990 to $ 40 billion in 2001 (with a peak at $ 100 billion in 2001).[1] In Europe funds invested in venture capital grew from $ 6.4 billion in 1998 to more than $ 10 billion in 1999.[2] Through its support to early stage projects, the venture capital sector has sustained the development of new businesses and technologies, boosting innovation and growth. In the US, Kortum and Lerner (2000) measure that venture capital investments represent 3% of R&D expenditures, and 8% of the innovative activity, in terms of number of patents. Hellmann and Puri (2000) confirm that venture capital concentrates in the most innovative businesses. Why is venture capital so successful at financing innovation? What makes venture capital different from alternatives sources of financing for start-ups?

Venture capitalists can be roughly described as hands-on investors who develop expertise in specific lines of business. Venture capital is more than money: the experience and care of the venture capitalists themselves is a source of value-added. A recurrent debate concerns the origin of this value-added: are venture capitalists good at selecting projects or do they really create value? The evidence is mixed: Sahlman (1988, 1990) reports that venture capitalists spend a lot of time to select projects, and remain also deeply involved in the post-investment development of those projects. Emphasizing the importance of the selection process, Fenn, Liang and Prowse (1995) estimate that only 1% of the projects received by venture capitalists obtain financing. Gorman and Sahlman (1989) find that venture capitalists also spend a lot of time with the firms they invest in. This involvement gives them the opportunity to extract information on the quality of their investment, in order to terminate the less promising ventures (Gompers (1995)). Venture capitalists also monitor and directly control the entrepreneurs (Lerner (1995), Hellmann and Puri (2002)), and provide managerial advice.[3]

The objective of this paper is to understand how venture capitalists implement an efficient selection process and to what extent this selection process influences their post-investment involvement. In line with the above empirical literature, we consider that the value-added of venture capitalists is two-fold: their expertise allows them to spot the most profitable projects and also to enhance their value by providing valuable advice. However, we do not view these two activities as separate tasks: the efficiency of the selection process determines the effectiveness of the venture capitalist's involvement. Quite plausibly, we assume that venture capital advis-

[1]National Venture Capital Association.

[2]European Venture capital Association.

[3]The importance of this advising role has been extensively documented empirically in Gorman and Sahlman (1989), Sahlman (1990), Bygrave and Timmons (1992), Gompers and Lerner (1999), and more recently Hellmann and Puri (2002). For theoretical treatments, see Schmidt (2003), Repullo and Suarez (1999), or Casamatta (2003).

ing is only valuable for truly profitable projects. The ability of venture capitalists to learn the true quality of projects will thus condition the desirability of their involvement. The important question is then: how can venture capitalists efficiently select projects?

To study these issues, we consider a model where a venture capitalist must decide whether to invest or not in a highly uncertain project, and whether to exert or not costly effort to improve the project's profitability once investment is made. We rely on the idea that venture capitalists have the ability to screen projects by conducting an investment analysis that generates a signal that reduces the uncertainty on the project's true quality. On top of his signal, the venture capitalist has the opportunity to ask for a second evaluation that will be performed by another venture capitalist. This learning process comes with a cost. Disclosing the existence of an investment opportunity to another venture capitalist makes him a potential rival : he could compete with the initial venture capitalist to obtain exclusive financing of the project. From the point of view of the venture capitalist first informed of a new project, revealing the existence of the project creates the conditions for profit-dissipating competition. In order to preserve part of his monopoly rents, the venture capitalist has no choice but to negotiate with his potential competitor, and share the project's surplus.

The main results of the model are the following. First, information gathering can only be implemented by forming a syndicate, i.e. by signing a co-investment, co-ownership contract between the two venture capitalists. Hence our model provides a rationale for the widely observed syndication of venture capital investments[4] (i.e. joint investment by several venture capitalists). Second, potential competition between venture capitalists is harmless for inexperienced venture capitalists because their evaluation of the project is not accurate enough to allow them to invest alone. They form a syndicate each time it is optimal to do so. At the opposite, very experienced venture capitalists suffer from potential competition. Therefore, they are more reluctant to syndicate : this is reflected by the fact that i) they choose more experienced partners, and ii) they sometimes forgo syndication. Third, syndication in turn affects the decision to sustain the project's development after investment is realized. Potential competition translates into underprovision of effort for moderately experienced venture capitalists, while it translates into overprovision of effort for very experienced venture capitalists. The intuition of this result is the following. Potential competition affects the learning process in the sense that it prevents venture capitalists from obtaining a more accurate evaluation of the venture they invest in. Consequently, moderately experienced venture capitalists, who are not (enough) optimistic about the project's success, are reluctant to exert effort. At the opposite, very experienced venture capitalists remain (too) optimistic about the project's success and provide too much effort. Last, syndication can also be costly for inexperienced venture capitalists if the effort decision is not observable. Indeed, a syndication contract entails leaving part of the firm's equity to the syndicate partner, which

[4]See for instance Bygrave (1987, 1988) or Lerner (1994).

can destroy a venture capitalist's incentives to exert effort. We find that since syndication is more likely for inexperienced venture capitalists, they are more likely to bear this additional cost of syndication.

These results allow to derive a number of empirical predictions concerning the link between experience, syndication and post-investment involvement of venture capitalists. First, venture capitalists who invest alone should be highly experienced. This can be related to the empirical result that syndication is positively correlated to the level of uncertainty of investments (See Bygrave (1987) and Chiplin and Wright (1997)). To the extent that more experienced venture capitalists obtain more precise signals on the projects' quality, syndication must decrease with experience (i.e. it must increase with uncertainty). Second, experienced venture capitalists should syndicate with experienced venture capitalists, which is consistent with the empirical findings of Lerner (1994). Last, more experienced venture capitalists should syndicate less, and be more involved in the development of projects after investment is realized, which is in line with Sapienza et al (1995). This last result is also consistent with Kaplan and Strömberg (2002b) who find that venture capitalists are more likely to add value when they are not syndicated and when they own more equity.

This paper is related to the growing literature on venture capital. An important difference is that while most of the research activity has focused on the post investment role of venture capitalists,[5] and studied the financial contracts between venture capitalists and investors,[6] we emphasize the pre-investment selection process of venture capitalists and focus on the syndication decision of venture capitalists. Noticeable exceptions are the empirical analysis of Kaplan and Strömberg (2002b), who study the determinants of venture capitalists investments and Garmaise (2001). The latter shares our assumption that venture capitalists have superior expertise in project evaluation compared to other agents. The main difference with our approach is that Garmaise (2001) concentrates on the financial contract between the entrepreneur and the venture capitalist, while we focus on the contractual arrangement between venture capitalists.[7] Also, Garmaise (2001) considers the case where venture capitalists with different information compete with each other. Instead, we allow venture capitalists to coordinate to avoid competition. Last, our paper is also related to Biais and Perotti (2003) who study the formation of a partnership by experts with different pieces of information. They share our assumption that revealing the existence of an investment project to another expert can be costly. They highlight the importance

[5]See Admati and Pfleiderer (1994), Bergemann and Hege (1998), Cornelli and Yosha (2003), and Dessì (2001) for a theoretical analysis of sequential investment and the optimal continuation decision, Schmidt (2003), Renucci (2001), Repullo and Suarez (1999), or Casamatta (2003) on the advising role of venture capitalists, and Chan, Siegel and Thakor (1990), Hellmann (1998) or Cestone (2002) on the control exerted by venture capitalists.

[6]See Kaplan and Strömberg (2002a) for a detailed empirical analysis of venture capital contracts.

[7]Our focus on the syndication contract is also related to Pichler and Wilhelm (2001) who provide a theory of syndicates in the investment banking industry. Their approach differs in the sense that they view syndication as a way to solve a moral hazard in team problem. We highlight the role of syndication to prevent competition.

of the complementarity between the evaluations of the different experts to mitigate the risk of idea-stealing. In our model, evaluations are not complementary in the sense that the project can be valuable without their joint realization and potential competition is avoided by syndication.

The organization of the paper is the following. The next section presents the model and technical assumptions. Section 3 derives the socially efficient learning and investment decisions. Section 4 introduces the cost of potential competition between venture capitalists and provides a rationale for syndication. Section 5 analyses the syndication decision and the learning process when the initial venture capitalist is under the threat of potential competition. Section 6 introduces another cost of syndication when effort is not observable. The last section concludes. Proofs are provided in the appendix, except when they are directly derived from the text.

2 The model

Consider an entrepreneur endowed with an innovative investment project. The project requires an initial investment, denoted I, and yields a verifiable risky outcome $\widetilde{R}$. For simplicity, we assume that the project can either succeed or fail, hence $\widetilde{R}$ can take two values : $R > 0$ in case of success and 0 in case of failure. The probability of success depends on the quality of the project. If the project is good, the probability of success is p_h (thus $1 - p_h$ is the probability of failure of a good project), while if the project is bad, the probability of success is $p_l < p_h$.[8] We assume that only good projects are profitable. With risk-neutral agents, and a riskless interest rate normalized to zero, this implies that:

$$p_h R \; > I > \; p_l R.$$

Since we are concerned with a new, innovative project, the true quality of the project is initially unknown. Denote q_0 the a priori probability that the quality of the project is good.

The entrepreneur is wealth-constrained. To implement the project, he must raise funds from outside investors. Some of those investors have special expertise in financing innovative projects. We call them venture capitalists (hereafter VC) and assume they have the following characteristics. First, VCs have the ability to better identify the true quality of the projects they are proposed, while traditional, non-specialized investors cannot.[9] This assumption reflects the fact that VCs concentrate their investments in specific lines of business and can use their expertise to collect information on the quality of those new projects. Consequently, we assume that venture capitalists when completing the investment analysis (or memorandum), obtain a

[8] In the remaining of the paper, we will indifferently refer to a good project, or to a project with success probability p_h to denote a project of good quality.

[9] See Sahlman (1988, 1990) for instance.

(costless) signal that is related to its true quality. The signal can be either good ($s = H$) or bad ($s = L$) and is all the more precise that the venture capitalist's expertise is high. In other words, all venture capitalists have the ability to screen projects, but they have different levels of (observable) ability.[10] Formally, the signal s_i received by a venture capitalist with expertise α_i has the following properties:

$$\begin{aligned} prob(s_i = h/p_h) &= \alpha_i, \\ prob(s_i = l/p_l) &= \alpha_i, \end{aligned}$$

where $\alpha_i \in [\frac{1}{2}; 1]$. The above equation simply means that the probability of receiving a good signal conditional on a project being good increases with the venture capitalist's expertise. After observing a signal, the venture capitalist updates his belief on the project's quality using Bayes' rule.

Second, VCs can also use their expertise to provide business advice once the project has been funded.[11] Correspondingly, we assume that VCs can exert a costly effort to increase the probability of success of the project, provided that the true quality is good.[12] To keep things simple, there are only two possible levels of effort. If the VC exerts effort (decision e), he incurs a private cost $c > 0$ and increases the probability of success of a good project by $\epsilon > 0$ (the probability of success of a bad project remains unchanged). If the VC does not exert effort (decision $\not{e}$), the probability of success remains unchanged.

The net present value of the project depends on the agents' beliefs on the project's quality, as well as on the effort decision of the VC in case the entrepreneur obtains VC financing. Conditional on effort being exerted, the NPV is written:

$$NPV(e, q) = -I - c + q(p_h + \epsilon)R + (1 - q)\ p_l R \tag{1}$$

where q is the probability of a good project *given* the agents' information. For instance, $q = q_0$ a priori. We denote $q_{s_1}, s_1 \in \{H, L\}$, the updated probability of a good project after receiving a first signal s_1, and $q_{s_1,s_2}, s_2 \in \{H, L\}$, the updated probability of a good project given two signals s_1 and s_2. Similarly, when no effort is exerted the NPV is written:

$$NPV(\not{e}, q) = -I + qp_h R + (1 - q)\ p_l R \tag{2}$$

Consistent with the fact that very innovative projects, while potentially highly profitable, also have a highly uncertain quality, the a priori NPV of the project is negative. Using equations

[10] This assumption captures the idea that although specialized in the same line of business, some venture capitalists may be more experienced than others.

[11] See Gompers and Lerner (1999) or Hellmann and Puri (2002).

[12] We make the assumption that the VC's effort is useless when the project is bad. This assumption reflects the idea that the efficiency of the VC's advice increases with the quality of the project.

(1) and (2), this implies the following conditions:[13]

$$\begin{cases} -I - c + q_0(p_h + \epsilon)R + (1 - q_0)p_l R & < \quad 0 \\ \text{and} & \\ -I + q_0 p_h R + (1 - q_0)p_l R & < \quad 0 \end{cases}$$

Given the above conditions, the entrepreneur needs to rely on VC financing to implement his project. The timing of the game is the following. The entrepreneur proposes an investment opportunity to a first VC (labelled VC_1). VC_1 receives a signal s_1. Then, VC_1 decides:

- either to reject the project,
- or to finance the project alone,
- or to call for a second evaluation performed by a second VC, labelled VC_2.

In the latter case, we assume that the signal s_2 is freely observed by VC_1 who either rejects or finances the project. Last, if (and after) the project is implemented, VC_1 takes the effort decision.

3 Efficient learning and optimal investment decision

In this section, we analyse what can be gained when calling for a second evaluation s_2. If asking for a second signal increases the project's value, we will say that the value of (the second piece of) information is positive.

After observing signal s_1, VC_1 updates his beliefs on the project's quality in the following way :

$$\begin{aligned} q_H &= \frac{\alpha_1 q_0}{\alpha_1 q_0 + (1-\alpha_1)(1-q_0)} \\ q_L &= \frac{(1-\alpha_1) q_0}{(1-\alpha_1) q_0 + \alpha_1(1-q_0)}. \end{aligned}$$

Accordingly, the information generated by VC_1 modifies the project's NPV. Note first that if bad news are received (signal $s_1 = L$), VC_1 is even more pessimistic on the project's profitability. In other words, $NPV(q_L) < NPV(q_0) < 0$, and VC_1 still prefers not to invest. Second, if VC_1 receives good news ($s_1 = H$), the value of the investment opportunity increases. Of course, this appraisal is stronger the more experienced VC_1 is. As a consequence, there exists a threshold of

[13] When deriving these conditions, we implicitly assume that business advice can be provided even if no signal has been received : this simply means that a VC can decide not to screen the investment opportunities he receives (eventhough it is assumed to be costless).

VC_1's experience above which the project's updated NPV becomes positive. Last, recall that the value of this innovative project results from the combination of the VC's evaluation and effort decision. When VC_1 finds it profitable to invest, it remains to state whether he finds it profitable to exert subsequent effort or not. Effort is only effective at improving good projects. Intuitively, exerting effort will only be profitable if the probability of a good project is high enough, or if the cost of effort is sufficiently small.

The next lemma summarizes how the project's NPV varies with s_1 and α_1.

Lemma 1 *If $s_1 = L$, VC_1's evaluation of the project remains negative.*
If $s_1 = H$:

- *if VC_1's effort is very efficient in the sense that $c(p_h - p_l) \leq \epsilon(I - p_l R)$ (denoted condition (1)): VC_1's evaluation becomes positive if his experience is greater than a threshold α_I. In that case, he always chooses to exert effort.*
- *If VC_1's effort is not very efficient (condition (1) does not hold) : his evaluation becomes positive when his experience is larger than α'_I. Also, he chooses to exert effort only if his experience is greater than $\alpha_e > \alpha'_I$.*

α_I, α'_I, and α_e are constants defined in the appendix.

When will the second piece of information be valuable ? For VC_1 to call for VC_2's evaluation, it must the case that the expected value of the investment opportunity given s_2 increases compared to the value that VC_1 alone attributes to the project. It is thus socially optimal to call for a second evaluation iff :

$$\begin{aligned}\max\{0; NPV(e/q_{s_1}); NPV(\not{e}/q_{s_1})\} \quad \leq \quad & prob(s_2 = H)\max\{0; NPV(e/q_{s_1,H}); NPV(\not{e}/q_{s_1,H})\} \\ & + prob(s_2 = L)\max\{0; NPV(e/q_{s_1,L}); NPV(\not{e}/q_{s_1,L})\}.\end{aligned}$$

The left-hand-side represents the value of the investment if VC_1 stays alone. The right-hand-side represents the value of the investment after receiving s_2. Clearly the value of the information generated by VC_2 is positive if it modifies the initial decision taken by VC_1. In other words, VC_1 does not need another piece of information to confirm his own analysis but rather to challenge it.

Figure 1 restricts to the case where condition (1) holds and VC_1 has received a good signal. It represents the regions where the value of the information generated by VC_2 is positive as well as the optimal investment decisions according to signals and levels of experience. Figure 2 presents the same results when condition (1) does not hold. The main difference between the two figures is the existence of a region where it is optimal to invest and not to exert effort when effort is not very efficient (i.e. when condition (1) does not hold). The case where $s_1 = L$ is analyzed in appendix.

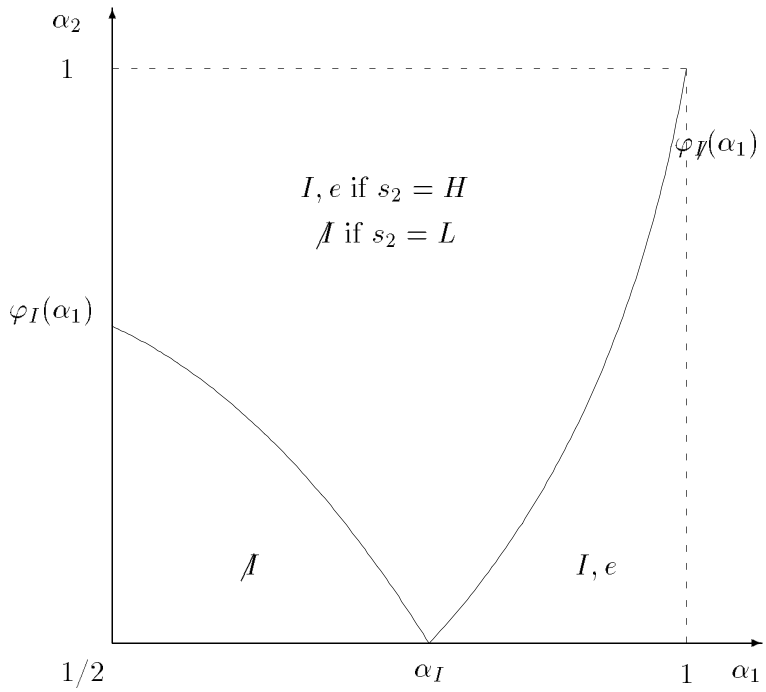

Figure 1: Information gathering when condition (1) holds and $s_1 = H$.

As illustrated in the figures, the quality of the second signal must be high enough so that the updated beliefs modify the investment decision.[14] When VC_1 is not very experienced, he prefers not to invest even though $s_1 = H$. Therefore, he needs a second good evaluation to accept to invest. The minimum level of VC_2's experience for signal s_2 to be valuable decreases with VC_1's experience : the more confident VC_1 is about his own evaluation, the less precise the second evaluation has to be to encourage investment. When VC_1 is more experienced, the second piece of information is used to discourage investment in case it carries bad news. Therefore, the opposite effect arises : since a (bad) second evaluation contradicts VC_1's own signal, the more experienced VC_1 is, the higher the experience of VC_2 required to change his mind.

When effort is not very efficient, it is optimal not to exert effort when the probability that

[14]We have not considered the optimal choice of VC_2's experience. This is because in our setting where signals are costless, the optimal value of α_2 is trivially 1. Our emphasis on the minimum level of α_2 above which information is valuable implicitly recognizes that choosing exactly the level of experience of VC_2 might be impossible or difficult or that there might exist a cost of asking for VC_2's analysis that is increasing with VC_2's experience.

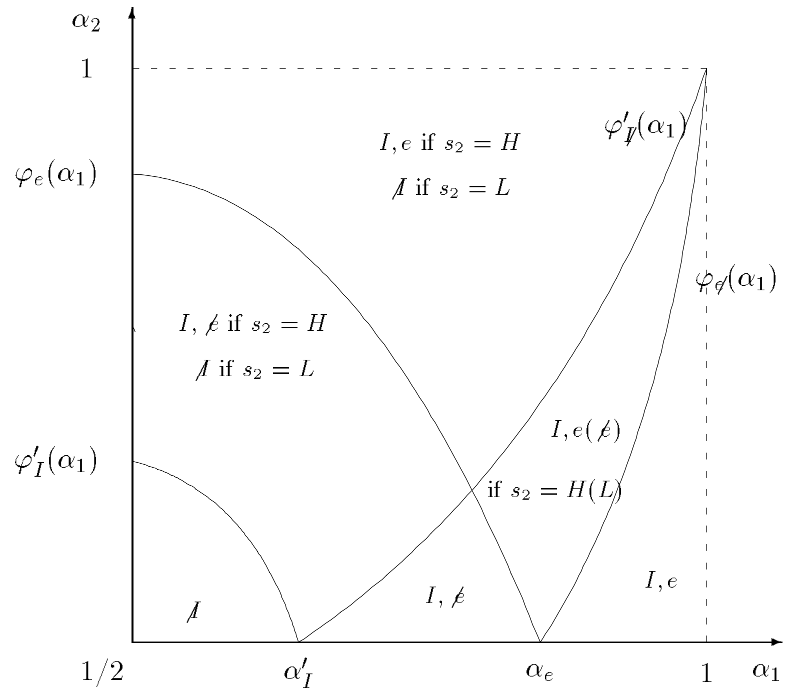

Figure 2: Information gathering when condition (1) does not hold and $s_1 = H$.

the project is good is not high enough. Therefore the second piece of information will be used not only to modify the investment decision but also to modify the effort decision. For instance, if VC_1 is moderately experienced, he prefers to invest and not exert effort unless he receives a good second signal. The experience of VC_2 required to exert effort decreases then with VC_1's own experience. The opposite arises when VC_1 is very experienced and is discouraged to exert effort after bad news from VC_2.

Proposition 1 states the main results of the section.

Proposition 1

- *When the information generated by VC_2 is used to encourage (resp. discourage) investment, the minimum level of experience of VC_2 decreases (resp. increases) with VC_1's own experience.*
- *When the information generated by VC_2 is used to encourage (resp. discourage) effort, the minimum level of experience of VC_2 decreases (resp. increases) with VC_1's own experience.*

4 The rationale for syndication : potential competition between venture capitalists

We considered so far the efficient learning process and investment decision. We now introduce an important determinant of VC_1's decision to call for the evaluation of a second venture capitalist. Asking for this second piece of information is potentially harmful : VC_1 has to reveal the very existence of this investment opportunity. This is particularly costly in an industry where profitable investment opportunities are scarce, and where competition is intense. Disclosing the existence of a new project to a potential rival destroys the monopoly position that VC_1 enjoys when evaluating alone the project proposal. The need to gather information thus creates the conditions for competition which, if it takes place, implies the dissipation of monopoly profits. To avoid competition, VC_1 must negotiate with VC_2 and share the surplus of the project.

If VC_1 informs a second VC about the existence of the innovative project, we assume that both VCs observe freely the two signals s_1 and s_2 generated by their analyses.[15] This is because signals are encompassed in the investment analyses available for both VCs. Note however that one must be an expert to extract the signal from these investment reports. This implies that although observable, these signals are not contractible.

We consider a game with simultaneous offers. If the project's NPV conditional on the two signals is negative, neither VC_1 nor VC_2 will propose to finance the entrepreneur's project. At the opposite, if the project's NPV conditional on the two signals is positive, each VC can separately propose a financial agreement to the entrepreneur, specifying the share of financial income (denoted $\delta_i, i \in \{1, 2\}$) they require in exchange for the initial investment I. Clearly, $\delta_1 = \delta_2$ since after information is generated, the two VCs have the same evaluation.[16] Also, $\delta_i, i \in \{1, 2\}$ is set such that each VC earns zero profit in expectation (δ_i is a measure of the price the entrepreneur must pay to obtain financing from the VC : under Bertrand competition, the price is equal to the marginal cost I).

Alternatively, the two VCs can decide to coordinate[17] to share the project's NPV. As is standard in this type of setting, the bargaining between the two VCs leads to the Nash solution : when the VCs have the same bargaining power,[18] they split evenly the surplus from negotiation.

[15] We thus abstract from the potential costs of information revelation studied by Biais and Perotti (2003). In our model, syndication arises from the cost of competition between VCs.

[16] The project's NPV depends also on the effort decision. This decision is similar for the two VCs since they have the same cost of effort. Overall, they attribute the same NPV to the project.

[17] This assumption departs from Garmaise (2001) who focuses on competition between VCs, in an asymmetric information setting.

[18] For simplicity, we assume that the two VCs have the same bargaining power. Relaxing this assumption, by allowing for instance the bargaining power of each party to increase with his relative level of experience, does not modify qualitatively the results.

If negotiation fails, as stated above, the two VCs engage in Bertrand competition and obtain zero profits. Their reservation utility in the bargaining process is thus equal to zero. Therefore the surplus from negotiation is equal to the project's NPV[19] and each VC obtains half of the project's NPV.

How can this coordination be implemented ? We assume that VCs cannot commit not to compete with each other. Recall that signals are not contractible and cannot be legally protected. This rules out the possibility for one VC to remunerate the other VC for his signal. The latter would still have an incentive to make an offer to the entrepreneur. Coordination can be implemented by writing a contract based on the (verifiable) project's final income that gives each party an equity stake in the project. To fix ideas, the contract specifies i) the fraction of the initial investment provided by each party (we denote βI the amount invested by VC_1), and ii) the corresponding share of the final income given to each party (we denote γR the amount given to VC_1 if the outcome is R).
Suppose that the NPV is maximal if effort is exerted, and that effort is provided by VC_1. To implement the Nash-Bargaining solution, γ and β verify:

$$\gamma\left(q(p_h+\epsilon)R+(1-q)p_lR\right)-\beta I-c=\frac{1}{2}NPV(e,q).$$

Do the two VCs need to be co-owners of the firm ? Consider alternatively a contract whereby one VC makes a transfer to the other VC conditional on his own investment. In the venture capital industry, VCs are only financial intermediaries. Such transfers are likely to be forbidden by the covenants of the VC funds agreements:[20] using the investors' money for other purpose than investment opens the door to collusive behavior between VCs. By the same reasoning, co-ownership implies co-investment : no shares can be given for free to one VC. This implies that i) VC_1 can only obtain a second evaluation by leaving a fraction $1-\gamma$ of the firm's equity, and ii) the contract implies co-investment, i.e. $\beta \in]0,1[$.

We interpret this co-investment, co-ownership contract as syndication between the two VCs. In our setting, syndication does not result from financial constraints or diversification motives. Syndication results from the need to gather information while preventing competition. This is in line with the empirical studies in the entrepreneurship literature that highlight the ressource-based explanation for syndication (Bygrave (1987, 1988), Lockett and Wright (2001)), namely the need to share information.

We have shown that VC_1 can only obtain a second evaluation through syndication. In our model the syndication contract is signed after signals are observed : can VC_1 do better by

[19]We implicitly assume that the entrepreneur has no bargaining power, hence the VCs can capture the whole project's value. Note that the analysis remains unchanged if we allow a positive bargaining power for the entrepreneur.

[20]See Gompers and Lerner (1996).

proposing an ex ante contract (i.e. before signals are observed)? First, note that since signals are not contractible, an ex ante contract does not rule out potential competition. Second, committing to share profits can be harmful for VC_1. Indeed, an ex ante contract annihilates VC_1's option to invest alone and earn monopoly profits when the cost of competition is high.

These elements are summarized in the next proposition.

Proposition 2 *Information gathering can only occur through a syndication contract defined by the share of ownership and the financial contribution of each VC. Deciding to syndicate after signals are observed dominates ex ante contracting.*

5 The decision to syndicate

In this section, we investigate when syndication actually takes place and compare the syndication decision to the efficient learning derived in section 3. The trade-off faced by VC_1 is now the following. He can rely on his own evaluation and enjoy a monopoly position. Alternatively, he can call for a second evaluation that yields more precise information on the project's true quality. In that case, VC_1 gives up half of the monopoly profits to avoid competition as stated in section 4. Formally, VC_1 chooses to syndicate if and only if:

$$\max\left\{0; NPV(e,q_{s_1}); NPV(\not{e},q_{s_1})\right\} < prob(s_2=H)\tfrac{1}{2}\max\left\{0; NPV(e,q_{s_1,H}); NPV(\not{e},q_{s_1,H})\right\}$$
$$+ prob(s_2=L)\tfrac{1}{2}\max\left\{0; NPV(e,q_{s_1,L}); NPV(\not{e},q_{s_1,L})\right\}.$$

We then compare this syndication decision with the optimal information gathering strategy (from section 3).

Proposition 3 *If VC_1 is rather inexperienced (in the sense that $\alpha_1 \leq \alpha_I$ when condition (1) holds or $\alpha_1 \leq \alpha'_I$ otherwise) or if VC_1 has received a bad signal, syndication occurs whenever information gathering is optimal.*

Proposition 3 means that potential competition has no incidence on inexperienced (or pessimistic) VCs. The intuition is the following: inexperienced VCs are not able to screen efficiently the projects under evaluation. Therefore they have nothing to lose when choosing to syndicate (their monopoly profits are equal to zero). Since syndication is costless, it takes place each time the second piece of information is valuable and the learning process is efficient. After a bad signal s_1, it is too risky for VC_1 to invest alone and the same result applies. Both the realization of the signal and the experience of the venture capitalist determine the extent to which he is hurt by potential competition.

Proposition 4 *Potential competition between VCs affects the learning process in the following way :*

- *an experienced VC_1 (in the sense that $\alpha_1 \in [\alpha'_I, \alpha_e]$ when condition (1) does not hold, and $\alpha_1 > \alpha_I$ otherwise) will be more demanding in terms of VC_2's experience.*
- *a very experienced VC_1 never syndicates and forgoes gathering information.*

When VC_1 is rather experienced, his evaluation is precise enough to find it profitable to invest alone. As a consequence, syndication is particularly costly since VC_1 has to give up positive monopoly profits. To compensate this loss, he requires a more precise signal s_2 (compared to the first best), hence a more experienced partner. Since the monopoly profits of VC_1 increase with his level of experience, he is more and more reluctant to syndicate (or, he requires more and more experienced partners): this may reach the point at which no level of VC_2's experience satisfies VC_1's requirement. In those cases, the cost of potential competition is too large compared to the benefits of more precise information. This does not happen in the first best since there is no cost of information gathering.

Corollary 1 *Potential competition leads to overinvestment when VC_1 is sufficiently experienced (in the sense that $\alpha_1 > \alpha_I$ when condition (1) holds, or $\alpha_1 > \alpha'_I$ otherwise).*

The intuition of corollary 1 is the following. When VC_1 is experienced, the evaluation made by a second VC is used to discourage investment in case of a bad signal s_2. Because of potential competition, VC_1 does not syndicate each time the second piece of information is valuable, and invests too much.

Corollary 2 *Potential competition leads to overprovision (resp. underprovision) of effort when condition (1) does not hold and VC_1's experience is greater (resp. smaller) than α_e.*

When VC_1 fails to gather information, he exerts the optimal level of effort given his own information. When he is very experienced, he always exerts effort with his information only, while a bad signal s_2 would discourage effort (see figure 2). At the opposite, when VC_1 is moderately experienced, he never exerts effort with his information only, while a good signal s_2 would have encouraged effort (see figure 2). When potential competition deprives VC_1 of the second evaluation, he sometimes exerts too much effort and sometimes too little.

The results stated in propositions 3 and 4 and in corollaries 1 and 2 are illustrated for the case where $s_1 = H$ and condition (1) does not hold in figure 3.

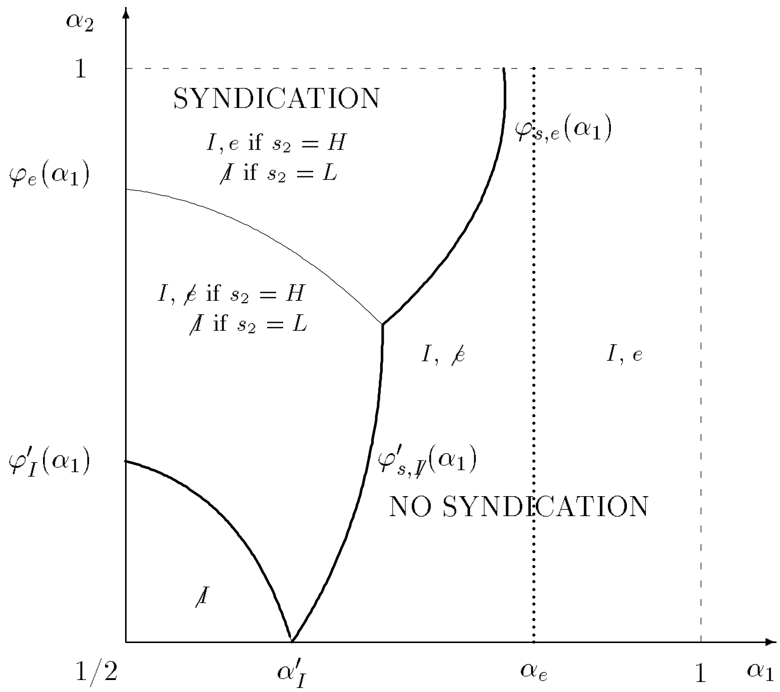

Figure 3: Syndication decision when condition (1) does not hold and $s_1 = H$.

Comparing figure 3 with the optimal information gathering policy depicted in figure 2 raises the following comments. First, note that inexperienced VCs are not affected by the cost of competition : when $\alpha_1 < \alpha'_I$, both graphs coincide. This illustrates the result of proposition 3: there is no cost to syndicate for inexperienced VCs since they have nothing to lose. Their low level of experience does not allow them to create value on their own. Second, the information gathering region shrinks when the experience of VC_1 grows. This is the consequence of the cost of syndication highlighted in proposition 4 : competition prevents VC_1 from collecting a second evaluation each time he should. Third, the cost of syndication increases with VC_1's experience and can finally deter information gathering. See that when VC_1 is very experienced, no syndication is possible while it would be optimal to get a second evaluation. Last, one region completely disappears : this is the region where the second signal is used to modify the effort decision. As a consequence, moderately experienced VC_1s exert too little effort and very experienced VC_1s exert too much effort as stated in corollary 2.

These results give the following implications on the link between expertise, syndication and provision of effort. First, venture capitalists who invest alone should be highly experienced. Second, experienced VCs should syndicate with experienced VCs. This is consistent with the empirical findings of Lerner (1994). We also expect syndication to decrease with the preciseness of VC_1's signal. Indeed, in our model the more experienced VC_1, the more precise is the signal. This can explain why syndication is positively related to the level on uncertainty (Bygrave (1987), Chiplin and Wright (1997)). Last, very experienced VCs should exert more effort, which is consistent with Sapienza et al (1995). This is also in line with Kaplan and Strömberg (2002b) who find that venture capitalists are more likely to add value when investment is not syndicated and when they own more equity. In our model, very experienced venture capitalists find it too costly to syndicate, exert on average too much effort and get a higher share of the firm equity since they invest alone.

6 Syndication and unobservable effort

We have assumed so far that the effort decision was observable and contractible. We now relax this assumption by assuming that the effort exerted by VC_1 is unobservable. In our simple setting, if VC_1 remains the sole investor, this distinction is irrelevant : the entrepreneur has no bargaining power, VC_1 is the sole owner and exerts effort whenever it is optimal to do so.

Under syndication, VC_1 has to leave to VC_2 a share of the final income $1-\gamma$. Define γ_{max} (< 1) as the maximal share of the final income that VC_1 can keep ; γ_{max} corresponds to the case where $\beta = 1$, and is defined by (in the case where effort is profitable):

$$\gamma_{max} = \frac{\left(\frac{1}{2}NPV(e,q) + I + c\right)}{q(p_h+\epsilon)R + (1-q)p_l R}.$$

Also, the incentive compatibility condition ensuring that VC_1 prefers to exert effort given his stake in the firm γ is written :

$$\gamma \geq \frac{c}{q\epsilon R}.$$

Therefore, VC_1 will syndicate and exert effort if $\gamma \in [\frac{c}{q\epsilon R}, \gamma_{max}]$. As long as this interval exists, moral hazard has no bite : under syndication, it is always possible to set γ such that VC_1 exerts the optimal effort decision. In the case where the interval does not exist, it is not possible to induce VC_1 to exert effort although it would be optimal to do so. In that case, potential competition between VCs leads to underprovision of effort.

When is it likely to be the case ? As illustrated in figure 3 (that is, when condition (1) does not hold), if VC_1 syndicates, it is optimal to exert effort when $\alpha_2 > \varphi_e(\alpha_1)$. This means that along the curve representing $\varphi_e(\alpha_1)$, $\frac{c}{q\epsilon R} = 1$. Clearly, for α_2 slightly above $\varphi_e(\alpha_1)$, the interval does not exist. There exists a region above $\varphi_e(\alpha_1)$ in which it is optimal to exert effort, but it is not possible to induce VC_1 to do so. This needs not be the case when condition (1) holds. In that case, as long as investment takes place, it is always optimal to exert effort. This is because effort is very efficient (condition (1) holds) : $NPV(e,q) > NPV(\not{e},q)$ each time investment is profitable. Therefore, one can find parameter values such that the unobservability of effort does not affect the results when condition (1) holds. We provide a numerical example in the appendix page 24.

This gives the following proposition which is graphically illustrated in the appendix page 24.

Proposition 5 *Suppose condition (1) does not hold. When effort is not observable, there is underprovision of effort under syndication, i.e. when VC_1 is not very experienced.*

The previous sections point out the cost of potential competition incurred by experienced VCs which translates into insufficient learning. Inexperienced VCs are immune from this cost and can implement through syndication the optimal information gathering decision. This section highlights a new cost of potential competition that is borne primarily by inexperienced VCs. When effort is not observable, there is a tension between the need to give up a fraction of the firm's equity to form a syndicate and the need to keep enough shares to be induced to work. We show that this tension always leads to underprovision of effort when effort is not very efficient (i.e. when condition (1) does not hold). Note that the cost of unobservable effort affects the regions where syndication takes place. Intuitively, since there is less syndication for more experienced VCs, this cost decreases with VC_1's experience.

The above analysis suggests the following empirical prediction : venture capitalists who are less experienced are more likely to syndicate and less likely to add value to the firms in their portfolio. Although we do not know direct evidence of this, this is consistent with the negative correlation between syndication and value added observed by Kaplan and Strömberg (2002b).

7 Conclusion

In this paper we investigate the efficiency of the selection process of venture capitalists. We provide a rationale for the syndication of VC investments based on the trade-off between the need to gather accurate information on the quality of an investment opportunity, and the need to maintain monopoly profits. Collecting evaluations from other VCs creates potential competition for the initial investor candidate. Signing a co-investment, co-ownership contract is a coordination device since it prevents profit-dissipating competition from actually taking place. Such a contract is costly for the initial investor in charge of evaluating the project since he must forgo part of the project's surplus. The higher the profits the initial investor can capture when being the sole investor, the more reluctant he is to syndicate. In those cases, the actual syndication decision will not induce efficient learning. This is the first cost of syndication that we emphasize. This cost increases with the initial VC's experience. The second cost of syndication is that it forces the two investors to share ownership of the firm, which has consequences regarding the effort decision made by one investor when effort is not observable. This cost decreases with the experience of the initial VC.

We derive results concerning the link between syndication and VCs experience consistent with empirical analyses. Experienced VCs tend to syndicate with each other, while very experienced VCs prefer not to syndicate. This implies that more syndication should arise in countries where the VC industry is young and rather inexperienced.

We also relate the selection process and syndication decision to the post investment involvement of VCs. This involvement is directly linked to the perception of the project's true quality. Optimistic very experienced VCs, confident about their evaluation, find it too costly to syndicate. Relying on their own signal, they provide (sometimes too much) effort to improve the project's profitability. Optimistic moderately experienced VCs also find it too costly to syndicate. However, due to their unprecise evaluation, they do not exert (enough) effort. Last, if there is moral hazard concerning the effort decision of the VC, syndication can be costly for very inexperienced VCs and alter their incentives. This results in the underprovision of effort by young or inexperienced VCs. Empirically, all three results imply that one should observe a positive correlation between the experience and the level of involvement of venture capitalists.

Appendix

Proof of lemma 1

Suppose first that $s_1 = L$. The updated probability of a good project is given by :

$$prob(p_h/s_1 = L) = \frac{(1-\alpha_1)q_0}{(1-\alpha_1)q_0 + \alpha_1(1-q_0)}.$$

Replacing q in equation (1) by this value, we get :

$$NPV(e/s_1 = L) \geq 0 \Leftrightarrow \alpha_1 \leq \frac{q_0\left((p_h+\epsilon)R - c - I\right)}{q_0\left((p_h+\epsilon)R - c - I\right) + (1-q_0)(I - p_l R + c)}.$$

Note that the right-hand side is strictly lower than $\frac{1}{2}$ since the a priori $NPV(e)$ is negative. Consequently, whatever VC$_1$'s expertise α_1, by definition greater than $\frac{1}{2}$, $NPV(e/s_1 = L) < 0$. The same reasoning applies to state that $NPV(\not{e}/s_1 = L) < 0$, which completes the proof of lemma 1 when $s_1 = L$.

Suppose next that $s_1 = H$. The updated probability of a good project is :

$$prob(p_h/s_1 = H) = \frac{\alpha_1 q_0}{\alpha_1 q_0 + (1-\alpha_1)(1-q_0)}.$$

Using equation (1), we get :

$$NPV(e/s_1 = H) \geq 0 \Leftrightarrow \alpha_1 \geq \frac{(1-q_0)(I - p_l R + c)}{q_0\left((p_h+\epsilon)R - c - I\right) + (1-q_0)(I - p_l R + c)} \equiv \alpha_I.$$

And using equation (2) :

$$NPV(\not{e}/s_1 = H) \geq 0 \Leftrightarrow \alpha_1 \geq \frac{(1-q_0)(I - p_l R)}{q_0(p_h R - I) + (1-q_0)(I - p_l R)} \equiv \alpha'_I.$$

Last :

$$NPV(e/s_1 = H) \geq NPV(\not{e}/s_1 = H) \Leftrightarrow \alpha_1 \geq \frac{(1-q_0)c}{q_0(\epsilon R - c) + (1-q_0)c} \equiv \alpha_e.$$

See that :

$$\begin{aligned} \alpha_e \leq \alpha_I \quad &\Leftrightarrow \quad c(p_h - p_l) \leq \epsilon(I - p_l R) \\ \alpha_I \leq \alpha'_I \quad &\Leftrightarrow \quad c(p_h - p_l) \leq \epsilon(I - p_l R). \end{aligned}$$

As a consequence, when condition (1) holds, $\max\{0; NPV(e/s_1 = H); NPV(\not{e}/s_1 = H)\} = NPV(e/s_1 = H)$ when $\alpha_1 \geq \alpha_I$ and 0 otherwise. When condition (1) does not hold, it is optimal not to invest when $\alpha_1 < \alpha'_I$, to invest and not exert effort when $\alpha_1 \in [\alpha'_I; \alpha_e]$, and to invest and exert effort when $\alpha_1 > \alpha_e$.

$\square$

Proof of proposition 1

To set the proof of proposition 1, we first need to characterize the optimal investment/effort decision when VC_1 calls for a second evaluation according to the signals and the levels of experience of the two agents.
Start with the case where $s_1 = H$.
Suppose first that $s_2 = H$. With bayesian updating, we get :

$$prob(p_h/s_1 = H, s_2 = H) = \frac{\alpha_1\alpha_2 q_0}{\alpha_1\alpha_2 q_0 + (1-\alpha_1)(1-\alpha_2)(1-q_0)}.$$

Using equation (1), it follows that :

$$NPV(e, q_{H,H}) \geq 0 \Leftrightarrow \alpha_2 \geq \frac{(1-\alpha_1)(1-q_0)(I - p_l R + c)}{\alpha_1 q_0((p_h+\epsilon)R - I - c) + (1-\alpha_1)(1-q_0)(I - p_l R + c)} \equiv \varphi_I(\alpha_1).$$

And using equation (2) :

$$NPV(\not e, q_{H,H}) \geq 0 \Leftrightarrow \alpha_2 \geq \frac{(1-\alpha_1)(1-q_0)(I - p_l R)}{\alpha_1 q_0(p_h R - I) + (1-\alpha_1)(1-q_0)(I - p_l R)} \equiv \varphi'_I(\alpha_1).$$

It follows that :

$$\begin{aligned} NPV(e, q_{H,H}) \geq NPV(\not e, q_{H,H}) \quad \Leftrightarrow \alpha_2 \quad &\geq \frac{(1-\alpha_1)(1-q_0)c}{\alpha_1 q_0(\epsilon R - c) + (1-\alpha_1)(1-q_0)c} \\ &\equiv \varphi_e(\alpha_1) \end{aligned}$$

One checks easily that when condition (1) holds, we have : $\varphi_e(\alpha_1) \leq \varphi_I(\alpha_1) \leq \varphi'_I(\alpha_1)$, $\forall \alpha_1$. Hence when both VCs receive good signals and condition (1) holds, it is always optimal to invest and exert effort, except if $\alpha_2 < \varphi_I(\alpha_1)$.

When condition (1) does not hold, $\varphi_e(\alpha_1) \geq \varphi_I(\alpha_1) \geq \varphi'_I(\alpha_1)$ $\forall \alpha_1$. When condition (1) does not hold and both VCs receive good signals, it is thus optimal to invest and exert effort when $\alpha_2 \geq \varphi_e(\alpha_1)$. No investment is optimal when $\alpha_2 < \varphi'_I(\alpha_1)$. In the remaining cases, it is optimal to invest and not exert effort.

The same analysis is carried for $s_2 = L$.

$$NPV(e, q_{H,L}) \geq 0 \Leftrightarrow \alpha_2 \leq \frac{\alpha_1 q_0((p_h+\epsilon)R - I - c)}{\alpha_1 q_0((p_h+\epsilon)R - I - c) + (1-\alpha_1)(1-q_0)(I - p_l R + c)} \equiv \varphi_{\not I}(\alpha_1).$$

And using equation (2) :

$$NPV(\not e, q_{H,L}) \geq 0 \Leftrightarrow \alpha_2 \leq \frac{\alpha_1 q_0(p_h R - I)}{\alpha_1 q_0(p_h R - I) + (1-\alpha_1)(1-q_0)(I - p_l R)} \equiv \varphi'_{\not I}(\alpha_1).$$

It follows that :

$$NPV(e, q_{H,L}) \geq NPV(\not e, q_{H,L}) \quad \Leftrightarrow \alpha_2 \quad \leq \frac{\alpha_1 q_0(\epsilon R - c)}{\alpha_1 q_0(\epsilon R - c) + (1-\alpha_1)(1-q_0)c} \equiv \varphi_{\not e}(\alpha_1)$$

When condition (1) holds, we have $\varphi_{\not e}(\alpha_1) \geq \varphi_{\not I}(\alpha_1) \geq \varphi'_{\not I}(\alpha_1)\ \forall \alpha_1$. This implies that when condition (1) holds and $s_2 = L$, investment and effort can only occur if $\alpha_2 \leq \varphi_{\not I}(\alpha_1)$.

When condition (1) does not hold, $\varphi_{\not e}(\alpha_1) \leq \varphi_{\not I}(\alpha_1) \leq \varphi'_{\not I}(\alpha_1)\ \forall \alpha_1$. Investment and effort occurs if $\alpha_2 \leq \varphi_{\not e}(\alpha_1)$. If $\alpha_2 \geq \varphi'_{\not I}(\alpha_1)$, it is optimal not to invest, else it is optimal to invest but not to exert effort.

Consider now the case $s_1 = L$.
If $s_2 = L$, it is clearly optimal not to invest. Suppose next that $s_2 = H$. Proceeding as before, we get :

$$NPV(e, q_{L,H}) \geq 0 \Leftrightarrow \alpha_2 \geq \frac{\alpha_1(1-q_0)(I - p_l R + c)}{(1-\alpha_1)q_0((p_h+\epsilon)R - I - c) + \alpha_1(1-q_0)(I - p_l R + c)} \equiv \nu_I(\alpha_1).$$

And :

$$NPV(\not e, q_{L,H}) \geq 0 \Leftrightarrow \alpha_2 \geq \frac{\alpha_1(1-q_0)(I - p_l R)}{(1-\alpha_1)q_0(p_h R - I) + \alpha_1(1-q_0)(I - p_l R)} \equiv \nu'_I(\alpha_1).$$

It follows that :

$$NPV(e, q_{L,H}) \geq NPV(\not e, q_{L,H}) \quad \Leftrightarrow \alpha_2 \quad \geq \frac{\alpha_1(1-q_0)c}{(1-\alpha_1)q_0(\epsilon R - c) + \alpha_1(1-q_0)c} \equiv \nu_e(\alpha_1)$$

One checks easily that when condition (1) holds, we have :

$$\nu_e(\alpha_1) \leq \nu_I(\alpha_1) \leq \nu'_I(\alpha_1)\ \forall \alpha_1.$$

Also, we always have $\nu_I(\alpha_1) \geq \frac{1}{2}$ since $NPV(e, q_L) \leq 0$. Hence when VC$_1$ has received a bad signal, it is optimal to reverse the (non) investment decision when VC$_2$ is sufficiently experienced, i.e. $\alpha_2 \geq \nu_I(\alpha_1)$. When condition (1) holds and effort is very efficient, it is always optimal to exert effort when investing.

When condition (1) does not hold, $\nu_e(\alpha_1) \geq \nu_I(\alpha_1) \geq \nu'_I(\alpha_1)\ \forall \alpha_1$. Also, $\nu'_I(\alpha_1)$ is always larger than $\frac{1}{2}$ since $NPV(\not e, q_L) \leq 0$. The same qualitative result as before applies : the (non) investment decision is reversed for VC$_2$ sufficiently experienced. Also, since effort is not very efficient (condition (1) does not hold), a regime with investment and no effort arises when VC$_2$ is not very experienced, i.e. when $\alpha_2 \in [\nu'_I(\alpha_1), \nu_e(\alpha_1)]$.

The second part of the proof consists in determining when the investment decision is reversed for at least one possible signal s_2.

When the initial signal s_1 is bad, VC$_1$ does not invest alone. Hence information is valuable when VC$_2$' s signal makes the project's NPV positive. This arises either when $\alpha_2 > \nu_I(\alpha_1)$ (if condition (1) holds) or when $\alpha_2 > \nu_I'(\alpha_1)$ (if condition (1) does not hold).

When the initial signal s_1 is good, an inexperienced VC$_1$ does not invest alone : he asks for a second evaluation if VC$_2$'s good signal makes the project's NPV positive (i.e. when $\alpha_2 > \varphi_I(\alpha_1)$ if condition (1) holds and when $\alpha_2 > \varphi_I'(\alpha_1)$ otherwise.). At the opposite, a more experienced VC$_1$ calls for VC$_2$ if the latter is experienced enough to deter investment when receiving a bad signal (hence, under condition (1), when $\alpha_2 > \varphi_{\not I}(\alpha_1)$). Last, VC$_1$ also calls VC$_2$ if his signal reverses the effort decision (i.e. when condition (1) does not hold). Information gathering can then induce effort when $\alpha_2 > \varphi_e(\alpha_1)$. Information gathering can also deter effort after a bad signal s_2 : this is the case when $\alpha_2 > \varphi_{\not e}(\alpha_1)$.

Last, check that both $\frac{\partial \varphi_I(\alpha_1)}{\partial \alpha_1}$ and $\frac{\partial \varphi_I'(\alpha_1)}{\partial \alpha_1}$ are negative so that the minimum level of VC$_2$'s experience needed to trigger investment decreases with α_1. At the opposite note that $\frac{\partial \varphi_{\not I}(\alpha_1)}{\partial \alpha_1}$ and $\frac{\partial \varphi_{\not I}'(\alpha_1)}{\partial \alpha_1}$ are positive. Similarly, $\frac{\partial \varphi_e(\alpha_1)}{\partial \alpha_1} \leq 0$ and $\frac{\partial \varphi_{\not e}(\alpha_1)}{\partial \alpha_1} \geq 0$.

□

Proof of proposition 3

The proof of this proposition is straightforward. Recall from lemma 1 that if $s_1 = L$ or if $s_1 = H$ and $\alpha_1 \leq \alpha_I$ (resp. $\alpha_1 \leq \alpha_I'$) when condition (1) holds (resp. does not hold), the optimal decision is not to invest. Hence, VC$_1$ decides to syndicate iff :

$$0 < prob(s_2 = H)\frac{1}{2}\max\{0; NPV(e, q_{s_1,H}); NPV(\not e, q_{s_1,H})\}$$
$$+prob(s_2 = L)\frac{1}{2}\max\{0; NPV(e, q_{s_1,L}); NPV(\not e, q_{s_1,L})\}.$$

Simplifying both sides by $\frac{1}{2}$ gives the same condition for syndication as in the first best.

□

Proof of proposition 4

Suppose first that $s_1 = H$ and condition (1) holds. The case where $\alpha_1 \leq \alpha_I$ is studied in proposition 3.

Suppose $\alpha_1 > \alpha_I$. It is optimal for VC$_1$ to invest and exert effort when staying alone (see lemma 1). Hence VC$_1$ syndicates iff :

$$NPV(e, q_H) < prob(s_2 = H)\frac{1}{2}NPV(e, q_{H,H}), \tag{3}$$

if $\alpha_2 \geq \varphi_{\not{I}}(\alpha_1)$. Indeed it is optimal to invest iff $s_2 = H$ (and to exert effort since condition (1) holds) when $\alpha_2 \geq \varphi_{\not{I}}(\alpha_1)$. Equation (3) simplifies to :

$$\alpha_2 > \frac{\alpha_1 q_0((p_h + \epsilon)R - I - c) + \frac{1}{2}(1-\alpha_1)(1-q_0)(p_l R - I - c)}{\frac{1}{2}\left[\alpha_1 q_0((p_H + \epsilon)R - I - c) - (1-\alpha_1)(1-q_0)(p_l R - I - c)\right]} \equiv \varphi_{s,\not{I}}(\alpha_1).$$

It is easy to check that $\varphi_{s,\not{I}}(\alpha_1) > \varphi_{\not{I}}(\alpha_1) \forall \alpha_1$. Hence potential competition makes VC$_1$ more demanding in terms of VC$_2$'s experience, which constitutes the first part of the proposition.

Also, $\varphi_{s,\not{I}}(\alpha_1) \leq 1$ iff :

$$\alpha_1 \leq \frac{(1-q_0)(I + c - p_l R)}{\frac{1}{2}q_0((p_h + \epsilon)R - I - c) + (1-q_0)(I + c - p_l R)} < 1. \tag{4}$$

Check that this inequality is consistent with $\alpha_1 > \alpha_I$. This condition means that when the experience of VC$_1$ is greater than the threshold defined above, he prefers not to syndicate, which constitutes the second part of the proposition.

Suppose now that $s_1 = H$ and condition (1) does not hold.

• When $\alpha_1 \in [\alpha'_I, \alpha_e]$, it is optimal for VC_1 to invest without effort when staying alone. VC_1 syndicates iff:

$$\begin{cases} NPV(\not{e}, q_H) < prob(s_2 = H)\frac{1}{2}NPV(\not{e}, q_{H,H}) & \text{if } \alpha_2 \in [\varphi'_I(\alpha_1), \varphi_e(\alpha_1)] \\ NPV(\not{e}, q_H) < prob(s_2 = H)\frac{1}{2}NPV(e, q_{H,H}) & \text{if } \alpha_2 \geq \varphi_e(\alpha_1) \text{ and } \alpha_2 \geq \varphi'_{\not{I}}(\alpha_1) \\ NPV(\not{e}, q_H) < prob(s_2 = H)\frac{1}{2}NPV(e, q_{H,H}) & \\ +prob(s_2 = L)\frac{1}{2}NPV(\not{e}, q_{H,L}) & \text{if } \alpha_2 \leq \varphi'_{\not{I}}(\alpha_1) \end{cases}$$

This reduces to

$$\begin{cases} \alpha_2 \geq \frac{2\alpha_1 q_0(p_h R - I) + (1-\alpha_1)(1-q_0)(p_l R - I)}{\alpha_1 q_0(p_h R - I) - (1-\alpha_1)(1-q_0)(p_l R - I)} \equiv \varphi'_{s,\not{I}}(\alpha_1) & \text{if; } \alpha_2 \in [\varphi'_I(\alpha_1), \varphi_e(\alpha_1)] \\ \alpha_2 \geq \frac{2\alpha_1 q_0(p_h R - I) + (1-\alpha_1)(1-q_0)(p_l R - I + c)}{\alpha_1 q_0[(p_h + \epsilon)R - I - c] - (1-\alpha_1)(1-q)(p_l R - I - c)} \equiv \varphi_{s,e}(\alpha_1) & \text{if } \alpha_2 \geq \varphi_e(\alpha_1) \text{ and } \alpha_2 \geq \varphi'_{\not{I}}(\alpha_1) \\ \alpha_2 \geq \frac{\alpha_1 q_0(p_h R - I) + (1-\alpha_1)(1-q_0)(p_l R - I + c)}{\alpha_1 q_0(\epsilon R - c) + (1-\alpha_1)(1-q_0)(c)} \equiv \varphi_{s,\not{e},\not{I}}(\alpha_1) & \text{if } \alpha_2 \leq \varphi'_{\not{I}}(\alpha_1) \end{cases}$$

It is easy to check that both $\varphi'_{s,\not{I}}(\alpha_1)$ and $\varphi_{s,e}(\alpha_1)$ are greater than $\varphi'_{\not{I}}(\alpha_1)$ $\forall \alpha_1$: potential competition makes VC_1 more demanding in term of VC_2's experience.

We have $\varphi'_{s,\not{I}}(\alpha_1) < 1$ iff :

$$\alpha_1 \leq \frac{2(1-q_0)(I-p_l R)}{q_0(p_h R - I) + 2(1-q_0)(I-p_l R)} < 1. \tag{5}$$

Check that this inequality is consistent with $\alpha_1 \in [\alpha'_I, \alpha_e]$.

Also $\varphi_{s,e}(\alpha_1) < 1$ iff :

$$\alpha_1 \leq \frac{2(1-q_0)(I-p_l R)}{q_0(p_h R - I) - q_0(\epsilon R - c) + 2(1-q_0)(I-p_l R)} < 1. \tag{6}$$

which is consistent with $\alpha_1 \in [\alpha'_I, \alpha_e]$.

Finally $\varphi_{s,\not{e},\not{I}}(\alpha_1) < 1$ iff :

$$\alpha_1 \leq \frac{(1-q_0)(I-p_l R)}{q_0(p_h R - I) - q_0(\epsilon R - c) + (1-q_0)(I-p_l R)} < 1. \tag{7}$$

which is not consistent with $\alpha_1 \geq \alpha'_I$.

• When $\alpha_1 \geq \alpha_e$, it is optimal for VC_1 to invest and make effort when staying alone. VC_1 syndicates iff:

$$\begin{cases} NPV(e, q_H) < prob(s_2 = H)\frac{1}{2}NPV(e, q_{H,H}) + prob(s_2 = L)\frac{1}{2}NPV(\not{e}, q_{H,L}) & \text{if } \alpha_2 \in [\varphi_{\not{e}}(\alpha_1), \varphi'_{\not{I}}(\alpha_1)] \\ NPV(e, q_H) < prob(s_2 = H)\frac{1}{2}NPV(e, q_{H,H}) & \text{if } \alpha_2 \geq \varphi'_{\not{I}}(\alpha_1) \end{cases}$$

This equation simplifies to :

$$\begin{cases} \alpha_2 > \frac{\alpha_1 q_0[(p_h+\epsilon)R-I-c]+(1-\alpha_1)(1-q_0)(p_l R-I-c)+\alpha_1 q_0(\epsilon R-c)}{\alpha_1 q_0(\epsilon R-c)+(1-\alpha_1)(1-q_0)c} \equiv \varphi_{s,I,\not{e}}(alpha_1) & \text{if } \alpha_2 \in [\varphi_{\not{e}}(\alpha_1), \varphi'_{\not{I}}(\alpha_1)] \\ \alpha_2 > \frac{2\alpha_1 q_0(p_h R-I)+(1-\alpha_1)(1-q_0)(p_l R-I+c)}{\alpha_1 q_0[(p_h+\epsilon)R-I-c]-(1-\alpha_1)(1-q_0)(p_l R-I-c)]} \equiv \varphi_{s,\not{I},e}(\alpha_1) & \text{if } \alpha_2 \geq \varphi'_{\not{I}}(\alpha_1) \end{cases}$$

It is easy to show that we have $\varphi_{s,I,\not{e}}(alpha_1) > \varphi'_{\not{I}}(\alpha_1)$ and that the condition $\varphi_{s,\not{I},e}(\alpha_1) < 1$ is not consistent with $\alpha_2 \geq \varphi'_{\not{I}}(\alpha_1)$. When $\alpha_1 \geq \alpha_e$, VC_1 prefers not to syndicate.

□

Proof of corollary 1

• Suppose $\alpha_1 > \alpha_I$ and condition (1) holds. When α_1 is larger than the threshold defined by equation (4), VC_1 cannot obtain a second evaluation ($\varphi_{s,\not{I}}(\alpha_1) > 1$). Relying on his signal only, he decides to invest (see lemma (1)), while a second bad signal would discourage investment.

• Suppose $\alpha_1 > \alpha'_I$ and condition (1) does not hold.

By the same reasoning as before, when α_1 is larger than the thresholds defined by equations (5) and (6), VC_1 relies on his signal only and invests while a second signal would discourage investment.

□

Proof of corollary 2

- Suppose $\alpha_1 \in [\alpha'_I, \alpha_e]$ and condition (1) does not hold.

When α_1 does not satisfy equation (7), VC_1 invests alone and does not exert effort while a second good signal would encourage effort. There is thus underprovision of effort.

- Suppose $\alpha_1 \geq \alpha_e$ and condition (1) does not hold.

VC_1 prefers not to syndicate and exerts effort all the time while a second bad signal would discourage effort. There is thus overprovision of effort.

□

A numerical example of the incidence of the unobservability of effort

Consider the following parameter values :

$$q_0 = 0.4 \quad p_l = 0.3 \quad p_h = 0.7 \quad R = 90 \quad I = 50 \quad \epsilon = 0.2 \quad c = 7$$

Check that these values imply that condition (1) holds.

Unobservable effort does not modify the effort decision under syndication iff

$$\frac{c}{q_{H,H}\epsilon R} \leq \frac{\left(\frac{1}{2}NPV(e, q_{H,H}) + I + c\right)}{q_{H,H}(p_h + \epsilon)R + (1 - q_{H,H})p_l R}.$$

Assume equality and call $\alpha_2^*(\alpha_1)$ the positive root of the above equation. The inequality is true if $\alpha_2 \geq \alpha_2^*(\alpha_1)$. For the parameter values that we have considered, we have $\alpha_2^*(\alpha_1) < \varphi_I(\alpha_1)$ and $\alpha_2^*(\alpha_1) < \varphi_{s,\not{I}}(\alpha_1)$. So whenever VC_1 decides to syndicate ($\alpha_2 > \varphi_I(\alpha_1)$ or $\alpha_2 > \varphi_{s,\not{I}}(\alpha_1)$, see propositions 3 and 4), one can find γ such that he always takes the optimal effort decision.

Last, modify the following parameter values as follows to study a case where condition (1) does not hold.

$$\epsilon = 0.1 \quad c = 8$$

The following figure plots the root $\alpha_2^*(\alpha_1)$ on figure 3 which represents the syndication and effort decision when condition (1) does not hold.

The dashed region represents the cost of syndication due to unobservable effort. In this zone, when effort is observable, VC_1 syndicates and exerts effort when both signals are good. When

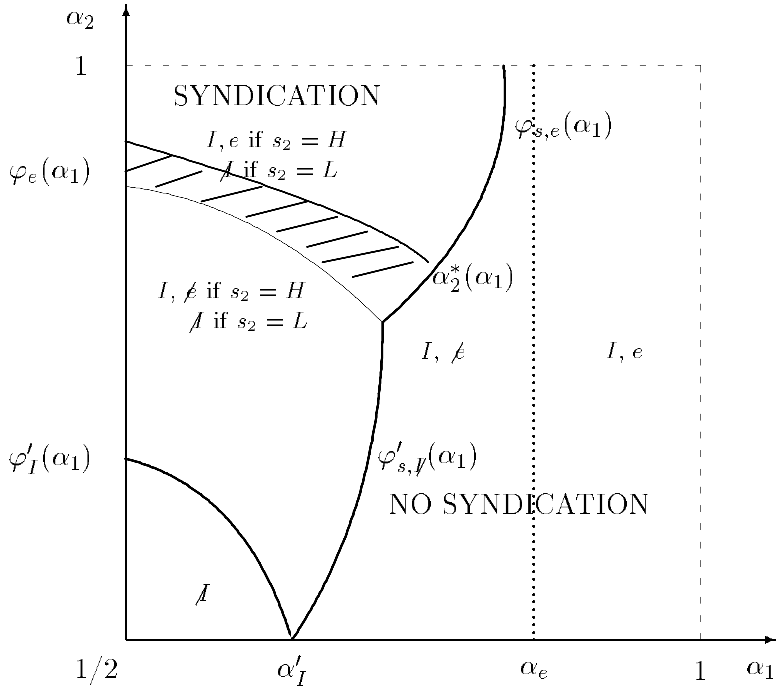

Figure 4: Unobservable effort and syndication decision when condition (1) does not hold and $s_1 = H$.

effort is not observable, VC_1 syndicates but does not exert effort when both signals are good : as stated in proposition 5, moral hazard leads to underprovision of effort when VC_1 is not very experienced.

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