Competition between Informed Venture Capitalists for the Financing of Entrepreneurs

Catherine Casamatta[1] Carole Haritchabalet[2]

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[1]CRG, University of Toulouse

[2]GREMAQ, University of Toulouse and University of Limoges.

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E-mail: catherine.casamatta@univ-tlse1.fr, carole.haritchabalet@univ-tlse1.fr. Corresponding address: Université de Toulouse I, Place Anatole France, 31042 Toulouse Cedex, France.

Abstract

This paper analyzes some determinants of competition in the venture capital industry. We consider a model where an entrepreneur who needs to raise funds has less information than venture capitalists about his project's quality. We explore how the entrepreneur can optimally choose his fund raising strategy to maximize his expected utility. Importantly, we assume that the entrepreneur derives a private benefit of control, so that he cares not only about expected monetary profits, but also about the probability to obtain financing. We show that if the entrepreneur enforces upfront competition by sending his project to all venture capitalists, he obtains high expected monetary profits, but has a low probability to obtain financing. If he initiates negotiation with one venture capitalist, before enforcing competition, he can increase the probability to obtain financing, although the deal terms are less favorable. For low levels of private benefits, the model predicts that the venture capitalists deal flow will be high, but that only experienced venture capitalists will make profits. For high levels of private benefits, expected profits increase for the less experienced venture capitalists, and the deal flow is lower for more experienced venture capital firms. Keywords: deal flow, asymmetric information competition, venture capital industry, fund raising strategy, informed investors, .

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1 Introduction

Venture capital financing has been largely explored by the financial literature over the last decade. Many papers have stressed the difficulties faced by entrepreneurs who seek financing, arising from project uncertainty, asymmetric information, and moral hazard issues. These papers have generally highlighted specific contractual arrangements to cope with these issues : the use of convertible bonds or preferred stocks, the staging of investment, the syndication of deals... While everyone agrees that early stage financing is an important issue, because innovative projects have potentially large return prospects, little has been said on the ability of the venture capital industry to finance profitable deals, and to generate profits for venture capital investors. The objective of this paper is to understand how the nature of competition in the venture capital industry affects entrepreneurs' ability to raise funds, and to shed light on specific patterns of the venture capital industry. In particular, this paper aims at identifying some determinants of the profits and deal flows of the venture capital industry.

To study these issues, the paper relies on the premise that venture capitalists can obtain more precise information by screening the investments deals they receive. The literature on early stage financing has provided numerous empirical evidence that venture capitalists are able to obtain specific information on their portfolio investments[1]. Typically, venture capital firms evaluate new projects by performing home-made investment analyses that constitute the basis for their investment (or re-investment) decisions (see Kaplan and Strömberg (2004)). Presumably, these specialized investors have a better knowledge on the likely chances of success of a venture than the entrepreneur himself. This gives them an informational advantage when negotiating a deal. We also take the view that competition can be fierce in the venture capital sector, since entrepreneurs have access to enlarged sources of funds. This idea captures the fact that venture capital supply has grown dramatically over the last decade. For instance, venture capital investments in the US doubled in the last ten years (growing from $ 10.8 billion in 1996 to $ 22.3 billion in 2005[2]). Of course, the nature of competition (i.e. whether venture capitalists will effectively compete for deals)ultimately depends on the fund raising strategy of entrepreneurs. These questions are at the heart of the analysis developed in the paper: How does competition among privately informed venture capitalists take place? Can entrepreneurs shape this competition with optimal fund raising strategies to increase their chances to obtain funds? or to increase their levels of profits? What are the resulting levels of profits and deal flows of venture capital firms?

Our analysis builds on the following important features. First, entrepreneurs, although able to conceive new and potentially profitable projects, are unable to know whether these projects are commercially viable or not. By this assumption, we follow the literature that emphasizes

[1] See e.g. Sahlman (1988, 1990), Fenn, Liang and Prowse (1995), Gompers (1995).
[2] Source: NVCA.

that entrepreneurs usually lack managerial knowledge[3]. Most of the literature has translated this inexperience into the need for entrepreneurs to obtain venture capital advising. We take a different view, and argue that their inexperience gives them an informational disadvantage compared to venture capitalists. Second, the ability of venture capitalists to obtain precise private information depends on their level of experience. This assumption reflects the idea that there is heterogeneity in venture capital. Venture capitalists build specific knowledge from their focus on industrial sectors, geographical areas, or simply from repeated investments (see Gompers (1996), Hsu (2004), and Kaplan and Schoar (2005)). Third, there can be competition in the venture capital industry. The entrepreneur is thus able to generate offers from more than one venture capitalist if he submits his project to several investors. This is consistent with Hsu (2004) who finds in his sample that about $\frac{1}{3}$ of the start-up firms receive more than one offer for their first-round investment. Last, we assume that entrepreneurs value monetary profits, and derive also a private benefit from their projects if they are implemented. This private benefit can reflect the entrepreneurs' satisfaction to see their idea developed, or simply their utility from having the control of their firm. The existence of non pecuniary benefits associated with entrepreneurial venture has been documented in a survey carried out by Blanchflower and Oswald (1992). In a similar spirit, Hamilton (2000) and Moskowitz and Vissing-Jorgensen (2002) find low monetary returns on entrepreneurial investments, and interpret these results as evidence of the existence of private benefits. As a consequence, entrepreneurs in our model will care about their expected monetary returns, but also about the probability to obtain financing when considering their optimal fund raising strategy.

We consider that an entrepreneur can choose among two fund-raising strategies. Either the entrepreneur decides to send his project to several venture capital firms at the same time, thereby enforcing competition. Or the entrepreneur can engage in a negotiation process with only one venture capitalist, delaying the decision to set competition. In this second game, we investigate how the ability to enforce competition shapes the initial offer made to the entrepreneur, and the level of his expected payoff. An important assumption of our model is that there are different types of venture capitalists in the industry. More precisely, some venture capitalists are more experienced than others, and are able to generate more precise signals on the quality of the projects they screen. This heterogeneity will affect the nature of competition and the optimal fund raising strategy of the entrepreneur.

In particular we find the following results. Considering first the negotiation game, two equilibria can arise. In the first equilibrium, the entrepreneur accepts any offer at the negotiation stage, and his expected utility is equal to his expected private benefit. This equilibrium is sustained by the second venture capitalist's belief that he is contacted only when the first venture

[3]This assumption is shared by papers emphasizing managerial skills uncertainty (Admati and Pfleiderer (1994)), or double-sided moral hazard (Repullo and Suarez (2004), Schmidt (2003), or Casamatta (2003)).

capitalist has received a low signal. If the initial offer is rejected, and competition is enforced, the second venture capitalist will therefore not bid aggressively. This in turn undermines effective competition. In the second equilibrium, the entrepreneur always rejects the first venture capitalist's offer, and enforces competition. In this second equilibrium, the outcome of the negotiation game is equivalent to the outcome of the initial competition game. This second equilibrium does not always exist because enforcing competition can be costly for the entrepreneur. First, it lowers the entrepreneur's probability to obtain financing. High levels of private benefit rule out this equilibrium. Second, the monetary profit that can be shared between the entrepreneur and the first venture capitalist at the negotiation stage can be larger than what they jointly obtain if the entrepreneur enforces competition. In that case, the entrepreneur is more willing to accept an agreement at the negotiation stage, which destroys his threat to enforce competition. Consider next the initial competition game. In that case, the equilibrium is in mixed strategies (as was already emphasized by von Thadden (2004)). The heterogeneity of the industry determines the profits earned by the venture capital firms, as well as the probability to obtain funding. In particular, we show that the more experienced venture capitalist earns higher expected profits. This is because an experienced venture capitalist suffers less from a winner's curse and is able to bid more aggressively, which in turn increases the probability to obtain financing.

Given the outcome of each game, we then explore what is the optimal fund raising strategy of the entrepreneur. When the level of private benefit is low, the entrepreneur cares more about monetary profits, and prefers to flood the market and enforces upfront competition. In that case, each venture capital firm's deal flow is high (both receive an investment candidate to analyze), but only the more experienced venture capitalist is able to make positive profits. As the level of private benefits increases, the entrepreneur cares more about the probability to obtain financing. In that case, enforcing upfront competition can be costly. When venture capitalists have private information on the project value, they compete under asymmetric information and face a standard winner's curse problem. As a result, they bid less often than they would under symmetric information. When the level of private benefits is large enough, the entrepreneur favors negotiation and sends his project to the less experienced venture capitalist first. As a consequence, the deal flow of the experienced venture capitalist shrinks (because he receives only the deals that have been rejected by the first venture capitalist), and so does his expected profit. At the opposite, the profit of the less experienced venture capitalist increases compared to his level in the initial competition game.

Our paper is related to the literature on venture capital financing. A major difference is that while a large body of that literature has emphasized the monitoring and value-added activities of venture capitalists,[4] and studied the financial contracts between venture capitalists and

[4]See Admati and Pfleiderer (1994), Bergemann and Hege (1998), Cornelli and Yosha (2003), and Dessì (2005) for a theoretical analysis of sequential investment and the optimal continuation decision, Schmidt (2003), Renucci

investors,[5] we emphasize their screening role. By considering that entrepreneurs have less information than investors on the quality of their project, we also depart from models that assume private information on the entrepreneur's side (e.g. Cornelli and Yosha (2003), Ueda (2004), or Dessì (2005)). The fact that some venture capitalists are more experienced than others has also been largely documented. Papers have explored the importance of the level of experience of venture capitalists in various contexts: syndication decisions (Lerner (1994), Hopp and Rieder (2006), Casamatta and Haritchabalet (2003), Cestone, Lerner, and White (2006)), value-added activities (Sapienza, Manigart, and Wermeir (1996)), or decision to exit (Gompers (1996)), but not to understand the nature of competition in the industry.

The model is also close to the topic of informed financing, initiated in the banking literature by Sharpe (1990) (see also von Thadden (2004) for a restatement of Sharpe's problem) and Rajan (1992) who study competition between asymetrically informed banks. More recent papers include Garmaise (2006), Inderst and Mueller (2006) and Peyrache and Quesada (2006). They all study situations with informed investors. Some of these papers mainly focus on a monopolistic informed investor, and study the optimal contract design (e.g. Inderst and Mueller (2006), Peyrache and Quesada (2006)). Others study competition between informed financiers (e.g. Garmaise (2006)). The main difference with our analysis is that we aim at endogenizing the nature of the competition game, by studying the optimal fund raising strategy of entrepreneurs. We are thus able to understand the determinants of the venture capital firms deal flow, and to relate it to their level of profits. Last, our paper shares ideas with the analysis of Anton and Yao (1994), and Berkovitch and Khanna (1991). Anton and Yao (1994) explore how the entrepreneur can use the threat of competition to extract innovation rents. However, they investigate how an informed entrepreneur can convey his information without being expropriated. We consider an uninformed entrepreneur, and show that asymmetric information across investors alters competition. Berkovitch and Khanna (1991) study the optimal acquisition mechanism between a merger and a tender offer. The main difference with our analysis is that tender offers can lead to competition because they are publicly observed. In our model, offers cannot be observed publicly, which leads to asymmetric information competition.

The paper is organized as follows. Section 2 presents the model and describes the timing of the games. Section 3 studies the outcome of the initial competition game between venture capitalists. Section 4 derives the equilibria of the negotiation game Section 5 studies the optimal choice of the entrepreneur between competition and negotiation, and explores the levels of profit and financing patterns of the venture capital industry. Section 6 concludes and proofs are provided in the appendix.

(2006), Repullo and Suarez (2004), 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.

[5] See Kaplan and Strömberg (2003) for a detailed empirical analysis of venture capital contracts.

2 The model

Investment project and returns

We consider a one-period corporate finance model, similar to the one used in Casamatta and Haritchabalet (2003). A cash-poor entrepreneur is endowed with an innovative investment project. Innovativeness generally entails high potential returns, coupled with a high level of uncertainty. We model these features by assuming that there is some uncertainty on the true quality of the project. For simplicity, there are two possible quality types: either good or bad. Project returns are risky, and can take two values, depending on the state of nature. In case of success, the project generates a cash-flow $R > 0$, while in case of failure, the project generates a cash-flow 0. Project quality affects the probability of success: if the project is good, success occurs with probability p. If the project is bad, the probability of success is lower. To lighten algebraic expressions, and because it does not impact our analysis, assume that the probability of success of a bad project is zero. Last, the project requires an initial outlay, denoted I.

Denote q_0 the a priori probability that the quality of the project is good: this probability is common knowledge, i.e. all agents in the model have the same prior. To fit the situation of early-stage financing, we want to capture the initial high level of uncertainty of such new projects, which are very unlikely to succeed. Formally, this means that the initial NPV of the project is negative, although the project is profitable if it turns out to be of good quality. Assuming risk-neutral agents, and normalizing the riskless interest rate to zero, this implies:

$$q_0 pR < I < pR.$$

The venture capital industry

The entrepreneur is cash-poor, and must raise funds from investors. Given the initial negative value of the project, he cannot raise funds from traditional investors, and must turn to specialized investors, i.e. venture capitalists (denoted hereafter VCs). Because of their repeated interactions with entrepreneurs, and because of their experience at financing early stage ventures, VCs are able to (imperfectly) infer the quality of new projects.[6] Technically, we assume that VCs when performing their investment analyses obtain a costless signal related to the project's true quality. This signal can be either high ($s = H$) or low ($s = L$) and is all the more precise that the venture capitalist's expertise (or experience) is high. To keep things simple while encompassing the main economic insights of the model, we restrict the analysis to an economy with two types of VCs. Some are very experienced while others are relatively new in the VC business. Formally, the

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

signal s received by a venture capitalist with expertise α has the following properties:

$$\begin{aligned} prob(s = H/\text{good}) &= \alpha, \\ prob(s = L/\text{bad}) &= \alpha, \end{aligned}$$

where $\alpha \in \{\underline{\alpha}; \overline{\alpha}\}$. Although all signals are informative, more experienced VCs (with level of expertise $\overline{\alpha}$) generate more precise signals: $\overline{\alpha} > \underline{\alpha} > \frac{1}{2}$.

After observing a signal, VCs update their belief on the project quality using Bayes' rule. Assume that any VC is sufficiently experienced so that his appraisal of the project becomes positive if he receives a high signal.[7] This means that:

$$\alpha > \alpha_{min},$$

where α_{min} is defined by: $NPV(q(_H\alpha_{min})) = 0$.

For simplicity, assume that there are two VCs in the economy, with different levels of experience. The industry is thus heterogeneous, with one VC of type $\overline{\alpha}$ and one VC of type $\underline{\alpha}$). This assumption is meant to capture realistic features of the industry, where some well-known and reputable venture capital funds compete with newer, less established funds.[8] The project's NPV will depend on the relative preciseness of the two signals. To focus on the most interesting case, we assume that if the more experienced VC receives a high signal, the project NPV is positive even if the less experienced VC receives a low signal:[9]

$$NPV(q(_H\overline{\alpha}, _L\underline{\alpha})) \quad > 0 > \quad NPV(q(_H\underline{\alpha}, _L\overline{\alpha})).$$

Entrepreneur's utility and fund raising strategies

We assume that the entrepreneur will obtain, on top of his financial return, a private benefit B of running his firm, if he manages to get financed. This assumption is in line with the literature on entrepreneurship, which considers the satisfaction derived from being an entrepreneur as one of the determinants of entrepreneurship. Blanchflower and Oswald (1992) document from survey data the existence of non pecuniary benefits in entrepreneurship. In a similar spirit, Hamilton (2000) and Moskowitz and Vissing-Jorgensen (2002) find low monetary returns on entrepreneurial investments, and interpret these results as evidence of the existence of private benefits. Therefore

[7] The analysis would not gain new insights to consider VCs whose appraisal remains negative after a high signal. As will appear more clearly later, these VCs would never have an incentive to offer a deal to the entrepreneur.

[8] For sake of completeness, one could also consider the case of an industry where all VCs have the same level of -high or low- experience. These cases do not add significant insights to the analysis, but considerably burden the presentation. The results are nevertheless available upon request.

[9] Again, if this is not true, the results are similar to those obtained when VCs have the same level of experience.

the utility of the entrepreneur can be written:

$$\begin{cases} U_E = & R_E + B, & \text{in case of success,} \\ U_E = & B, & \text{in case of failure,} \end{cases}$$

where R_E denotes the fraction of cash-flows attributed to the entrepreneur when the project generates a cash-flows R. Note that we implicitly assume that the entrepreneur obtains no monetary benefit if the project fails. It is however conceivable that VCs promise the entrepreneur a positive reward even when the cash-flow is zero. All that matters for our results is the *expected* utility derived by the entrepreneur, so that our results go through if one allows for more general distributions of monetary benefits for the entrepreneur. The important aspect is that the distribution of monetary benefits offered by the VCs does not affect the probability to obtain financing at all. This is the case in our framework given that if a venture capitalist offers a deal, the deal is binding, i.e. the project is financed with probability one, if the entrepreneur accepts the deal.

The entrepreneur initially chooses a fund raising strategy, to maximize his expected utility. Given our assumptions, there are two possible generic fund raising strategies: either the entrepreneur sends his project proposal simultaneously to all potential investors, or he first sends his project to one VC, thereby postponing competition to a latter stage, in case negotiation fails. The first strategy is called "upfront competition", while the second is denoted "negotation". Note that in the second fund raising strategy, the entrepreneur further has to choose which VC to contact first.

If the entrepreneur adopts the "upfront competition" strategy, the timing and assumptions are as follows:

1. The entrepreneur proposes his investment project to each venture capitalist. Each VC knows that his competitor has been contacted.[10]

2. Each VC performs an investment analysis, obtains a signal s_i, and updates his belief on the project's quality. Each signal s_i is private information for VC_i.

3. Each venture capitalist proposes (or not) a financial contract to the entrepreneur. Whether an offer was made or not, cannot be observed by competitors. A fortiori, the content of the offer is not observable.

[10] One could also consider the case where each VC does not know which fund raising strategy has been chosen, i.e. the case where a VC does not know whether he will face a competitor or not. As will appear more clearly in the analysis, this type of uncertainty is taken into account in our generic strategies, since VCs sometimes refrain from bidding. Thus, even when they know that a competitor has been contacted, VCs do not know whether they will face a competing offer or not.

4. The entrepreneur chooses (if any) the offer that gives him the highest expected utility. Then investment takes place, revenues are realized, and are shared according to the contractual arrangement.

If the entrepreneur initiates negotiation with one VC, the timing is as follows.

1. The entrepreneur proposes his investment project to a first venture capitalist (denoted VC_1). As before, any competitor in the industry knows that VC_1 has been contacted.
2. VC_1 performs an investment analysis, obtains a signal s_1, and updates his belief on the project's quality. The signal is private information for VC_1.
3. VC_1 proposes (or not) a financial contract to the entrepreneur. As before, whether an offer is made, as well as its content is not observed by competitors. If an offer is made, and the entrepreneur accepts the contract, investment takes place, and revenues are realized.
4. If the entrepreneur rejects VC_1's offer, or if no offer has been made, the entrepreneur can contact another VC, called VC_2, who privately observes a signal s_2 on the project's quality. Again, contacting VC_2 is public information.
5. VC_1 and VC_2 can propose a financial contract to the entrepreneur.[11] The latter chooses the bid that gives him the highest expected utility.

We will see that the entrepreneur's expected utility, as well as his optimal fund raising strategy differ according to parameter values. This will have consequences for cross sectional empirical predictions. To the extent that the entrepreneur's expected utility crucially determines the incentives to become entrepreneur, our results will also help to discuss some determinants of entrepreneurship.

We solve the model backward, and first determine what are the outcomes of the upfront competition strategy (section 3) and of the negotiation strategy (section 4). We then determine what is the optimal strategy to maximize the entrepreneur's expected utility (section 5).

3 Upfront competition

We explore in this section what is the outcome of the upfront competition game between the two VCs when they compete under asymmetric information to get a deal with the entrepreneur. After observing his signal, each VC has to choose whether or not to make an offer, and which

[11] In that case, the first venture capitalist is able to modify his initial offer. This assumption is meant to fit the plausible feature that once an offer has been rejected, it is not binding any more.

financial contract to offer to the entrepreneur. In our setting where investment is binary and where the final payoff of the project is either R or 0, the choice of the financial contract reduces to only one parameter γ, which represents the fraction of the firm's equity kept by the venture capitalist in exchange for his investment I.[12] Alternatively, this financial contract can measure the implicit valuation $\frac{I}{\gamma}I$ proposed by a VC. VCs privately observe their signal, and potentially make simultaneous[13] competing bids: γ_i and γ_j. The pure-strategy space is $\Gamma_i = [0,1] \cup \emptyset$, the strategy $\emptyset$ means that VC_i does not make any offer. The entrepreneur infers the informational content of each bid, and chooses the bid that grants him the highest expected utility. Given offers $\{\gamma_i; \gamma_j\}$, the entrepreneur's expected utility if he chooses offer γ_i is:

$$\begin{cases} U_E = & 0, & \text{if} \gamma_i = \gamma_j = \emptyset, \\ U_E = & q(\gamma_i, \gamma_j)p(1-\gamma_i)R + B, & \text{otherwise}, \end{cases}$$

where $q(\gamma_i, \gamma_j)$ denotes the probability that the project is good given the offers made. The entrepreneur's expected utility depends i) on the probability that the project is good and succeeds, and ii) on his monetary reward given success. Clearly, his optimal choice is then: $\min[\gamma_i; \gamma_j]$. Intuitively, once offers are made, the choice between one offer and the other does not modify the informational content of the offers (i.e. the probability that the project is good given the offers $q(\gamma_i, \gamma_j)$). The entrepreneur then chooses the offer that grants him the highest fraction of earnings, or the highest valuation bid.

We now characterize the equilibrium strategies of the VCs. Recall that each VC privately observes his signal on the project's quality. We consider the Nash equilibrium of the simultaneous bid game, where VC_i chooses a bidding strategy $\gamma_i(s)$, taking into account his own signal, and the equilibrium strategy $\gamma_j^*(s)$ of VC_j.

The following lemma characterizes the optimal bidding strategy $\gamma_i^*(L)$ of a VC after observing a low signal ($s = L$).

Lemma 1 *When VC_i observes a low signal ($s = L$), at the equilibrium $\gamma_i^*(L) = \emptyset$, whatever the level of experience of VC_i.*

The intuition of lemma 1 is the following. The initial NPV of the project is negative. Therefore, the updated NPV of the project after VC_i receives a low signal is also negative. If VC_i makes an investment offer after a low signal, and if he anticipates that the other VC does not

[12] As mentioned earlier, one could think of more general contracts, whereby the entrepreneur gets a positive monetary pay-off in case of failure. This would not modify the results, since only the expected profit matters for the entrepreneur. We thus abstract from the design of the financial contract bid, which is studied in Garmaise (2006), and which has no bite here.

[13] Offers can be sequential, but they cannot be observed by the competing party. It implies in particular that the entrepreneur cannot show one offer to a competitor.

bid after a low signal, the highest expected payoff he can obtain is negative: at most, he gets $NPV(q(L_\alpha))$, which is negative. Therefore, to make positive profits, he must win with a higher probability when his competitor receives a high signal than when his competitor receives a low signal. This is clearly not an equilibrium strategy for the second bidder.

We use the result of lemma 1 to determine the equilibrium strategy $\gamma_i^*(H)$ of VC_i after he receives a high signal ($s = H$). Note that the model we consider is an application of first price auctions with discrete types.[14] As is standard in this type of setting, since the evaluations of each bidder increase with their type (i.e. their signal), and since we have a finite number of types, no pure strategy equilibrium exists[15], as stated in the next lemma.

Lemma 2 *There exists no pure strategy PBE of the competition game between the two venture capitalists.*

The result of lemma 2 is standard in this type of asymmetric information auction setting (see e.g. von Thadden (2004)). Given lemma 2, we look for a mixed-strategy equilibrium, where each VC after observing a high signal randomizes over his pure strategies. This equilibrium will be characterized by a probability distribution F_i over Γ_i. The support of the mixed strategies, as well as the expected profits that VCs obtain from this competition, depend on the level of experience of the VCs. The next proposition characterize the equilibrium in the VC industry.

Proposition 1 *When the industry is heterogeneous, in the sense that one VC is more experienced than the other, the equilibrium of the asymmetric information competition between the two VCs is unique and has the following properties.*

When $VC_{\overline{\alpha}}$ receives a high signal, with probability $\overline{x}$, he randomizes according to the continuous distribution $\overline{F}(\gamma)$ on $[\hat{\gamma}_{\underline{\alpha}}, 1]$ and, with probability $(1 - \overline{x})$, he plays $\gamma_{\overline{\alpha}}^* = 1$. When $VC_{\underline{\alpha}}$ receives a high signal, with probability $\underline{x}$, he randomizes according to the continuous distribution $\underline{F}(\gamma)$ on $[\hat{\gamma}_{\underline{\alpha}}, 1]$ and, with probability $(1 - \underline{x})$, he does not participate. The expected profit of $VC_{\overline{\alpha}}$ is strictly positive and equal to $I(\frac{q(H_{\overline{\alpha}})}{q(H_{\underline{\alpha}})} - 1)$, while the expected profit of $VC_{\underline{\alpha}}$ is equal to zero. The functions $\underline{F}$, $\overline{F}$, the constants $\overline{x}$, $\underline{x}$,and $\hat{\gamma}_{\underline{\alpha}}$ are defined in the appendix. We denote $prob_{L_{\underline{\alpha}}/H_{\overline{\alpha}}}$ the probability that $VC_{\underline{\alpha}}$ receives a low signal, given that $VC_{\overline{\alpha}}$ has received a high signal.

The intuition of proposition 1 is the following. When the industry is heterogeneous, the more experienced VC who observes a high signal, knows that the project has a positive NPV, even when his (less experienced) competitor has received a low signal. Therefore, he always wants to make an offer to the entrepreneur, and earns a positive expected profit. Of course, the more

[14] See Milgrom and Weber (1982).

[15] see e.g. Fudenberg and Tirole (1996) p. 225).

experienced VC's profit when his competitor has received a low signal is not very large. To compensate this low profit, he must win sufficiently often when his competitor has received a high signal. This is the case if the less experienced VC sometimes forgoes to participate even after a high signal. By definition of a mixed strategy equilibrium, a player must obtain the same level of profit for each strategy he can choose. As a result, the less experienced VC obtains zero expected profits, where the expectation is computed conditionally on receiving a high signal. For the same reason, the more experienced VC is able to earn strictly positive profits.

Corollary 1 *There is overinvestment in the upfront competition game, in the sense that all positive NPV projects are financed, but some negative NPV projects obtain financing.*

Corollary 1 states an important implication of the equilibrium in the upfront competition game. The proof is the following. In our information setting, the optimal investment policy is to finance projects if and only if the more experienced VC has received a high signal.[16] In the equilibrium described in proposition 1, the more experienced VC always proposes a deal to the entrepreneur if he receives a high signal. As a consequence, all positive NPV projects are financed. However, the less experienced VC sometimes makes an offer, and finances the project, if he receives a high signal and his competitor receives a low signal: this happens with probability $prob_{L_{\overline{\alpha}},H_{\underline{\alpha}}}\underline{x}$. Therefore, some negative NPV projects are accepted, and the industry exhibits overinvestment. The next section explores what can be achieved if the entrepreneur decides to negotiate with one VC before enforcing competition.

4 Negotiation

We now investigate the outcome of the initial negotiation game between the entrepreneur and one VC. An important question to determine the optimal fund-raising strategy of the entrepreneur is whether he can obtain a higher expected utility when initiating negotiation. Note that after choosing this fund-raising strategy, the entrepreneur further has to decide which VC to start negotiating with. Again, we solve the problem backward and determine first what are the equilibrium outcomes of initiating negotiation with each VC. We then conclude on the entrepreneur's optimal negotiation strategy.

To solve the game described in section 2, we look for a perfect Bayesian equilibrium (PBE) in which at each stage of the game, the strategies chosen by each agent will be optimal given their

[16]The optimal investment policy in our setting maximizes the expected monetary profits only. If one takes also into account the private benefit of the entrepreneur, the optimal investment policy may change: if private benefits are large, one may wish to finance projects which monetary NPV is negative, but which *social* NPV is positive. We abstract from these considerations.

beliefs, and the beliefs will be computed from these equilibrium strategies using Bayes' rule. A key element for the competition threat to be effective, is that VC_2 assigns a positive probability to the event that VC_1 has received a high signal, if the game gets to the competition stage. This can only happen if either VC_1 does not propose an investment contract to the entrepreneur after a high signal, or if the entrepreneur rejects the investment contract proposed by VC_1.

The next propositions present the characteristics of the different PBE of the negotiation game.

Proposition 2 *There always exists an equilibrium in which VC_1 makes a monopoly offer to the entrepreneur when he receives a high signal, and where the entrepreneur accepts the offer, i.e. does not enforce competition. In this equilibrium, the entrepreneur obtains zero monetary profit.*

The intuition of proposition 2 is the following. Suppose that VC_2 believes that he is contacted only when VC_1 has received a low signal. In that case, VC_2 believes that he will face no competing bid if he makes an offer. As a consequence, his best response is to make a monopoly offer if $NPV(q(_L1, _H2)) > 0$, and to make no offer otherwise. In both cases, the entrepreneur obtains zero monetary profit if he reaches the competition stage. Therefore, VC_1 optimally offers a contract in which he captures the whole project surplus when he receives a high signal. The entrepreneur accepts this contract, since he does not obtain a higher utility when refusing. His utility amounts then to the level of his expected private benefit.

Proposition 3 *When the entrepreneur contacts the less experienced VC first, there sometimes exists a second equilibrium in the negotiation game in which the entrepreneur makes positive monetary profits. In this equilibrium, the entrepreneur always rejects VC_1's offer, and competition always takes place. The conditions under which this equilibrium exists are provided in the appendix.*

A consequence of proposition 3 is that the entrepreneur cannot obtain positive monetary profits when negotiating with one VC only. The only way for him to ensure positive monetary profits is to always enforce competition. In that case, the outcome of the negotiation game is similar to the outcome of the initial competition game. In other words, the entrepreneur cannot use the threat of competition to get some bargaining power at the negotiation stage.

The key point of the analysis is that the entrepreneur and VC_1 know that $s_1 = H$ (because VC_1 made an offer). Therefore, if VC_1's offer is rejected, and competition is enforced, they must leave a positive profit to VC_2 to counterbalance his loss when he finances a project and $s_1 = L$. This lowers their expected profits under competition, and makes them more willing to negotiate ex ante. If their continuation profit is smaller than their joint negotiation profit, VC_1 can propose to the entrepreneur a slightly higher expected utility than what the latter

obtains under competition. In equilibrium, the entrepreneur does not enforce competition when he receives such an offer from VC_1, and the competition threat is not effective. But in that case, VC_1 optimally makes an offer that allows him to extract the whole monetary surplus. Therefore, the equilibrium in which the entrepreneur enforces competition does not always exist.

The joint profit of the entrepreneur and of VC_1 can be higher at the competition stage than at the negotiation stage for the following reason. Competition profits increase because the second signal adds value to the project. Indeed, if competition is enforced, the first VC does not bid all the time (because he is less experienced), and some negative NPV projects are not financed, while they would be at the negotiation stage. This also explains why this equilibrium does not exist if the entrepreneur contacts the more experienced VC first: if competition eventually takes place, he will never refrain from bidding. Finally, note that this equilibrium is less likely when the entrepreneur's private benefit increases. Indeed, if the entrepreneur rejects the initial offer and enforces competition, he lowers the probability to obtain financing, and thus his expected private benefit.

If the joint competition profits are higher than what the entrepreneur and VC_1 obtain under negotiation, any offer from VC_1 is rejected by the entrepreneur, who enforces competition with probability one.[17] An interesting feature of this equilibrium is that the entrepreneur may end up accepting an offer that is strictly worse than the one he rejected. Thus, this equilibrium is consistent with the empirical evidence provided by Hsu (2004), who finds that start-ups do not necessarily accept the highest valuation deal. He explains this feature by the certification role of VCs, pointing out the fact that entrepreneurs value being financed by a more reputable VC, while we emphasize specific patterns of competition between asymmetrically informed VCs.

Last, these results state that, in some situations, the entrepreneur is unable to derive bargaining power from the threat of competition, and to obtain a higher valuation for this project. Because competition between VCs is plagued by asymmetric information, the entrepreneur is hurt if he chooses to enforce competition rather than to negotiate. The reason is that when the entrepreneur infers that the first signal is high, he internalizes the consequence of the second VC's winner's curse if he enforces competition, which annihilates the threat of competition. When the second signal is much more precise than the first, this cost of enforcing competition can be outweighed by the benefit of obtaining the second signal, and competition can occur in equilibrium.

We conclude this section by exploring the efficiency of the investment decision in the negotiation game.

[17] Note that there might exist equilibria in which either VC_1 makes the same offer whatever his signal, or makes no offer, and the entrepreneur enforces competition with probability one. Again, for such equilibria to exist, it must be the case that the surplus that can be shared by VC_1 and the entrepreneur at the negotiation stage is lower than their joint expected profit if competition takes place.

Corollary 2 *If the entrepreneur contacts the more experienced VC first, investment is efficient in the sense that all positive NPV projects are financed, and no negative NPV project is. If the entrepreneur contacts the less experienced VC first, there is overinvestment, since some negative NPV projects also obtain financing.*

Corollary 2 follows directly from the result stated in proposition 2. If the entrepreneur contacts the more experienced VC first, his project is financed each time VC_1 receives a high signal, and not otherwise. This is clearly the optimal investment strategy, and the expected profit is maximal in that case. If the entrepreneur contact the less experienced VC first, all positive NPV projects are financed, but also some negative NPV projects: projects obtain financing when $s_1 = H_{\underline{\alpha}}$, or when $s_1 = L_{\underline{\alpha}}$ and $s_2 = H_{\overline{\alpha}}$. Straightforward computation show that :

$$prob_{H_{\underline{\alpha}}} + prob_{H_{\overline{\alpha}},L_{\underline{\alpha}}} B = prob_{H_{\overline{\alpha}}} + prob_{H_{\underline{\alpha}},L_{\overline{\alpha}}}.$$

There is thus overinvestment when the entrepreneur contacts the less experienced VC first, and the expected profit in the industry is lower. In spite of the superior efficiency of initiating negotiation with the more experienced VC, this fund-raising strategy will appear strictly dominated from the entrepreneur's point of view, as will be shown in the next section that . The reason is that although the total expected monetary profit is higher, the entrepreneur cannot capture any part of it. Also, because of his private benefit, the entrepreneur will care about the probability to obtain financing.

5 Entrepreneur's optimal fund raising strategy

In this section, we analyze which alternative will be chosen by the entrepreneur. To do this, we compare the entrepreneur's expected utility when he initiates upfront competition, and when he decides to negotiate first with one VC.

We first need to determine which VC will be contacted first by the entrepreneur, if he decides to initiate negotiation.

Proposition 4 *If the entrepreneur decides to negotiate, he will always send his project to the less experienced VC first.*

The proof of proposition 4 is the following. Recall that in the equilibrium presented in proposition 2, the entrepreneur obtains zero expected monetary profits, because at each stage, only one VC makes an offer, and extracts all the project monetary surplus. To maximize his expected utility, the entrepreneur will simply choose the strategy that grants him the highest expected private benefit, i.e. the highest probability to obtain financing. If he contacts the more

experienced VC first, he obtains financing only if the latter receives a high signal. Indeed, if the competition stage is reached, the second VC will not propose any deal. His expected utility is then:

$$U_E = prob_{H_{\overline{\alpha}}} B.$$

If the entrepreneur contacts the less experienced VC first, he obtains financing if the latter receives a high signal, or if the second VC receives a high signal. His expected utility is therefore:

$$\begin{aligned} U_E &= prob_{H_{\underline{\alpha}}} + prob_{H_{\overline{\alpha}}, L_{\underline{\alpha}}} B, \\ &= prob_{H_{\overline{\alpha}}} + prob_{H_{\underline{\alpha}}, L_{\overline{\alpha}}} B, \end{aligned}$$

which is clearly higher. Finally, note that if the entrepreneur contacts the less experienced VC first, there can also exist an equilibrium in which the initial offer is rejected, and competition is always enforced. If the entrepreneur obtains a higher expected utility under that equilibrium, he will a fortiori contact the less experienced VC first.

The following proposition now describes the optimal fund-raising strategy of the entrepreneur.

Proposition 5 *If the level of private benefit B is sufficiently low, in the sense that:*

$$B \leq \frac{1}{(1-\underline{x}) prob_{L_{\overline{\alpha}}, H_{\underline{\alpha}}}} . \left[prob_{H_{\overline{\alpha}}} \left(q(H_{\overline{\alpha}}) pR - \frac{q(H_{\overline{\alpha}})}{q(H_{\underline{\alpha}})} I \right) + prob_{L_{\overline{\alpha}}, H_{\underline{\alpha}}} \underline{x} (q(L_{\overline{\alpha}}, H_{\underline{\alpha}}) pR - I) \right], \quad (1)$$

the entrepreneur initiates upfront competition. Otherwise, he prefers to start negotiating with the less experienced VC.

Proposition 5 implies that when the entrepreneur values only monetary profits, he always chooses to enforce competition initially. Recall from the equilibria derived in sections 3 and 4 that the entrepreneur cannot obtain more than the competition profits in the negotiation game. Therefore, the entrepreneur is always better off sending his project to the whole VC industry.

Importantly, entrepreneurs do not always have an interest to "flood the market" with their investment projects. As mentioned previously, enforcing upfront competition is also potentially costly. Because of the winner's curse, the less experienced VC refrains from making an offer each time he receives a high signal. Consequently, the probability of obtaining financing are different in the two fund-raising strategies. When the entrepreneur derives a sufficiently high level of private benefit from implementing his project, he favors the negotiation strategy, even though his monetary profits are lower. Indeed, if the entrepreneur starts negotiating with the less experienced VC first, the probability to obtain financing is strictly larger than under upfront competition: the entrepreneur obtains financing each time any of the two VCs has received a high signal. If the entrepreneur enforces upfront competition, this is not the case anymore, since

the less experienced VC does not always make an offer after a high signal. Therefore, negotiation can dominate competition.

The optimal fund-raising strategy of the entrepreneur obviously has consequences for the VC industry. In particular, it affects the deal flow and level of expected profits of each VC in the following way.

Proposition 6 *When B is low in the sense that equation (1) holds, the deal flow of the two VCs is large, and only the most experienced VC earns positive expected profits. As B increases in the sense that equation (1) does not hold any more, the level of expected profits of the less experienced VC increases, while that of the more experienced VC decreases. Also, the more experienced VC deal flow decreases.*

Clearly, the two VCs are not indifferent to the entrepreneur's strategy choice. The more experienced VC strictly prefers the upfront competition, because it ensures him a high deal flow. Since he has an informational advantage over both the entrepreneur and the other VC, he is able to extract surplus from his superior signal. When negotiation is chosen, the more experienced VC receives only the deals that have been rejected by his competitor, which lowers his deal flow and his expected profit. At the opposite, the less experienced VC strictly prefers the negotiation strategy since he can offer a deal without the fear of being challenged when his competitor has received a high signal. Proposition 6 also suggests that different types of VCs will attract different types of entrepreneurs. If one assumes that different types of entrepreneurs exist in the economy, low-private benefit entrepreneurs will send their projects to both inexperienced and experienced VCs, while high-private benefit entrepreneurs will favor less experienced VCs. Overall, the deal flow of less experienced VCs will be higher than that of more experienced venture capital firms.

The next proposition concludes on the efficiency of the entrepreneur's decision, when one values monetary profits only.

Proposition 7 *There is less overinvestment, and total expected monetary profits are higher, when the entrepreneur initiates upfront competition (i.e. when equation (1) holds), than when the entrepreneur negotiates with the less experienced VC.*

The result stated in proposition 7 follows from the previous discussions on the level of over-investment induced by the two fund-raising strategies. The efficient investment decision is to finance projects if and only if the more experienced VC has received a high signal. In all the other cases, the investment project has, by assumption, a negative NPV. Under negotiation, the probability to finance projects is:

$$prob_{H_{\underline{\alpha}}} + prob_{H_{\overline{\alpha}},L_{\underline{\alpha}}}$$

, which is equal to

$$prob_{H_{\overline{\alpha}}} + prob_{H_{\underline{\alpha}},L_{\overline{\alpha}}}$$

. Under competition, the probability to finance projects is:

$$prob_{H_{\overline{\alpha}}} + prob_{H_{\underline{\alpha}},L_{\overline{\alpha}}\underline{x}}$$

. In both cases, there is overinvestment, since all positive NPV, but some negative NPV projects are financed, but there is less overinvestment in the upfront competition strategy. As a consequence, expected profits are higher. Again, although upfront competition is more efficient, it may not be the optimal choice of the entrepreneur who also enjoys a private benefit of being funded.

6 Conclusion

In this paper, we investigate how competition takes place in the VC industry for entrepreneurs who seek financing for innovative projects. We consider a model whereby a cash-poor entrepreneur proposes an investment project to venture capitalists. An important assumption is that venture capitalists are able to extract private information on the true value of the project, which constitutes an informational advantage when dealing with the entrepreneur. We compare the utility that the entrepreneur can obtain when he proposes his project to two VCs at the same time, who then compete under asymmetric information, and when he starts negotiating with one VC only. In this latter game, the entrepreneur can always reject the first VC's offer, and enforce competition.

Our analysis builds on two important assumptions: first, VCs have different signal precisions, which make them more or less vulnerable when competing with each other. As a consequence, their equilibrium strategies and expected profits will be different. Second, the entrepreneur enjoys non monetary benefits when his project is implemented. When deciding his optimal fund-raising strategy, he will care not only about the expected monetary profits he will obtain from each offer he receives, but also about the probability to obtain financing at all. This will affect the efficiency of the investment decision, and the performance of the industry.

Our results are that, first, the entrepreneur cannot use the threat of competition to extract profit when negotiating with one VC only. Either he accepts any offer by the first VC, and makes zero profits, or he always enforces competition. This last equilibrium does not always exist because enforcing competition is costly for both the entrepreneur and the initial venture capitalist. Winner's curse at the competition stage makes the entrepreneur more willing to find an agreement at the initial stage of negotiation, which destroys his bargaining power. Second, the optimal fund-raising strategy of the entrepreneur depends on his level of private benefit.

When his private benefit is low, he favors upfront competition, which leads to a high deal flow for both VCs, positive expected profits for the more experienced VC, and zero expected profits for the less experienced VC. It means that the less experienced VC cannot earn more than the relevant market return given the project risk. When the level of private benefit is high, the entrepreneur prefers to start negotiating with the less experienced VC first. This raises the latter's expected profit, and reduces both the deal flow and the expected profit of the more experienced VC. Finally, this strategy reduces efficiency in the sense that more negative NPV projects are financed and total expected monetary profits decrease.

Appendix

Proof of lemma 1

Suppose first that VC_i anticipates that $\gamma_j^*(L) = \emptyset$. Then announcing $\gamma_i(L) = \emptyset$ is clearly a dominant strategy, since the maximum profit that VC_i can obtain is : $NPV(q(_{Li})) < 0$.

Suppose next that VC_i anticipates that $\gamma_j^*(L) = \gamma_j^* > 0$, and that $\gamma_j^*(H) = \gamma_j^{**} > 0$. For VC_i to make a bid after a low signal, he must win more often when VC_j has received a high signal than when VC_j has received a low signal. This anticipation on VC_j's strategies is clearly not rational since the latter would make negative profits.

□

Proof of Lemma 2

We know from lemma 1 that VC_j does not make any offer when $s_j = L$. Let us establish that there is no pure strategy equilibrium when $s = H$. Suppose that VC_i anticipates that $\gamma_j^*(H) = \gamma_j^*$. The expected payoff of VC_i is:

$$\begin{cases} prob_{L_j/H_i}(\gamma_i q(_{Hi}, _{Lj})pR - I) & \text{if } \gamma_i > \gamma_j^*, \\ prob_{L_j/H_i}(\gamma_i q(_{Hi}, _{Lj})pR - I) + prob_{H_j/H_i}\lambda(\gamma_i q(_{Hi}, _{Hj})pR - I) & \text{if } \gamma_i = \gamma_j^*, \\ prob_{L_j/H_i}(\gamma_i q(_{Hi}, _{Lj})pR - I) + prob_{H_j/H_i}(\gamma_i q(_{Hi}, _{Hj})pR - I) & \text{if } \gamma_i < \gamma_j^*, \end{cases}$$

where $prob_{L_j/H_i}$ denotes the probability that VC_j receives a low signal given that VC_i has received a high signal. When both VCs make the same bid, we assume that the probability that VC_i wins is equal to λ.

See first that if $\gamma_i = \gamma_j^*$, one can always find $\epsilon > 0$ such that if VC_i prefers not to deviate (i.e. if λ is high enough), this is not an equilibrium strategy for VC_j, who prefers to deviate and undercut VC_i's bid.

Define $\hat{\gamma}_i$ as follows:

$$\max[0, prob_{L_j/H_i}(q(_{Hi}, _{Lj})pR - I)] = prob_{L_j/H_i}(\hat{\gamma}_i q(_{Hi}, _{Lj})pR - I) + prob_{H_j/H_i}(\hat{\gamma}_i q(_{Hi}, _{Hj})pR - I).$$

$\hat{\gamma}_i$ is the bid such that VC_i is indifferent between bidding $\hat{\gamma}_i$ if he wins with probability one, and bidding the highest possible bid, if he wins only when VC_j has received a low signal. Note that the less experienced Vc bids nothing if he wins only when the other signal is low, while the most

experienced VC bids 1 in that case. Therefore:

$$\begin{aligned}\hat{\gamma}_{\underline{\alpha}} &= \frac{I}{q(_H\underline{\alpha})pR},\\ \hat{\gamma}_{\overline{\alpha}} &= \frac{prob_{L_{\underline{\alpha}}/H_{\overline{\alpha}}}(q(_H\overline{\alpha},{}_L\underline{\alpha})pR-I)+I}{q(_H\overline{\alpha})pR}.\end{aligned}$$

We have that $\hat{\gamma}_{\overline{\alpha}} < \hat{\gamma}_{\underline{\alpha}}$ if

$$I\left(\frac{q(_H\overline{\alpha})}{q(_H\underline{\alpha})}-1\right) > prob_{L_{\underline{\alpha}}/H_{\overline{\alpha}}}(q(_H\overline{\alpha},{}_L\underline{\alpha})pR-I).$$

Note that

$$\frac{q(_H\overline{\alpha})}{q(_H\underline{\alpha})} = \frac{\overline{\alpha}q_0[\underline{\alpha}q_0+(1-\underline{\alpha})(1-q_0)]}{\underline{\alpha}q_0[\overline{\alpha}q_0+(1-\overline{\alpha})(1-q_0)]}$$

and

$$prob_{L_{\underline{\alpha}}/H_{\overline{\alpha}}}(q(_H\overline{\alpha},{}_L\underline{\alpha})pR-I) = \frac{\overline{\alpha}(1-\underline{\alpha})q_0}{\overline{\alpha}q_0+(1-\overline{\alpha})(1-q_0)}pR - I\frac{\overline{\alpha}(1-\underline{\alpha}q_0)+\underline{\alpha}(1-\overline{\alpha})(1-q_0)}{\overline{\alpha}q_0+(1-\overline{\alpha})(1-q_0)}.$$

Therefore $\hat{\gamma}_{\overline{\alpha}} < \hat{\gamma}_{\underline{\alpha}}$ is equivalent to

$$\overline{\alpha}[(I-q_0pR)(1-\underline{\alpha})(\underline{\alpha}-\frac{I(1-q_0)}{q_0pR-I})] > I(1-q_0)\underline{\alpha}(1-\underline{\alpha}).$$

Observe that the LHS is always positive when q_0pR-I is negative so that this condition boils down to

$$\overline{\alpha} > \frac{I(1-q_0)\underline{\alpha}}{\underline{\alpha}(I-q_0pR)+I(1-q_0)},$$

which is always satisfied when $q(_H\overline{\alpha},{}_L\underline{\alpha})pR-I>0$.

If $\gamma^*_{\overline{\alpha}} < \hat{\gamma}_{\underline{\alpha}}$, then the optimal strategy of $VC_{\underline{\alpha}}$ is to play $\gamma_{\underline{\alpha}} = \emptyset$. In this case, the optimal strategy of $VC_{\overline{\alpha}}$ is to play 1, hence this is not an equilibrium. If $\gamma^*_{\overline{\alpha}} > \hat{\gamma}_{\underline{\alpha}}$, then $VC_{\underline{\alpha}}$ optimally plays $\gamma^*_{\overline{\alpha}}-\epsilon$, but $VC_{\overline{\alpha}}$ wants to deviate from his initial strategy. Hence this is not an equilibrium. Finally, if $\gamma^*_{\overline{\alpha}} = \hat{\gamma}_{\underline{\alpha}}$, $VC_{\underline{\alpha}}$ makes negative profits and prefers to play $\emptyset$. In that case, $VC_{\overline{\alpha}}$ increases his bid. Therefore, there is no pure strategy equilibrium when a VC observes a high signal.

Proof of proposition 1

Lemma 2 states that there is no pure-strategy equilibrium in the upfront competition game. We first look for the bounds of the support of the mixed-strategy equilibrium. Recall that $\hat{\gamma}_{\underline{\alpha}} > \hat{\gamma}_{\overline{\alpha}}$. $VC_{\overline{\alpha}}$ and $VC_{\underline{\alpha}}$ will thus play a mixed strategy with support $[\hat{\gamma}_{\underline{\alpha}}, 1]$.

Clearly, for $VC_{\underline{\alpha}}$ to play a mixed strategy with support $\Sigma_{\underline{\alpha}} = [\hat{\gamma}_{\underline{\alpha}}, 1]$, it must be the case that $VC_{\overline{\alpha}}$ plays 1 with strictly positive probability (otherwise, $VC_{\underline{\alpha}}$ will make negative profits when bidding 1). This is only possible if $VC_{\underline{\alpha}}$ does not participate with strictly positive probability (otherwise, the expected profit of $VC_{\overline{\alpha}}$ is lower when he bids 1 than when he bids $\hat{\gamma}_{\underline{\alpha}}$). Therefore, the equilibrium we are considering has the following features: after receiving a high signal, $VC_{\overline{\alpha}}$, with probability $\overline{x}$, randomizes according to the continuous distribution $\overline{F}(\gamma)$ on $[\hat{\gamma}_{\underline{\alpha}}, 1]$ and, with probability $(1-\overline{x})$, bids 1. After a high signal, $VC_{\underline{\alpha}}$, with probability $\underline{x}$, randomizes according to the continuous distribution $\underline{F}(\gamma)$ on $[\hat{\gamma}_{\underline{\alpha}}, 1]$ and, with probability $(1-\underline{x})$, does not participate.

To determine the distribution function of the mixed strategy, recall that by definition, for each strategy $\gamma_{\overline{\alpha}}$ played by $VC_{\overline{\alpha}}$, his expected profit must be equal to : $I\left(\frac{q(H_{\overline{\alpha}})}{q(H_{\underline{\alpha}})} - 1\right)$. In particular, when $VC_{\overline{\alpha}}$ bids 1, at equilibrium we must have:

$$prob_{L_{\underline{\alpha}}/H_{\overline{\alpha}}}(q(H_{\overline{\alpha}}, L_{\underline{\alpha}})pR - I) + prob_{H_{\underline{\alpha}}/H_{\overline{\alpha}}}(1-\underline{x})(q(H_{\overline{\alpha}}, H_{\underline{\alpha}})pR - I) = I\left(\frac{q(H_{\overline{\alpha}})}{q(H_{\underline{\alpha}})} - 1\right).$$

This is equivalent to :

$$\underline{x} = \frac{(1 - \frac{I}{q(H_{\underline{\alpha}})pR})(q(H_{\overline{\alpha}})pR)}{prob_{H_{\underline{\alpha}}/H_{\overline{\alpha}}}(q(H_{\overline{\alpha}}, H_{\underline{\alpha}})pR - I)}.$$

See that $\underline{x}$ is strictly positive since $1 - \frac{I}{q(H_{\underline{\alpha}})pR} > 0$.

By the same reasoning, for any $\gamma_{\overline{\alpha}}$ in $[\hat{\gamma}_{\underline{\alpha}}, 1]$, we must have:

$$\underline{F}(\gamma) = \frac{(\gamma - \frac{I}{q(H_{\underline{\alpha}})pR})q(H_{\overline{\alpha}})pR}{\underline{x}prob_{H_{\underline{\alpha}}/H_{\overline{\alpha}}}(\gamma q(H_{\overline{\alpha}}, H_{\underline{\alpha}})pR - I)}.$$

It is easy to see that $\underline{F}$ has all the properties of a distribution function : $\underline{F}$ is increasing in γ, $\underline{F}(\hat{\gamma}_{\underline{\alpha}}) = 0$, and $\underline{F}(1) = 1$.

Similarly, for each strategy $\gamma_{\underline{\alpha}}$ played by $VC_{\underline{\alpha}}$, his expected profit must be equal to zero. In particular, if $\gamma = 1$, we must have:

$$prob_{L_{\overline{\alpha}}/H_{\underline{\alpha}}}(q(H_{\underline{\alpha}}, L_{\overline{\alpha}})pR - I) + prob_{H_{\overline{\alpha}}/H_{\underline{\alpha}}}(1-\overline{x})\lambda(q(H_{\overline{\alpha}}, H_{\underline{\alpha}})pR - I) = 0.$$

This is equivalent to:

$$1 - \overline{x} = \frac{prob_{L_{\overline{\alpha}}/H_{\underline{\alpha}}}(I - q(H_{\underline{\alpha}}, L_{\overline{\alpha}})pR)}{prob_{H_{\overline{\alpha}}/H_{\underline{\alpha}}}\lambda(q(H_{\overline{\alpha}}, H_{\underline{\alpha}})pR - I)}.$$

See that $1-\overline{x}$ is strictly positive, and strictly lower than 1 if λ is large enough (in particular, this is always true for $\lambda = 1$).

As before, imposing that $VC_{\underline{\alpha}}$'s expected profit is equal to zero for any bid γ defines the probability distribution function $\overline{F}$.

□

Proof of proposition 2

Consider an equilibrium candidate in which VC_1, whatever his level of experience, plays $\gamma_1 = \emptyset$ if $s_1 = L$, and $\gamma_1 = 1$ if $s_1 = H$.Suppose next that VC_2 believes that any offer by VC_1 is accepted by the entrepreneur. His equilibrium belief is thus that $s_1 = L$ if he is contacted. Given his belief, he will play $\gamma_2 = \emptyset$ if $s_2 = L$, and $\gamma_2 = \emptyset$ if he is less experienced, or $\gamma_2 = 1$ if he is more experienced, if $s_2 = H$. Given VC_2's equilibrium strategy, the entrepreneur accepts VC_1's offer, because he cannot earn more by enforcing competition. If he does, VC_1 will play 1 (if he is more experienced) or $1 - \epsilon$ (if he is less experienced). The entrepreneur's expected utility if thus B if he accepts the initial offer, or if he enforces competition (provided ϵ is close to zero). Given that, the first-stage strategy of VC_1 is optimal.

□

Proof of proposition 3

1) Suppose that the entrepreneur contacts $VC_{\overline{\alpha}}$ first. We will show that there is no equilibrium in which the entrepreneur rejects $VC_{\overline{\alpha}}$'s offer with probability $\delta > 0$. Consider such an equilibrium candidate, in which VC_1 makes an offer γ_1 when $s_1 = H$, and no offer when $s_1 = L$, and in which the entrepreneur reject VC_1's offer with probability $\delta > 0$ so that VC_2 wants to participate if he receives a high signal.

Suppose that $\delta < 1$. In that case, the entrepreneur will play a mixed strategy. The minimum feasible bid of VC_2 ($\hat{\gamma}_2(\delta)$) verifies that VC_2 is indifferent between bidding $\hat{\gamma}_2(\delta)$ and winning with probability one, and bidding nothing. We thus have $\hat{\gamma}_2(\delta) = \frac{I}{q(H_2,\delta)pR}$, where $q(H_2, \delta)$ represents the probability that the quality of the project is good given that VC_2 has received a high signal and that he believes that any offer of VC_1 is rejected with probability δ. We have:

$$q(H_2, \delta) = \frac{q_0\alpha_2(\alpha_1\delta + (1-\alpha_1))}{q_0\alpha_2(\alpha_1\delta + (1-\alpha_1)) + (1-q_0)(1-\alpha_2)(\alpha_1 + (1-\alpha_1)\delta)}.$$

One can show that $q(H2, \delta)$ increases with δ so that $\hat{\gamma}_2(\delta)$ decreases with δ. Therefore, if the game reaches the competition stage, the equilibrium strategies are those defined in proposition 1. The expected utility of the entrepreneur, if he rejects VC_1's offer, and enforces competition is written:

$$\begin{aligned} E(U_E(\delta < 1)) \quad = \quad & prob_{H_2/H_1}[x_2(\delta)\{E_{\gamma_1<\gamma_2}(1-\gamma_1)q(H1, H2, \delta)pR + E_{\gamma_1>\gamma_2}(1-\gamma_2)q(H1, H2, \delta)pR\} + \\ & (1-x_2(\delta))E_{F_1}(1-\gamma_1)q(H1, H2, \delta)pR] + prob_{L_2/H_1}[E_{F_1}(1-\gamma_1)q(H1, L2, \delta)pR] + (B) \end{aligned}$$

where $E_{\gamma_1<\gamma_2}$ denotes the expectation operator given that $\gamma_1 < \gamma_2$, and E_{F_1} denotes the expectation operator over the whole distribution function F_1. Note that since the entrepreneur knows that $s_1 = H$, and since VC_1 is more experienced, he expects to be financed with probability one at the competition stage. After manipulations, equation (2) leads to:

$$\begin{aligned} E(U_E(\delta<1)) &= B + q(H1)pR - I - (\hat{\gamma_2}(\delta)q(H1)pR - I) \\ &\quad -prob_{H_2/H_1}x_2(\delta)E_{\gamma_1>\gamma_2}(\gamma_2 q(H1, H2, \delta)pR - I). \end{aligned}$$

The entrepreneur's expected utility is equal to his private benefit B, plus the project's NPV given VC_1's signal, minus the expected profit of VC_1 under competition, (this profit is positive since $\hat{\gamma_2}(\delta) > \hat{\gamma_1}$, minus a third positive term. This third term represents the (positive) expected profit that must be left to VC_2 when $s_1 = H$ to compensate his loss when VC_2 bids and $s_1 = L$.

The surplus that the entrepreneur and VC_1 can share under negotiation is equal to $q(H1)pR - I + B$. Therefore, $E(U_E(\delta<1)) + E(\Pi_{VC_1}) < q(H1)pR - I + B$, where $E(\Pi_{VC_1})$ is VC_1's expected profit under competition. This implies that VC_1 can always propose γ_1 such that he and the entrepreneur are *both* better off negotiating than going to the competition stage. In other words, for any $\delta < 1$, VC_1 always wants to deviate from the offer that makes the entrepreneur indifferent between accepting and rejecting the offer : VC_1 makes a strictly better offer to the entrepreneur who always accepts. As a consequence, the equilibrium candidate in which $\delta < 1$ does not exist.

Suppose next that $\delta = 1$. By analogy with the above case, when the entrepreneur always enforces competition, his expected utility is equal to:

$$\begin{aligned} E(U_E) &= q(H1)pR - I - (\hat{\gamma_2}q(H1)pR - I) \\ &\quad -prob_{H_2/H_1}x_2 E_{\gamma_1>\gamma_2}(\gamma_2 q(H1, H2)pR - I) + B. \end{aligned}$$

The entrepreneur's expected utility is just the project's NPV given VC_1's signal, minus the positive expected profit of VC_1 under competition, minus the positive rent left to VC_2 when $s_1 = H$, plus the private benefit. The surplus that the entrepreneur and VC_1 can share under negotiation is equal to $q(H1)pR - I + B$. Therefore, VC_1 can always propose γ_1 such that he and the entrepreneur are *both* better off negotiating than going to the competition stage, and the above equilibrium candidate does not exist. In equilibrium, when the entrepreneur contacts the more experienced VC first, $\delta = 0$ and the entrepreneur obtains zero profit.

2) Suppose next that the entrepreneur contacts $VC_{\underline{\alpha}}$ first. Consider an equilibrium candidate in which VC_1 makes an offer γ_1 when $s_1 = H$, and no offer when $s_1 = L$. Again, assume $\delta > 0$, so that VC_2 participates if he is contacted and receives a high signal. We have $\hat{\gamma_1} > \hat{\gamma_2}(\delta = 1)$. However since $\hat{\gamma_2}(\delta)$ is decreasing with δ, the minimum bid of VC_2 can be larger or smaller than the minimum bid of VC_1.

Consider first the values of δ such that $\hat{\gamma}_1 > \hat{\gamma}_2(\delta)$. The equilibrium strategies are those defined in the first part of the proof and we know that an equilibrium in which $0 < \delta < 1$ does not exist.

If $\delta = 1$, the expected utility of the entrepreneur, if he always refuses the offer of VC_1 and enforces competition ($\delta = 1$) is written:

$$\begin{aligned} E(U_E) &= prob_{H_2/H_1}[x_1 \{E_{\gamma_1<\gamma_2}(1-\gamma_1)q(H_1,H_2)pR + E_{\gamma_1>\gamma_2}(1-\gamma_2)q(H_1,H_2)pR\} + \\ &\quad (1-x_1)E_{F_2}(1-\gamma_2)q(H_1,H_2)pR + B] + prob_{L_2/H_1}x_1[E_{F_1}(1-\gamma_1)q(H_1,L_2)pR + B]. \end{aligned}$$

After manipulations, the entrepreneur's expected utility if he enforces competition becomes:

$$\begin{aligned} E(U_E) &= x_1(q(H_1)pR - I) + prob_{H_2/H_1}(1-x_1)(q(H_1,H_2)pR - I) \\ &\quad -prob_{H_2/H_1}[(1-x_1)E_{F_2}(\gamma_2 q(H_1,H_2)pR - I) - x_1 E_{\gamma_1>\gamma_2}(\gamma_2 q(H_1,H_2)pR - I)] \\ &\quad +[prob_{H_2/H_1} + prob_{L_2/H_1}x_1]B. \end{aligned}$$

Recall that the profit of VC_1 at the competition stage is zero in expectation. Therefore the joint profit of the entrepreneur and VC_1 at the competition stage is larger than the surplus they share under negotiation iff:

$$E(U_E) > q(H_1)pR - I + B$$

. Formally, there exists an equilibrium in which the entrepreneur always refuses VC_1's offer, and enforces competition iff:

$$\begin{aligned} prob_{H_2/H_1}[(1-x_1)E_{F_2}(\gamma_2 q(H_1,H_2)pR - I) - x_1 E_{\gamma_1>\gamma_2}(\gamma_2 q(H_1,H_2)pR - I)] < \\ (1-x_1)prob_{L_2/H_1}(I - B - q(H_1,L_2)pR). \quad (3) \end{aligned}$$

When equation (3) holds, the joint profit of the entrepreneur and VC_1 increases if competition is enforced, compared to the negotiation stage. This equilibrium can occur because the second signal increases the value of the project. This can overcome the rent left to VC_2 when $s_1 = H$. The LHS of equation (3) represents the rent to be left to VC_2 when $s_1 = H$, and the RHS represents the increase in the project's NPV after the second signal. Competition is valuable because VC_1 does not always bid when $s_2 = L$, therefore some negative NPV projects are not financed (while they would be at the negotiation stage). Note that the benefit of competition is mitigated by the loss of the private benefit B when such projects are not financed anymore. Intuitively, when B is large, the benefit of competition vanishes. If the former effect is smaller than the latter, VC_1 cannot make an offer that discourages competition, and an equilibrium in which the entrepreneur always enforces competition (i.e. $\delta = 1$) exists.

Consider next the values of δ such that $\hat{\gamma}_1 < \hat{\gamma}_2(\delta)$. When VC_2 believes that VC_1's offer is rejected with probability δ, his minimum bid is defined as follows :

$$\hat{\gamma}_2(\delta) = \frac{prob_{L_1/H_2,\delta}(q(H_2,L_1,\delta)pR - I) + I}{q(H_2,\delta)pR}. \quad (4)$$

Equation (4) is equivalent to:

$$\hat{\gamma}_2(\delta) = \frac{q_0\alpha_2(1-\alpha_1)pR + \delta I[q_0\alpha_1\alpha_2 + (1-\alpha_1)(1-\alpha_2)(1-q_0)]}{\alpha_2 q_0(\alpha_1\delta + (1-\alpha_1))pR}. \tag{5}$$

Using equation (5), condition $\hat{\gamma}_1 < \hat{\gamma}_2(\delta)$ holds if and only if :

$$\delta < \frac{\alpha_2[q_0\alpha_1 pR - I(\alpha_1 q_0 + (1-\alpha_1)(1-q_0))]}{I\alpha_1(1-q_0)(2\alpha_2 - 1)} \tag{6}$$

It is easy to see that this condition can be satisfied since the RHS is positive. In that case, VC_2 does not want to bid until $\hat{\gamma}_1$ since he can obtain a strictly higher expected payoff by bidding 1 each time he receives a high signal. Therefore, he randomizes over a strictly smaller interval: he bids less aggressively. This implies that VC_1 never bids below $\hat{\gamma}_2(\delta)$, and that he also earns positive expected profits.

We now characterize the mixed strategy equilibrium when the minimum bid of each VC is $\hat{\gamma}_2(\delta)$. When VC_2 receives a high signal, with probability $x_2(\delta)$, he randomizes according to the continuous distribution $F_2(\gamma)$ on $[\hat{\gamma}_2(\delta), 1]$ and, with probability $(1 - x_2(\delta))$, he plays $\gamma_2^* = 1$. When VC_1 receives a high signal, he randomizes according to the continuous distribution $F_1(\gamma)$ on $[\hat{\gamma}_2(\delta), 1]$. The expected profit of VC_2 is strictly positive and equal to $prob_{L_1/H_2,\delta}(q(H_2, L_1, \delta)pR - I)$. The expected profit of VC_1 is also positive and equal to $\hat{\gamma}_2(\delta)(q(H_1)pR - I)$.

Proceed as in proposition 1 to determine that in equilibrium, VC_2, after a high signal, plays 1 with probability $1 - x_2(\delta)$ and with probability $x_2(\delta)$ randomizes according to the continuous distribution $F_2(\gamma)$ on $[\hat{\gamma}_2(\delta), 1]$ where

$$1 - x_2(\delta) = \frac{\hat{\gamma}_2(\delta)}{q(H_1)pR - I + prob_{L_2/H_1}(I - q(H_1, L_2(\delta))pR)} prob_{H_2/H_1}(q(H_1, H_2(\delta))pR - I),$$

and

$$F_2(\gamma) = \frac{(\gamma - \hat{\gamma}_2(\delta))q(H_1)pR}{prob_{H_2/H_1}x_2(\delta)(\gamma q(H_1, H_2, (\delta))pR - I)}.$$

After a high signal, VC_1 randomizes according to the continuous distribution $F_1(\gamma)$ on $[\hat{\gamma}_2(\delta), 1]$ where

$$F_1(\gamma) = \frac{\gamma q(H_2, \delta)pR - I - prob_{L_1/H_2,\delta}(q(H_2, L_1, \delta)pR - I)}{prob_{H_1/H_2,\delta}(\gamma q(H_1, H_2, \delta)pR - I)}.$$

The expected utility of the entrepreneur, if he refuses the offer of VC_1, given that VC_2 believes that any offer of VC_1 is rejected with probability δ such that $\hat{\gamma}_1 < \hat{\gamma}_2(\delta)$, is written:

$$\begin{aligned} E(U_E(\hat{\gamma}_1 < \hat{\gamma}_2(\delta)) \quad = \quad & prob_{H_2/H_1}[\{E_{\gamma_1<\gamma_2}(1-\gamma_1)q(H_1, H_2, \delta)pR + E_{\gamma_1>\gamma_2}(1-\gamma_2)q(H_1, H_2, \delta)pR\} + \\ & prob_{L_2/H_1}[E_{F_1}(1-\gamma_1)q(H_1, L_2, \delta)pR] + B. \end{aligned} \tag{7}$$

Equation (7) can be simplified as follows:

$$\begin{aligned} E(U_E(\hat{\gamma}_1 < \hat{\gamma}_2(\delta)) &= q(_{H}1)pR - I - (\hat{\gamma}_2(\delta)q(_{H}1)pR - I) \\ &\quad -prob_{H_2/H_1}E_{\gamma_1>\gamma_2}(\gamma_2 q(_{H}1, _{H}2, \delta)pR - I) + B. \end{aligned}$$

The entrepreneur's expected utility is equal to the project's NPV given VC_1's signal, minus the expected profit of VC_1 under competition, minus the rent left to VC_2 when $s_1 = H$, plus the private benefit B. Clearly, $E(U_E(\hat{\gamma}_1 < \hat{\gamma}_2(\delta)) + E(\Pi_{VC_1}) < q(_{H}1)pR - I + B$. Therefore, VC_1 can propose γ_1 such that both he and the entrepreneur are better off negotiating than enforcing competition, and the above equilibrium candidate does not exist.

□

Proof of proposition 5

When upfront competition is enforced, the expected utility of the entrepreneur is equal to the total expected monetary profits, minus the expected profit of $VC_{\overline{\alpha}}$, plus the expected private benefit. Formally, under upfront competition, we have:

$$\begin{aligned} E(U_E) &= prob_{H_{\overline{\alpha}}}[q(_{H}\overline{\alpha})pR - I + B] + prob_{H_{\underline{\alpha}},L_{\overline{\alpha}}}\underline{x}[q(_{L}\overline{\alpha}, _{H}\underline{\alpha})pR - I + B] \\ &\quad -prob_{H_{\overline{\alpha}}}I\left[\frac{q(_{H}\overline{\alpha})}{q(_{H}\underline{\alpha})} - 1\right]. \end{aligned} \tag{8}$$

When the entrepreneur initiates negotiation with the less experienced VC, he obtains:

$$E(U_E) = prob_{H_{\underline{\alpha}}}B + prob_{L_{\underline{\alpha}},H_{\overline{\alpha}}}B. \tag{9}$$

Using equations (8) and (9), it follows that the entrepreneur prefers upfront competition iff:

$$B \leq \frac{1}{(1-\underline{x})prob_{L_{\overline{\alpha}},H_{\underline{\alpha}}}}.\left[prob_{H_{\overline{\alpha}}}\left(q(H_{\overline{\alpha}})pR - \frac{q(H_{\overline{\alpha}})}{q(H_{\underline{\alpha}})}I\right) + prob_{L_{\overline{\alpha}},H_{\underline{\alpha}}}\underline{x}(q(L_{\overline{\alpha}}, H_{\underline{\alpha}})pR - I)\right],$$

□

Proof of proposition 6

SHOW THAT THE EXPECTED PROFIT OF $VC_{\overline{\alpha}}$ DECREASES WITH NEGO.

□

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