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Abstract

In early round investments by VC syndicates, the VCs which compose the syndicate often have very different levels of experience. In later round VC syndicates, often no VC from the earlier round syndicate is present. We show that a theory of informational hold-up by the incumbent syndicate can relate and explain these two observations. Consistent with the theory, we find empirically that the heterogeneity in experience of VC syndicate partners is (i) negatively related to the extent to which outside VCs trust in the entrepreneur and (ii) positively related to the likelihood of syndicate switching in a later round.

Keywords: Venture Capital, Syndication, Staged Investment, Heterogeneity, Switching, Network Centrality.

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1 Introduction

A common feature of venture capital financing is that investments are staged. Investment in a project is staged, when capital is infused over time in a sequence of financing rounds. Staging gives abandonment options. It allows a venture capitalist (henceforth VC) to observe interim information about a project's viability before continuing financing (Gompers (1995)). The ability to deny financing mitigates hold-up by the entrepreneur, as it pushes the entrepreneur to exert effort, not divert cash flows and not manipulate short term appearances (Bergemann and Hege (1998), Noldeke and Schmidt (1998), Neher (1999), Landier (2002), Cornelli and Yosha (2003), and Yung (2019)).

VCs emphasise their ability to interpret information so as to assess projects accurately. There is a wide consensus that this ability is determined by past experience, with more experienced VCs better at screening and selecting entrepreneurial projects (Lerner (1994)). Past experience is one of the strongest source of differentiation among VCs: entrepreneurs are willing to forego offers with higher valuations in order to affiliate with more experienced VCs (Hsu (2004)) and there exists a positive sorting mechanism in which more experienced VCs invest in better projects (Sørensen (2007)).

A second common feature of venture capital financing is that VCs form syndicates. Two or more VCs form a syndicate when they jointly finance an investment round. Syndication has reinforcing effects. It improves accuracy, as more than one VC evaluates the project before an additional round of investment is financed.[1] Incentive problems arise between associates, but syndication is a coordination device that prevents profit-dissipating competition between VCs from actually taking place (Casamatta and Haritchabalet (2007)). Syndicating VCs can be induced to truthfully reveal their non-verifiable and manipulable signals to each other with an appropriate design of cash-flow rights (Cestone et al. (2008)). A common result of these agency theories is that experienced VCs should syndicate with other similarly experienced VCs.

So other things being equal, information issues and incentive problems point towards the desirability of VC experience. Therefore, entrepreneurs should seek to obtain the financial back-

[1]Syndication also permits VCs to diversify their portfolios. Venture capital returns are skewed: VCs write off over half of their investments and generate a substantial portion of their return from just a few highly successful ventures (Kerr et al. (2014)). Syndication allows VCs to share risks so as to increase the odds of having a huge success.

ing of most experienced VCs. This desirability of experience extends to syndicates, with the association of highly experienced VCs with highly experienced VCs being the most desirable.[2]

But what are the implications for less experienced VCs? Does the desirability of VC experience result in a pecking order, where second tier VCs syndicate with second tier VCs, third tier VCs with third tier VCs, and so on? Do syndicates associate VCs with different levels of experience instead? Also, if highly experienced VCs finance an early round and assess projects more accurately than other VCs, can a project find follow-on financing if none of the early round VCs participate to the follow-on round? Do the VCs who participate in a follow-on round include those who previously invested in the firm?

Looking at all VC funding rounds which took place in the U.S. in the five-year window between 2010 and 2014 and measuring the experience of a VC firm by simply counting the number of investment rounds it has participated to date since 1975, we observe:

1. Within VC syndicates, VCs have remarkably different levels of experience: Across all investment rounds, the experience of the VCs which compose a syndicate have at median level a coefficient of variation equal to 0.68 and a Gini coefficient equal to 0.72.[3]
2. From one round of investment to another, complete switching of VCs is more common than one might expect: As much as 24% of syndicated rounds have *all* of the investing VCs no longer investing in any of the subsequent rounds, conditional on an entrepreneur receiving subsequent funding.

These features are somewhat more pronounced in early rounds of investments. Table 1 gives a complete by-round comparison. It appears that syndicate experience heterogeneity and switching rate decline with round sequence numbers.

We are not the first to notice this sort of anomalies: Lerner (1994) found evidence that within the top two quintiles of VC firms, first-round syndicates are disproportionately heterogeneous.[4] Hochberg et al. (2015) analyse the extent to which VCs syndicate in order to aggregate four

[2]Assessing a project accurately is (more fundamentally) likely to require more than one area of technical expertise. Then if VCs had specialized expertise, another rationale for syndication would be to assemble VCs with different and complementary areas of expertise. However, as long as expertise is primarily acquired through experience, highly experienced VCs should still associate with highly experienced VCs.

[3]Both normalized measures can take values between 0 (all equal) and 1 (most dispersed). See Section 3.2.

[4]Although Lerner's study is largely seen as providing evidence that established VCs (measured by size) syndicate with other established partners, he noticed some inconsistent patterns in the data and remarked that: *"It is*

orthogonal resources (experience itself, available capital, investment scope, and access) and find little evidence of similarity based matching. Cumming and Dai (2013) report that 23% of follow-on rounds of financing have lead VCs (defined as the VC that had invested the largest cumulative amount of capital by the time of the round of interest) that are different from those of the previous rounds.

The objective of this paper is to show that the above observations can be rationalized and related to a theory of relationship finance and informational hold-up by the lender, in the spirit of Sharpe (1990) and Rajan (1992). The key informational asymmetry postulated here is that a lender obtains information about the project in the course of lending which the entrepreneur cannot easily communicate to others. The resulting informational advantage over alternative lenders gives the lender ex-post monopoly power vis-a-vis the entrepreneur. In the above banking theories, the associated hold-ups by the lender have the following implications: firms are "informationally captured" as they stay with the same bank although it does not make the best offer (Sharpe (1990)); banks extract value from the firm owner in exchange of continued lending (Rajan (1992)).

Several papers study informational hold-ups by the lender in contexts that apply to venture capital. In Fluck et al. (2009), a commitment to later round syndication restrains the temptation of the early round VC to hold-up the entrepreneur. Ewens et al. (2016) find that projects where only previous VCs participate to follow-on financings are 20% more likely to lead to failures than projects where new VCs participate. They attribute this to lower opportunity costs of VCs over the VC fund life-cycle. In Azarmsa and Cong (2020) the entrepreneur controls the information production. This reduces the lender's ex-post monopoly power, but impedes relationship finance itself, as the entrepreneur now inefficiently holds up the lender. In Mella-Barral (2020) the more experienced the incumbent VC, the more the signal sent by his non-participation to alternative financiers would be negative. Then the more he can extract ex-post concessions from the entrepreneur.

We adapt the theory of informational hold-up by the lender to VC syndicates. We consider an entrepreneur with a project whose quality is uncertain. The project requires an investment

not obvious, for instance, why top-tier firms syndicate first round investments more frequently with second-quintile organizations (35%) than with other top-quintile firms (14%)." Second-tier firms also choose to syndicate first round investments more frequently with top-quintile partner (27%) than with other second-quintile firms (25%).

which can be staged in two rounds. An early round investment provides firsthand information about the quality of the project to those who finance the round, before the follow-on investment is undertaken. This information cannot be easily communicated by the entrepreneur to alternative lenders. We relate the extent of the informational advantage of incumbent lenders in the follow-on round to the level of trust placed by alternative lenders in information conveyed by entrepreneur. VCs have different levels of experience, with more experienced VCs obtaining better signals. However, even the most experienced VC is never willing to invest in the follow-on round without the second opinion of a sufficiently experienced other VC. Then financing requires the association of two VCs in a VC syndicate. The questions we address are: which VC syndicate is most attractive to the entrepreneur in the early round? will there be syndicate switching in the follow-on round?

With a hold-up by the lender, higher VC experience is not monotonically desirable any-more. An early round syndicate that consists of two most experienced VCs is unattractive: this syndicate is the most accurate and the best informed in the follow-on round; the probability of switching to another syndicate is then zero. Then, ex-post monopoly power permits this incumbent syndicate to capture the full value of the project.

We show that the entrepreneur prefers an early round syndicate with heterogeneous levels of experience: a syndicate that comprises one most experienced VC and one VC whose experience is markedly lower. We analyse the impact of the level of trust on the equilibrium outcome: when alternative VCs trust less the entrepreneur, the incumbent VCs can hold up more the entrepreneur in the follow-on round. Then the entrepreneur prefers an early round syndicate which is less accurate and where VCs have more heterogeneous levels of experience. Because the early round syndicate is less accurate, syndicate switching in the follow-on round takes place more often.

This theory yields the following predictions, which we can then take to the data:

1. The heterogeneity in experience of VC partners in the early round syndicate is decreasing in the level of trust placed by alternative VCs in the entrepreneur.
2. The probability of syndicate switching in the follow-on round is increasing in the heterogeneity in experience of VC partners in the early round syndicate.

We empirically test these predictions using a novel data set from Pitchbook that includes all the VC investments in the US between 2010 and 2014. The data not only provides detailed information on VC investment rounds and VC-backed ventures, but also on individuals' career records for founding team members that are affiliated with those VC-backed ventures.

To find a proxy for the level of trust placed by external VCs on an entrepreneurial firm, we construct networks consisting of social ties originated from prior founding and professional experience of founding team members of a new venture. We consider social ties owned by founding team members through taking a diverse variety of professional roles, including founders, employees, advisors, and board members. The networks reflect the social ties owned by entrepreneurial firms up to the time of a funding round, and update by years to capture any newly formed links. We use the network closeness centrality as a proxy for trust level placed by external investors on an entrepreneurial firm. The rationale for the proxy follows extant literature that contends entrepreneurs rely on networks of social ties to establish legitimacy with key resource holders such as potential investors (Hsu (2007), Stuart et al. (1999), Uzzi (1999)).

Our empirical results are consistent with the theoretical predictions:

1. We find that the heterogeneity in experience of VC syndicate partners is negatively related to network centrality of an entrepreneurial firm based on relationships formed through prior professional experience of founding team members. This negative relationship is statistically significant for the first and second rounds of funding. In light of potential selection bias due to syndicate formation, we perform two-stage Heckman procedure of estimation and find our results remain intact.
2. Using a sample of syndicated funding rounds that receive subsequent funding after the focal rounds, we track the occurrence of *Switching* that identifies *all* of the syndicate members no longer invest in any subsequent rounds. We find that, higher heterogeneity in experience of VC syndicate partners is associated with higher likelihoods of *Switching* in a subsequent funding round. This negative relationship is statistically significant for rounds of all sequence numbers. We further control for selection by jointly estimating a system of equations that allow for correlations of error terms in equations describing the following events: syndication, survival, and switching by all syndicating members in follow-on rounds. Our results are robust to controlling for selection bias.

We find that the negative relationship between syndicate heterogeneity and network centrality is not statistically significant for the third or later rounds of funding. This indicates that the hold-up by the lender argument is mostly relevant in early rounds of financing. This is in line with findings from previous literature that VCs invest smaller amounts in early rounds than in later rounds due to higher informational asymmetries associated with early-round financing (Gompers (1995)).[5]

We also find that the positive relationship between syndicate heterogeneity and likelihoods of VC firms' switching in later rounds remains statistically significant for the third or later rounds of funding. This indicates that switching of heterogeneous syndicates can take place in later rounds, even though hold-up threats by VCs are most pronounced in early rounds.

Cumming and Dai (2013) find the existence of a graduation effect, whereby entrepreneurial firms with upwardly revised perceived probability of success are (i) more likely to switch lead VCs and (ii) to switch to more reputable new lead VCs. We find a similar positive effect from the proxy of perceived quality of an entrepreneurial firm (i.e. estimated likelihood of success of a venture) on VC switching. Through by-round analysis, we actually find that the graduation effect is statistically significant, but only in rounds later than the third round. This suggests that the two results on syndicate switching nicely complement each other: the hold-up by the lender argument being mostly relevant in earlier rounds of financing, and the graduation argument being mostly relevant in later rounds of financing.

The paper is organized as follows: Section 2 introduces the set-up of the model, derives the equilibrium outcome, discusses implications and formulates testable hypothesis. Section 3 describes the data and variables employed in the empirical analysis. Section 4 carries out the empirical analysis. Section 5 concludes.

2 The Model

2.1 Set-up

At date 0, an entrepreneur holds a project which requires an investment of 1 to be realized. The entrepreneur has no money of her own. There exists a perfectly competitive market for venture capital. VCs are deep pocketed financier with an ability to interpret information. The

[5]In our data set, the mean deal size (amount invested by VCs in a round) is \$3.76m for first rounds, \$6.64m for second rounds, \$10.81m for third rounds, and \$18.41m for third rounds.

entrepreneur and all VCs are risk neutral and discount at a zero interest rate.

The project can be good (G) or bad (B). At date 0, the entrepreneur and all VCs attach a probability $\pi \in (0;1)$ to the project being of the good type. The required investment can be staged in an early investment $\gamma \in (0;1)$ at date 1 and a follow-on investment $1-\gamma$ at date 2. The project gives a return $\rho \in \mathbb{R}_{>1}$ at date 3, but only if the project is good and the entrepreneur exerts an effort after the early round investment, incurring a private cost $\varepsilon \in \mathbb{R}_{>0}$. The project generates no return otherwise.

Refer to the VCs who finance the early investment and the entrepreneur as insiders. The early investment γ at date 1 allows insiders to obtain firsthand soft information about the project. Insiders obtain this information as it appears in real-time between dates 1 and 2. The information is not verifiable. It cannot be fully expressed in the form of objective performance indicators or milestones. Let $\varphi \in (0;1)$ be the quality of the information collected by insiders at date 2. At date 2, inside VCs use this information to update their beliefs about the project type before offering to finance the remaining funds $1-\gamma$.

If inside VCs do not offer follow-on financing at date 2, the entrepreneur can seek alternative financing from other VCs, referred to as outside VCs. However, outside VCs do not have a direct access to the information generated by the early investment. The entrepreneur cannot easily communicate her soft information. She faces problems of credibility: outside VCs doubt that positive information conveyed to them is true and worry that negative information is hidden from them. Consider that outside VCs place a level of trust $\theta \in (0;1)$ in the entrepreneur and assess that the information they are given is of quality $\varphi\,\theta$.

VCs differ in the extent of their ability to interpret information of a given quality. Some generate a more accurate assessment of the project type than others. This depends on the amount of past experience of each VC.[6] Any VC can receive at date 2 a signal which depends on the level of his experience and the quality of the information he has:

– An inside VC i with experience $\alpha_i \in [0;1]$ can receive a signal $s_i \in \{\underline{s}_i, \overline{s}_i\}$. Consider that

[6]That the ability of a VC to interpret information is determined by his past experience is the most common assumption in the literature. See examples in empirical work, Hsu (2004), Sørensen (2007), Nahata (2008), Cumming and Dai (2013), as well as in theoretical work, Casamatta and Haritchabalet (2007), Cestone et al. (2008), Casamatta and Haritchabalet (2014), Mella-Barral (2020).

the conditional probability, $P(\overline{s}_i|G)$, of i receiving signal $\overline{s}_i$ if the project is good is

$$P(\overline{s}_i|G) \;=\; \frac{1 \,+\, \alpha_i\,\varphi}{2}\;, \qquad \text{with}\;\; P(\underline{s}_i|B) = P(\overline{s}_i|G)\;. \tag{1}$$

– An outside VC k with experience $\alpha_k \in [0;1]$ can receive a signal $s_k \in \{\underline{s}_k, \overline{s}_k\}$. Given that the quality of outsider's information is $\varphi\,\theta$, consider that the conditional probability, $P(\overline{s}_k|G)$, of k receiving a signal $\overline{s}_k$ if the project is good is

$$P(\overline{s}_k|G) \;=\; \frac{1 \,+\, \alpha_k\,\varphi\,\theta}{2}\;, \qquad \text{with}\;\; P(\underline{s}_k|B) = P(\overline{s}_k|G)\;. \tag{2}$$

– The entrepreneur has zero ability to interpret information.

To focus on VC syndicate, we restrict the analysis to parameter values

$$(\pi, \gamma, \rho, \varepsilon, \varphi, \theta) \;\;\in\;\; \mathcal{S}^{No\,Solo}\;. \tag{3}$$

$\mathcal{S}^{No\,Solo}$ is the set of parameter values such that no VC is willing to finance the project alone. Under (3), it is negative NPV at date 1 for a VC with level of experience equal to 1 (the highest possible) to invest alone in the early round. With only one signal, even such a VC is unable to revise sufficiently upwards his beliefs before the follow-on investment, to justify his early round investment.

To have access to two signals, two VCs can join forces in a pair-syndicate. A syndicate consists of a pair of VCs who undertake jointly a round of financing. The benefit from combining VCs within a syndicate comes exclusively from having two instead of one opinion.[7]

Signals are conditionally independent. Specifically:

– In an inside syndicate (i, j), the signal $s_i \in \{\underline{s}_i, \overline{s}_i\}$ received by the inside VC i is conditionally independent from the signal $s_j \in \{\underline{s}_j, \overline{s}_j\}$ received by the other inside VC j.

– In an outside syndicate (k, l), the signal $s_k \in \{\underline{s}_k, \overline{s}_k\}$ received by the outside VC k is conditionally independent from the signal $s_l \in \{\underline{s}_l, \overline{s}_l\}$ received by the other outside VC l. It is also conditionally independent from the signals received by inside VCs i and j.

We abstract from conflicts of interests between VCs within a syndicate. In a syndicate, each VC observes the signal of the other VC. Then the two decide cooperatively to make a financing

[7]We do not assume that VCs partner for complementarity purposes because they have different areas of expertise. VC experience is an aggregate measure of the ability of a VC to interpret information.

offer or not. A VC does not incur private costs to process information and obtain a signal. VCs update their beliefs about the project return using Bayes' rule. For tractability, we consider that syndicates cannot comprise more than two VCs.[8]

Information and signals are not verifiable. Entrepreneurial effort is observable but not contractible. Under these assumptions, a date-1 contract is an agreement whereby a syndicate provides funds at date 1 in return for a payment at date 3, if the project is good. The syndicate can commit more funds than the required early investment γ. Usage of these funds is contractible and included in the contract. Specifically, the contract can include (i) a dividend immediately paid to the entrepreneur and (ii) funds in excess of γ which reduce the funds required to complete financing in the follow-on round. A date-2 contract is an agreement whereby a syndicate provides the remaining required funds to complete the project at date 2 in return for a payment at date 3, if the project is good. In all contracts, two VCs in a syndicate pay equal "price-per-share" with pari-passu rights, hence have perfectly aligned incentives. Feasible contracts between the entrepreneur and a syndicate at date 1 and at date 2 are detailed in the Appendix.

The sequence of decisions in the extensive form game is detailed in the Appendix.

At date 1, there is a competitive supply of VCs with level of experience α, for all $\alpha \in [0; 1]$. Prior to lending, a syndicate has no bargaining power relative to the entrepreneur. For simplicity of the game, consider that the entrepreneur chooses one syndicate (i, j) and that syndicate makes a perfectly competitive date-1 contract offer (such that the expected payoff of the syndicate at date 1 is zero) or no offer.

At date 2, the incumbent syndicate (i, j) makes a follow-on financing date-2 contract offer, or does not make an offer. However, the balance of power is changed: the syndicate that lends in the early round (at date 1) has an informational advantage over outside syndicates in the follow-on round (at date 2). This informational advantage gives the inside syndicate monopoly power vis-a-vis the entrepreneur (as in Sharpe (1990) and Rajan (1992)). We take that the inside syndicate (i, j) is a Stackelberg leader at date 2.

Other VCs are still in competitive supply at date 2. An outside syndicate has no bargaining power relative to the entrepreneur at date 2. For simplicity of the game, consider that if the

[8]Note that absent this restriction, syndicates containing very numerous VCs would yield the first best outcome. Given that VC signals are independent and VCs incur no private costs, collecting signals from a large number of outside VCs permits to determine with certainty the quality of the project.

entrepreneur rejects (i,j)'s follow-on offer or (i,j) does not make an offer, the entrepreneur can choose one outside syndicate (k,l) and that syndicate makes a perfectly competitive date-2 contract offer or no offer.[9]

2.2 Equilibrium Outcome

The equilibrium concept we consider is perfect Bayesian equilibrium. The derivation of the equilibrium strategy can be found in the Appendix. Here we only state the equilibrium outcome. To do so, we introduce additional notation. Denote

$$\overline{p} \equiv \frac{1+\varphi}{2}, \quad \underline{p} \equiv \frac{1+\varphi\,\theta}{2}. \tag{4}$$

Let $\tilde{\alpha}$ be the level of experience

$$\tilde{\alpha} \equiv \frac{b - \sqrt{b^2 - 4\,a\,c}}{a\,\overline{p}\,\varphi} - \frac{1}{\varphi}, \tag{5}$$

$$\text{where} \quad a \equiv (-1+\gamma+\rho)\,\pi\,(1-\underline{p}^2) + (1-\gamma)(1-\pi)\left[1-(1-\underline{p})^2\right](1-\overline{p})/\overline{p}, \tag{6}$$

$$b \equiv a + c + (1-\gamma)(1-\pi)\,(1-\underline{p})^2\,[\overline{p} + (1-\overline{p})/\overline{p}], \tag{7}$$

$$c \equiv \gamma + (1-\gamma)\,(1-\pi)\,(1-\overline{p}). \tag{8}$$

For any $\alpha_i \in [0;1]$ and $\alpha_j \in [0;1]$, let $v(\alpha_i,\alpha_j)$ be the project value function

$$v(\alpha_i,\alpha_j) \equiv -\gamma - (1-\gamma)\left[\frac{(1-\varphi\,\alpha_i)}{2}\,\frac{(1-\varphi\,\alpha_j)}{2}(1-(1-\underline{p})^2)+(1-\underline{p})^2\right](1-\pi)$$
$$+(\rho-(1-\gamma))\left[\underline{p}^2 + \frac{(1+\varphi\,\alpha_i)}{2}\,\frac{(1+\varphi\,\alpha_j)}{2}\,(1-\underline{p}^2)\right]\pi - \varepsilon. \tag{9}$$

We obtain:

Proposition 1 *If the project value $v(1,\tilde{\alpha}) > 0$, the entrepreneur seeks and obtains early round financing from a syndicate (i,j) where the first VC i has highest experience $\alpha_i = 1$, and the second VC j has experience $\alpha_j = \tilde{\alpha}$.*

If inside VCs i and j receive signals $\overline{s}_i$ and $\overline{s}_j$, the early round syndicate (i,j) also offers to finance the follow-on round and the entrepreneur accepts the offer. Otherwise, (i,j) does not

[9]We do not consider the winner's curse between outside syndicates. With multiple bidders, a bidding syndicate would adjust its expectation to reflect that, if its offer is selected, it can infer that the signals received by other bidding syndicates were lower than the ones it received. In the context of Sharpe (1990), see von Thadden (2004).

offer follow-on financing and the entrepreneur seeks follow-on financing from an outside syndicate (k, l)*, where both VCs have highest experience* $\alpha_k = 1$ *and* $\alpha_l = 1$*.*

If outside VCs k *and* l *receive signals* $\overline{s}_k$ *and* $\overline{s}_l$*, the alternative syndicate* (k, l) *offers to finance the follow-on round and the entrepreneur accepts the offer. Otherwise, the project is not completed.*

If the project value $v(1, \tilde{\alpha}) \leq 0$*, the project cannot find financing.*

To understand best Proposition 1, start from the end. Suppose the inside syndicate (i, j) does not make a follow-on financing offer at date 2 or the entrepreneur rejects (i, j)'s offer. The entrepreneur has to seek follow-on financing from an outside syndicate (k, l).

The most attractive syndicate (k, l) comprises two VC's with highest experience ($\alpha_k = \alpha_l = 1$). The logic is straightforward: (i) the game is one shot as this is the last round of financing, (ii) if an outside syndicate makes an offer it is a competitive offer and (iii) any outside syndicate has the same quality of information $\theta\,\varphi$. Therefore, the entrepreneur's expected continuation payoff increases in the precision of each outside syndicate member.

VCs k and l do not only update their beliefs that the project is good by considering the signals $s_k \in \{\underline{s}_k, \overline{s}_k\}$ and $s_l \in \{\underline{s}_l, \overline{s}_l\}$ they receive. They also consider the fact that the inside syndicate (i, j) is not financing the follow-on round. The higher the experience of the VCs in the early round syndicate (i, j), the stronger the negative impact of the signal of non-continued participation of (i, j) on the updating of beliefs of the outside syndicate (k, l). In the equilibrium outcome, k and l turn out to only offer follow-on financing if they receive positive signals $\overline{s}_k$ and $\overline{s}_l$. This is because no financier is willing to finance the follow-on round without a sufficient upwards revision of beliefs (under (3)).

Move backwards in time before the inside syndicate (i, j) decides to make a follow-on offer or not. VCs i and j receive signals $s_i \in \{\underline{s}_i, \overline{s}_i\}$ and $s_j \in \{\underline{s}_j, \overline{s}_j\}$ at date 2, using the information of quality φ they obtained firsthand as insiders. Both the syndicate (i, j) and the entrepreneur know that if the entrepreneur refuses the follow-on financing offer of (i, j), her reservation strategy consists of seeking financing from an outside syndicate. She would then suffer from the negative signal of non-continued participation of the inside syndicate.

Suppose i receives signal $\underline{s}_i$ or j receives signal $\underline{s}_j$. With one negative signal, there is no feasible project return to (i, j) such that it is positive NPV at date 2 for them to offer follow-on financing. So the inside syndicate (i, j) does not offer follow-on financing. The entrepreneur seeks financing from an outside syndicate (k, l).

Suppose now i receives signal $\overline{s}_i$ and j receives signal $\overline{s}_j$. Here, there exists payments to (i, j) at date 3 such that it is positive NPV to (i, j) at date 2 to offer follow-on financing. Furthermore, its informational advantage over outsiders gives the inside syndicate (i, j) monopoly power vis-a-vis the entrepreneur. The best response of (i, j) is to make a Stackelberg leader follow-on financing offer that leaves the entrepreneur marginally better off than following her reservation strategy. Thus the entrepreneur accepts the offer. The early round syndicate essentially holds up the entrepreneur in the follow-on round. The hold-up-by-the-lender resides in the fact that the syndicate who lent in the early round benefits from the negative impact its own non-participation would have on the entrepreneur. Importantly for the argument which follows next, the share of the project return that the inside VCs i and j extract from the entrepreneur (the extent of the hold-up) is commensurate to their levels of experience, α_i and α_j.

Move finally to the early round of investment. At date 1, the entrepreneur approaches a syndicate (i, j) and this syndicate makes a perfectly competitive financing offer. Clearly, the higher the experience of the VCs i and j, the higher the syndicate's ex-ante valuation of the project. Then, the more attractive the early round offer this syndicate can make. However, anticipation of the hold-up by the lender creates a counter effect: whoever finances the early round at date 1 becomes the inside syndicate at date 2 and will behave as described above. The higher the experience of the VCs i and j, the stronger the negative impact a non-continued participation of (i, j) would have on the updating of beliefs of the outside syndicate (k, l). Then the larger the extent of the hold-up by the inside syndicate (i, j) in the follow-on round becomes. Essentially the entrepreneur faces a trade-off: a more experienced early round syndicate increases valuation of the project, but is more threatening in the follow-on round.

No syndicate can credibly commit not to hold up the entrepreneur in the follow-on round. We show that committing more funds than required in the early round (providing (i) an immediate dividend to the entrepreneur or (ii) funds in excess of γ which reduce the funds needed to complete financing in the follow-on round) is not a helpful pre-commitment device: the project has negative value without the option-like advantage of staged investments; a competitive early round offer where the syndicate commits more funds than γ yields less value to the entrepreneur, because it destroys more option value than it limits the hold-up-by-the-lender. The most attractive early round offer any given syndicate can make is a competitive offer where the syndicate provides only the minimum required investment γ.

We establish – Lemma 1 in the Appendix – that the early round syndicate that is most attractive to the entrepreneur belongs to a set of syndicates $\mathcal{S} \equiv \{(i,j) \mid w = 0\}$. A syndicate consisting of a pair of VCs (i,j) is within $\mathcal{S}$ if the levels of experience of the VCs, α_i and α_j, are such that their expected payoff at date 1 equals zero. Intuitively, the entrepreneur has all the bargaining power at date 1 and her best choice of early round syndicate $(i,j) \in \mathcal{S}$ provides her the entire value of the project. Even if this syndicate will be in a position to hold her up at date 2 as described above.

A syndicate of two most experienced VCs (such that $(\alpha_i, \alpha_j) = (1,1)$) is not attractive: being the most accurate and best informed syndicate at date 2 (as insider), if such a syndicate does not finance the follow-on round, no alternative syndicate wants to do it. This pushes the value of the entrepreneur's reservation strategy at date 2 down to zero. Then, such an early round syndicate is in a position to capture the full value of the project from the entrepreneur at date 2.

The levels of experience of VC couples in $\mathcal{S}$ are illustrated in Figure 1 panel (a). The set $\mathcal{S}$ starts from a homogeneous syndicate (i,j) where α_i and α_j are such that $\alpha_i = \alpha_j$. This corresponds to point A in the Figure. The set runs down to a most heterogeneous syndicate (i,j) where α_i and α_j are most distinct. Analytically, this most heterogeneous syndicate $(i,j) \in \mathcal{S}$ is such that $(\alpha_i, \alpha_j) = (1, \tilde{\alpha})$, where the expression of $\tilde{\alpha}$ is given by (5). This corresponds to point B in the Figure.

We further show – Lemma 2 in the Appendix – that within the set of VC couples $\mathcal{S}$, the entrepreneur prefers a syndicate with most heterogeneous levels of experience (such that $(\alpha_i, \alpha_j) = (1, \tilde{\alpha})$). The intuition behind this heterophily is as follows:

If approached by the entrepreneur, any VC couple $(i,j) \in \mathcal{S}$ makes a competitive offer at date 1. It then finances the follow-on round if it receives two positive signals $(\overline{s}_i \cap \overline{s}_j)$ at date 2. All couples in $\mathcal{S}$ are about equally threatening to the entrepreneur and about equally likely to finance the follow-on round. Figure 1 panel (b) illustrates that all choices in $\mathcal{S}$ have about the same probability of receiving two positive signals, $P(++) \equiv P(\overline{s}_i \cap \overline{s}_j)$, and therefore to finance the follow-on round. By complement, all VC couples in $\mathcal{S}$ are about equally likely to not participate to the follow-on round of financing (to receive either $\underline{s}_i \cap \overline{s}_j$ or $\overline{s}_i \cap \underline{s}_j$ or $\underline{s}_i \cap \underline{s}_j$).

We show – Lemma 3 in the Appendix – that amongst syndicates who have the same probability of receiving two positive signals ($\overline{s}_i \cap \overline{s}_j$) at date 2, the most heterogeneous syndicate is the one most likely to receive only one negative signal ($\underline{s}_i \cap \overline{s}_j$ or $\overline{s}_i \cap \underline{s}_j$) and least likely to receive two negative signals ($\underline{s}_i \cap \underline{s}_j$). In the context of VC couples in $\mathcal{S}$, this feature is illustrated in Figure 1 panel (c). The panel shows the probability that an early round syndicate $(i, j) \in \mathcal{S}$ receives one positive and one negative signal, $P(-+) \equiv P(\overline{s}_i \cap \underline{s}_j) + P(\underline{s}_i \cap \overline{s}_j)$, and the probability that it receives two negative signals, $P(--) \equiv P(\underline{s}_i \cap \underline{s}_j)$. $P(--)$ decreases and $P(-+)$ increases, as the syndicate is more heterogeneous (gliding from A to B).

So, from the entrepreneur's perspective, all syndicates in $\mathcal{S}$ are about as likely to finance the follow on round. But a more heterogeneous syndicate in $\mathcal{S}$ is more likely to receive one negative signal only and less likely to receive two negative signals than a more homogeneous syndicate in $\mathcal{S}$. Then, a non-participation to the follow-on round of a more heterogeneous inside syndicate sends a milder negative signal to outsiders than a non-continued participation of a more homogeneous inside syndicate. Therefore, the former influences less negatively the updating of beliefs of the outside syndicate (k, l) than the latter. This is illustrated in Figure 1 panel (d). The panel shows the updated probability of a most experienced outside syndicate (k, l) (such that $(\alpha_k, \alpha_l) = (1, 1)$) that the project is good after receiving two positive signals ($\overline{s}_k$ and $\overline{s}_l$) and the negative signal of non-continued participation of the early round syndicate $(i, j) \in \mathcal{S}$. The updated belief of the outside syndicate is highest when the inside syndicate is most heterogeneous (corresponding to point B).

Amongst early round syndicates in $\mathcal{S}$, the most heterogeneous syndicate gives the entrepreneur the biggest chance of obtaining alternative follow-on financing, should she need it. The value of the entrepreneur's reservation strategy in the follow-on round is then highest. Because of that, the entrepreneur obtains highest value at date 1 selecting an early round syndicate (i, j) such that $(\alpha_i, \alpha_j) = (1, \tilde{\alpha})$.

Finally, turn to our starting restriction (3) that financing of the project requires the association of two VCs in a syndicate, because no VC is willing to finance the project alone. (3) amounts to considering that the input parameters $(\pi, \gamma, \rho, \varepsilon, \varphi, \theta)$ are such that the project value is bounded from above. More specifically, a most experienced VC i (such that $\alpha_i = 1$) will update his beliefs with same precision if he finances the early round alone or syndicating with a second VC j with no ability (such that $\alpha_j = 0$): the second signal received by j being absolutely uninformative, it amounts to receiving only i's signal. Then, given that early round VCs make competitive offers, $(\pi, \gamma, \rho, \varepsilon, \varphi, \theta) \in \mathcal{S}^{No\,Solo}$ is equivalent $v(1,0) < 0$.

Still, a project that satisfies (3) does not necessarily obtain syndicate financing. Precisely, Proposition 1 establishes that the project only finds syndicate financing if $v(1,\tilde{\alpha}) > 0$.

2.3 Implications and Testable Hypothesis

The most attractive early round syndicate comprises one VC with highest available level of experience (equal to 1 in the model) and one VC with a level of experience $\tilde{\alpha}$. We show:

Corollary 1 (Heterogeneity) *$\tilde{\alpha}$, the level of experience of the second VC in the early round syndicate j, is strictly larger than 0 and strictly smaller than 1.*

Clearly, the lower $\tilde{\alpha}$, the more the two VCs constituting the early round syndicate have heterogeneous levels of experience.

The entrepreneur prefers the association of one highest experience VC and one VC with less experience in the early round, to reduce the impact of the hold-up by these lenders in the follow-on round. The extent to which $\tilde{\alpha}$ is lower than 1 is determined by the magnitude of the informational advantage of the inside syndicate. This advantage is large when the outside syndicate (k,l) does not trust much any information conveyed by the entrepreneur. We show:

Corollary 2 (Heterogeneity and Trust) *$\tilde{\alpha}$, the level of experience of the second VC in the early round syndicate, is strictly increasing in θ, the level of trust outsiders place in the entrepreneur.*

The fact that the second early round VC has reduced experience has an implication on the likelihood an alternative syndicate accepts to finance the follow-on round. We show:

Corollary 3 (Switching) *In the equilibrium outcome, the probability that a switching of syndicate occurs in the follow-on round is strictly positive.*

This feature comes from the hold-up by the lender. Absent the hold-up by the lender, the classic result that VC experience is monotonically desirable holds, and (unless parameter values are changed between rounds) no syndicate switching should occur in the follow-on round:[10] In the equilibrium outcome with the hold-up by the lender (Proposition 1), the early round syndicate does not have the highest experience and is heterogeneous. As a result, syndicate switching in the follow-on round sometimes occurs. The dynamics of heterogeneity and switching are then related:

Corollary 4 (Switching and Heterogeneity) *The probability of syndicate switching in the follow-on round is strictly decreasing in the level of experience of the second VC in the early round syndicate.*

A more heterogeneous early round syndicate increases the likelihood that the outside syndicate finances the follow-on round, because it enhances the updated belief of the outside syndicate that the project is good after the non-participation of the inside syndicate.

Corollaries 2 and 4 yield the following testable hypothesis:

Hypothesis 1 (Heterogeneity and Trust) *The heterogeneity in experience of VC partners in early round syndicates should be negatively related with outside VCs' trust in the entrepreneur.*

Hypothesis 2 (Switching and Heterogeneity) *The frequency of syndicate switching in follow-on rounds should be positively related with the heterogeneity in experience of VC partners in the earlier round syndicate.*

3 Data Description and Variables

3.1 Data Source and Sample

We test Hypotheses 1 and 2 using data extracted from Pitchbook. The initial sample covers financing rounds of U.S. headquartered entrepreneurial firms between 2007 and 2020. Pitchbook

[10]In the internet Appendix, we solve the model under the "no hold-up by the lender" assumption that the informational advantage *does not* increase the bargaining power of the inside syndicate vis-a-vis the entrepreneur in the follow-on round. The equilibrium outcome is such that (a) both i and j have highest level of experience and (b) if syndicate (i, j) does not finance the follow-on round, no one does.

provides comprehensive coverage of VC investment deals since 2007. As a relatively new comer in VC data suppliers, Pitchbook has the advantage of broader coverage in recent years.[11]

The data provides detailed information on VC investments, which includes the dates and investment amounts for different financing rounds, the identities of investing VC firms, development stages and industry sectors of entrepreneurial firms, locations and founding dates of entrepreneurial firms, and the dates and types of an exit (e.g. IPO, acquisition, or liquidation). Another advantage of Pitchbook over the other data sets is that it reports detailed information about individuals' career records for founding team members that are affiliated with those VC-backed ventures. In addition, to account for historical investment experience of VC firms prior to year 2007, we further supplement data from Thomson One that covers investments taking place since 1975.

In constructing the sample, we start with all the VC funding rounds taking place in the U.S. in a five year window from 2010 to 2014. By starting the sample in 2010, we leave at least three years since 2007 to accumulate prior investment experience by VC firms.[12] The sample ends in 2014, as we collect information on exit events through February of 2020 and thus allow for five years to identify the final outcome of investing in a given entrepreneurial firm.[13] Moreover, we focus on venture capital deals and exclude investment deals labelled as "Angel", "Incubator/Accelerator", or "Grant." Following Ewens et al. (2021), we also excluded first rounds with financings greater than $100 million, as they are more likely to involve non-VC-backed startups.

In our empirical analysis, we examine if heterogeneous VC syndicates arise in response to potential informational hold-up by incumbent VC firms. Accordingly, we consider syndicated deals that involve at least two VC firms. Our final sample contains 19,284 VC funding rounds raised by 12,983 U.S. entrepreneurial firms between year 2010 and 2014, and 12,908 of those

[11]In the Appendix, we compare data coverage between Pitchbook and Thomson One's Venture One by counting the distinct number of VC deals recorded in each data source with disclosed round amounts for the period of 2007 to 2014. Pitchbook starts to have more coverage than Thomson One since year 2009, and its coverage advantage has been increasing over years, with twice number of deals covered than Thomson One for year 2014.

[12]When building VC experience measures, in addition to Pitchbook data, we also make use of data extracted from Thomson One to supplement information on historical investments made by VC firms between 1975 and 2007. Section 3.2 describes the details.

[13]We use exit outcome in Probit estimation that generates probability of success of an entrepreneurial firm at the time of a funding round. Following Cumming and Dai (2013), we include such predicted probability as a control in our testing of Hypothesis 2, as explained in Section 4.2.

funding rounds are backed by syndicates consisting of more than one VC firm. Furthermore, in testing Hypothesis 2, we track if entrepreneurs switch VC investors in subsequent rounds, and thus, consider entrepreneurial firms that received more than one round of funding.[14] As a result, our analysis will be subject to bias caused by selection due to syndication as well as due to survivorship to next rounds. We therefore control for selection in our study.

3.2 Experience Heterogeneity in VC Syndicates

We measure VC firms' experience using counts of their prior investment rounds. Such a measure is consistent with previous literature (Sørensen (2007), Nahata (2008), Hong et al. (2020)). As Pitchbook starts comprehensive coverage of VC investments only since year 2007, we supplement historical investment records of VC firms prior to 2007 using data from Thomson One that dates back VC investments to year 1975. Hence, we measure VC firm experience by counting their investments made since 1975 to the time of a focal investment.

For each syndicated round, we measure heterogeneity of VC experience in the syndicate using two alternative measures: (*i*) coefficient of variation (CV) of VC experience and (*ii*) Gini coefficient of VC experience.[15]

Suppose a VC syndicate consists of N VC firms with measures of experience $x_1, x_2, \dots x_N$. The coefficient of variation of VC experience of this syndicate is the ratio of the standard deviation to the mean of the N experience levels, normalized by a factor of $1/\sqrt{N-1}$:

$$CV \equiv \frac{\sqrt{\frac{1}{N}\sum_{j=1}^{N}\left(x_i - \left(\frac{1}{N}\sum_{i=1}^{N} x_i\right)\right)^2}}{\frac{1}{N}\sum_{i=1}^{N} x_i} \frac{1}{\sqrt{N-1}} . \tag{10}$$

The Gini coefficient of VC experience is half the ratio of the average absolute difference of all pairs to the mean of the N experience levels, normalized by a factor $N/(N-1)$:

$$Gini \equiv \frac{1}{2} \frac{\frac{1}{N^2}\sum_{i=1}^{N}\sum_{j=1}^{N}|x_i - x_j|}{\frac{1}{N}\sum_{i=1}^{N} x_i} \frac{N}{N-1} . \tag{11}$$

[14] Among the 12,983 U.S. headquartered entrepreneurial firms receiving funding between 2010 and 2014, 7,955 have received more than one round of financing.

[15] Previous literature adopt similar approach in measuring heterogeneity of VC syndicates. For example, Du (2016) use CV to measure syndicate heterogeneity.

Normalization ensures that the coefficients lie between 0 and 1, for any number of partners in the syndicate.[16] In the event that all VC firms have a measure of experience equal to zero, which represents less than 1% of the observations, we assign a value of zero to CV and $Gini$.

Panel A of Table 1 reports means and medians for CV and $Gini$ coefficients in syndicated rounds. Overall, our sample presents a high level of heterogeneity of VC experience within a syndicate, as suggested by a mean of 0.73 (median of 0.68) for coefficient of variation, as well as a mean of 0.68 (median of 0.72) for Gini coefficient (see column 1 of Panel A Table 1). Furthermore, columns 3 through 10 present a comparison across rounds of different sequence numbers: later rounds have lower heterogeneity than earlier rounds, with the first-round syndicates showing the highest coefficients (i.e. CV and $Gini$) at both median and mean levels.

3.3 Switching

We track if *all* investing VC firms in a syndicated round discontinue investment in later rounds, conditional on an entrepreneurial firm receives a subsequent funding round. *Switching* equals to one if *none* of the investing VC firms in the current syndicated rounds participate in *any* of the subsequent funding rounds, and zero otherwise. As shown in Panel B Table 1, likelihoods of non-participation by all investing VC firms in subsequent rounds decrease, as round sequence number goes up, with the highest *Switching* rates (i.e. 26%) present in the first rounds. Furthermore, for each group with round sequence numbers later than the first (i.e. 2nd, 3rd, and 4th and later rounds), we perform a mean equality test with the first-round group. We find a significant difference at 5% or lower significance level for the 2nd and 3rd round groups. For 4th and later rounds, their switching rates are only slightly lower than the first round group (i.e. 25% v.s. 26%), and such difference is not statistically significant.

[16] The ratio of the standard deviation to the mean of N non-negative numbers lies between 0 and $\sqrt{N-1}$. Half the ratio of the average absolute difference of all pairs to the mean of N non-negative numbers lies between 0 and $(N-1)/N$. In both cases, the maximum value is reached when one number is strictly positive and all others are equal to 0. See Katsnelson and Kotz (1957). Deltas (2003) shows that normalizing a Gini coefficient by a factor $N/(N-1)$ also eliminates small sample downward bias.

3.4 Network Centrality

To quantify the extent to which outsiders trust an entrepreneur, we calculate the centrality of entrepreneurial firms in a network consisting of social ties owned by entrepreneurial ventures up to a focal funding round. The logic of the proxy builds on the extant literature that suggests entrepreneurs rely on network linkages to establish legitimacy with resource holders, such as potential investors (Stuart et al. (1999), Uzzi (1999), Hsu (2007)). Specifically, we draw from the literature and consider social ties built by entrepreneurial firms' founding team members through a variety of professional roles, including founders, employees, board members, and advisors. First, given the high-level of clustering of high-tech entrepreneurial activities and the highly-connected nature of VC communities, social interactions from prior founding experience provides means for entrepreneurs to communicate existence and quality of entrepreneurial ideas to outsiders (Stuart and Sorenson (2003), Kolympiris et al. (2011), Hochberg et al. (2007), Hochberg et al. (2010), Bubna et al. (2020)). Through observing the track records of prior founding attempts, outsiders access information useful for evaluating the quality of a new venture (Hsu (2007), Kaplan and Strömberg (2003), Sitkin (1992)). Second, prior employment experience engenders social ties that can facilitate flows of information, which in turn benefits resource acquisition for new ventures (Gompers et al. (2005)). This results in information and status advantages for entrepreneurs with career experience at prominent established firms, reducing the "perceived uncertainty of a venture" and leading to higher likelihoods of obtaining funding (Burton et al. (2002), Shane and Stuart (2002)).

We therefore consider networks consisting of social ties originated from prior career experience of founding team members. The data contains in total 158,960 people (i.e. founding team members of VC-backed ventures) affiliated with 97,814 organizations with a variety of professional roles including founders, employees, advisors, and board members. We leverage on the rich information in the data regarding the exact dates that each person starts their professional roles in a given organization. For each year in the period from 2010 to 2014, we construct a network where nodes represent organizations that are either VC-funded entrepreneurial firms, or other firms that those entrepreneurial firms' founding team members are previously or currently affiliated with professionally.[17] A link between two nodes forms as one person has taken professional

[17]Though we consider U.S.-headquartered entrepreneurial ventures in the sample, founding team members affiliated with those U.S. ventures may have developed social ties outside the U.S.. Therefore, we also include in

roles in two organizations. Our network construction is similar to Bonaventura et al. (2020) that build a worldwide network of professional relationships among entrepreneurial firms. However, our approach differs in that we do not consider professional relationships of VC partners who invest in an entrepreneurial firm, as we seek to capture social capital owned by entrepreneurial firms before receiving supports from external investors. Figure 2 Panel A illustrates as an example the network connections owned by the entrepreneurial firm, *Avitide*, at the time of its first funding round, showing the direct ties originated from founding and employment relationships of its affiliated key personnel.

The network is time-varying, as a new company is founded or a person starts affiliation with a new organization. Once created, a link is maintained in the network for all subsequent years of analysis. As a result, our network describes dynamically-updating social ties for U.S. headquartered entrepreneurial ventures. Panel B of Figure 2 plots the number of nodes and edges contained in each year's network. Panel C presents by year the ratio of number of nodes in the largest connected component (LCC) over the total number of nodes in the network. Such ratio grows by year and reaches a level of 0.26 in 2014.[18] A high ratio of number of nodes in the LCC over total number of nodes in the network suggests a high level of connectedness of all the firms contained in the network.

We use closeness centrality as a proxy for the extent to which external investors trust an entrepreneurial firm. The higher the centrality of an entrepreneurial venture in the network, the easier for information to flow and the higher ability of the venture to build reputation through direct and indirect links.

the network the foreign entities that those founders are affiliated with.

[18]The ratio of number of nodes in the LCC over total number of nodes in the network stays constant at around 40% in the most recent two years (i.e. 2018 and 2019) by our calculation (not presented in the figure).

4 Empirical Analysis

4.1 Heterogeneous Syndicates and Network Centrality of Entrepreneurial Firms

In this section, we test Hypothesis 1 and examine the relationship between outside VCs' trust in an entrepreneur and heterogeneity of VC experience in syndicates. As introduced in Section 3.4, we use network centrality as a proxy for trust of external investors in an entrepreneurial firm. We perform the estimation using the following specification:

$$Het(Exp)_{evst} = \alpha + \beta_1 \text{Centrality}_{evst} + \beta_2 C_{et} + \beta_3 X_{vt} + \phi_s + \tau_t + \epsilon_{evst}, \tag{12}$$

where e, v, s, and t index the entrepreneurial firm, VC syndicate, state location of the entrepreneurial firm, and year, respectively. The dependent variable, $Het(Exp)_{evst}$, represents the measure for experience heterogeneity of investing VC firms in a focal syndicated round, namely, coefficient of variation or Gini coefficient. Centrality_{evst} represents the closeness centrality of entrepreneurial firm e in a network consisting of professional relationships owned by founding team members until year t, as introduced in Section 3.4.

C_{et} represents a set of controls for characteristics of entrepreneurial firms. We control for the maturity of an entrepreneurial firm at the time of a focal funding round by including logged value of *Company Age* and development stage dummies. *Company Age* is the number of years since founding of the company until the time of a focal investment round. We also include *Seed Stage* and *Early Stage* dummies that indicate the development stage of an entrepreneurial firm at the time of a focal funding round.[19] Furthermore, we control for industry classification of entrepreneurial firms. Pitchbook uses an industry classification system comparable to the Global Industrial Classification Standard (GICS), in which entrepreneurial firms are grouped into seven industry sectors including "Business Products and Services," "Consumer Products and Services," "Energy," "Financial Services", "Healthcare," "Information Technology," and "Materials and Resources." We construct dummies indicating the primary industry sector that an entrepreneurial firm is associated with.

X_{vt} is a set of controls of VC firm characteristics, including (a) logged number of VC investors

[19] Pitchbook reports the following different stages of development of entrepreneurial firms: seed, early stage, and later stages.

in a focal round, and (*b*) logged experience level of lead investor. The lead investor plays a vital role in the consummation of a VC deal by "providing an anchor investment, setting the valuation and instilling confidence in other potential investors based on their due diligence"(PitchBookData (2020)). The identity of lead investors is available for around 70% of the funding rounds in the entire sample.[20] In the 30% of rounds where a flag for the lead investor is missing, we follow Ewens et al. (2021) and assume the lead investor is the VC with the largest number of years since its first investment at the time of the funding round. We quantify the experience of a lead VC firm using the number of prior investment rounds that a lead VC firm participated in, *Exp of Lead*.

Finally, we control for logged round investment size. We also include fixed effects for geographic state locations of entrepreneurial firms, ϕ_s, and fixed effects for investment year, τ_t. Standard errors are clustered at state level of entrepreneurial firms.

Our theory predicts that the hold-up threats by VC firms against entrepreneurs arise during the initial rounds of investments when information is particularly scarce for external investors to evaluate the potentials of an entrepreneurial firm. Therefore, we examine the relationship between closeness centrality and heterogeneous syndicates by performing estimation by rounds of different sequence numbers (i.e. first, second, third funding rounds, and 4th and later rounds). We estimate equation (12) using OLS and present the results in Table 3. A negative relationship between closeness centrality and VC experience heterogeneity arises for funding rounds of all sequence numbers. However, such relationship is statistically significant only for the first and second rounds (see columns 1 and 2 in Table 3 for results based on coefficient of variation, and columns 5 and 6 for results based on Gini).[21]

Our OLS estimation is subject to potential sample selection bias: the dependent variable, $Het(Exp)$, is only observable if an entrepreneurial firm receives funding from a syndicate. To

[20] Unlike Thomson One, Pitchbook do not provide information on investment amount contributed by each individual investors. This restrains us from following previous literature and relying on per VC firm investment amount to define leaders.

[21] As the only exception, for the 4th and later round group, closeness centrality is negatively associated with CV with 10% significance but is not significantly related to Gini.

correct for such bias, we perform the following two-step Heckman procedure:

$$\text{Syndicate}_{evst} = \text{Prob}(\alpha + \gamma_1 \text{Ind HHI}_{evst} + \gamma_2 C_{et} + \gamma_3 X_{vt} + \phi_s + \tau_t + \psi_{evst}), \quad (13a)$$

$$Het(Exp)_{evst} = \alpha + \beta_1 \text{Centrality}_{evst} + \beta_2 C_{et} + \beta_3 X_{vt} + \beta_4 \lambda_{evst} + \phi_s + \tau_t + \epsilon_{evst}\ . \quad (13b)$$

In the first step, we estimate a selection equation by Probit that uses a binary dependent variable, *Syndicate*, that equals to one if the focal funding round receives funding from a syndicate, and zero otherwise (as shown in equation (13a)). Furthermore, regarding the exclusion restriction, we follow Tian (2012) and include in the selection equation an instrument, *Ind HHI*, that measures industry concentration of investments by the lead VC firm since 2007 prior to a focal round.[22] The logic of the instrument is as follows: one of the motivations for VC syndication is for risk diversification (Lerner (1994) and Brander et al. (2002)). As a result, if a VC firm concentrates investments in a particular industry field, it will have an increased incentive to co-invest with other VC firms. Specifically, for the lead VC firm of a given round, we build their Herfindahl-Hirschman Index to measure dispersion of prior investments made in entrepreneurial firms in different industry groups. Pitchbook reports the primary industry group that each entrepreneurial firm is associated with, and there are in total 18 different industry groups. *Ind HHI* ranges between zero and one, and a higher value indicates a higher degree of concentration in a VC firm's prior investments across different industry groups. In the selection equation, we also include the following controls: entrepreneurial firm centrality, logged age of entrepreneurial firm, development stage dummies, logged round investment size, industry sector dummies of entrepreneurial firms, logged experience of lead VC, entrepreneurial firm industry sector dummies, fixed effects for state locations of entrepreneurial firms, and fixed effects for investment years. In the second step of estimation as shown in equation (13b), we include the inverse-Mills ratio, λ_{evst}, generated from the first step estimation. We perform such two-step estimation by rounds of different sequence numbers.

The results from the two-step Heckman estimation are presented in Table 4. Panel A shows the results from the second step estimation. After controlling for the selection of syndication, we

[22] Our instrument strategy follows Tian (2012) in measuring industry-wise concentration in the portfolio of a lead VC firm. However, our approach is not exactly the same as Tian (2012)'s. Due to data limitation, we are not able to precisely track the companies contained in the portfolio managed by a VC firm at a given time, and such information is necessary for the construction of Tian (2012)'s style of instrument. Instead, we calculate HHI of industry concentration by considering all investments made by a focal lead VC firm prior to a focal round.

continue to find a significant and negative relationship between heterogeneity of VC experience in syndicates and entrepreneurial firms' network centrality for the first and second rounds (columns 1, 2, 5, 6 in Table 4 Panel A). However, such negative relationships are not statistically significant for the third or later rounds (columns 3, 4, 7, and 8 in Table 4 Panel A). Furthermore, the coefficients on the inverse Mills ratios show statistical significance in estimation using samples of rounds prior to the 4th rounds, highlighting the importance of adjusting for selection to obtain consistent estimates for those early rounds. Panel B of Table 4 reports coefficients from estimating the selection equation (13a). Consistent with our prediction, the industry concentration of lead VCs' prior investment portfolio positively affects the likelihoods of assembling a syndicate.

4.2 Switching and Heterogeneous Syndication

Hypothesis 2 predicts that entrepreneurial firms are more likely to switch VC investors in follow-on funding rounds, when the early-round syndicate is more heterogeneous. We test Hypothesis 2 performing the following estimation:

$$\text{Switching}_{evst} = Prob(\alpha + \beta_1 Het(Exp)_{evst} + \beta_2 C_{et} + \beta_3 X_{vt} + \phi_s + \tau_t + \varepsilon_{evst}), \qquad (14)$$

where e, v, s, and t index the entrepreneurial firm, VC syndicate, state location of the entrepreneurial firm, and year, respectively. The dependent variable, Switching_{evst}, as explained in Section 4.2, is binary indicating if *none* of the investing VC firms in the focal round invests in subsequent funding rounds received by the entrepreneurial firm. Our main variable of interest is the heterogeneity of VC experience as captured by $Het(Exp)_{evst}$ in the equation, and we use two alternative heterogeneity measures, namely CV and Gini.

We include a variety of additional regressors that might have an impact on entrepreneurs' decision to switch investors. Specifically, C_{et} indicates a set of controls for entrepreneurial firms' characteristics, including estimated probability of success (*Est. Exit Prob*) and industry sector dummies. Cumming and Dai (2013) documents the following "graduation" phenomenon by entrepreneurial firms across rounds: as more information is disclosed across rounds of funding about potentials of a venture, entrepreneurial firms with increased perceived probabilities to succeed are more likely to switch investors. Therefore, we construct *Est. Exit Prob* following Cumming and Dai (2013): we run a probit regression in which the dependent variable equals to one if an entrepreneurial firm eventually exits through an IPO or through a merger and acquisition, and zero otherwise. We consider investments taking place during a period from 2010 until 2014, leaving at least five years until our data extraction date (i.e. February of 2020) to track the successful exits of an entrepreneurial firm. We include independent variables that control for characteristics of entrepreneurial firms, VC syndicates, and rounds. Those controls entail the development stages of an entrepreneurial firm at the time of a funding round, dummies of company geographic states, dummies of company industry sectors, number of investing VC firms in a round, *Company Age* and the investment size of a round. Consistent with Cumming and Dai (2013), all these independent variables are significantly correlated to the probability of successful exits. We continue to calculate the predicted probability of successful exits for an entrepreneurial firm at each funding round, and use it as a proxy for the perceived quality of an entrepreneurial firm.

X_{vt} refers to characteristics of investing VC firms, including (a) logged value of the maximum experience of VC firms in a syndicate,[23] (b) ratio of the average size of investing funds in the focal round relative to the next round size, (c) distance between VC firms and entrepreneurial firms, (d) indicator of whether any VC firm in the syndicate is headquartered in foreign countries, and (e) indicator of mismatching between stage preferences of VCs and the current development stage of an entrepreneurial firm. The logic of including those controls is as follows. As suggested in Cumming and Dai (2013), VC firms' experience affects switching decision by entrepreneurs. Furthermore, if the required investment amount for a subsequent funding round exceeds the capability of the existing VC firms', an entrepreneurial firm has an increased incentive to switch investors (Cumming and Dai (2013)). To capture such effect, we construct the ratio of the average of investing funds' size in the focal round to the size of the subsequent round received by the same entrepreneurial firm. In addition, previous research suggests geographic proximity positively affects effectiveness of monitoring by VC firms on entrepreneurial firms (Bernstein et al. (2016), Cumming and Dai (2010)), and thus, is likely to affect the likelihoods of switching. Therefore, we include two measures, *Dis. to VC < 50 miles* and *Dis. to VC 50-100 miles*, indicating if the geographic distance between VC firms and an entrepreneurial firm is less than 50 miles or between 50 and 100 miles, respectively. As we are interested in tracking the switching by *all* investing VC firms, information asymmetry faced by each individual investing VC firm in a syndicate is likely to have an impact on their switching decision. We therefore assign a value of one to the dummy indicator if there is *at least one* of the investing VC firms located

[23]The results are robust to using the average experience levels of investing VC firms in a given round.

in a distance from the focal entrepreneurial firm that falls into the range of interests (i.e. less than 50 miles or between 50 and 100 miles).[24] We also include a dummy indicating whether any of investing VC firms in a syndicate is headquartered in a foreign country. Finally, VC firms typically specialize in investments at a certain stage (Cumming and Dai (2013), Gompers et al. (2020), Cabolis et al. (2020)). As a result, when an entrepreneurial firm grows to a later stage of development, it may have an incentive to switch from VC firms specialized in seed or early stage to another VC firm that is focused on later stage investments. Accordingly, we include a binary variable, *Stage Mismatch*, that equals to one if investment preferences of *at least one* of investing VC firms in a round are different from the development stage of the focal entrepreneurial firm.

Finally, we include fixed effects for geographic state locations of entrepreneurial firms, ϕ_s, and fixed effects for investment year, τ_t. Standard errors are clustered at state level of entrepreneurial firms.

We estimate equation (14) using separate samples of rounds of different sequence numbers. Performing by-round estimation not only controls for idiosyncratic features that are relevant only for a given round stage, but also helps us closely examine whether switching patterns of heterogeneous syndicates change by rounds. Table 5 presents average marginal effects derived from Probit estimation of equation (14). In line with Hypothesis 2, we find that the degree of experience heterogeneity within a syndicate consistently has a positive and significant effect on the likelihoods of switching in the next round, holding all other things constant. Such significant effects arise for rounds of all sequence numbers. In terms of economic significance, for entrepreneurial firms receiving funding from a syndicate in their first funding round, as CV increases by one standard deviation (0.41 for the first round observations in the sample), the likelihoods for switching of all syndicating VC firms increase by 3.8%. The magnitude of such increase represents about 15% of the average switching rate for first round observations (i.e. 26%).

Our results are subject to potential bias due to the selection of the sample. Our dependent variable, *Switching*, is only observable if an entrepreneurial firm survives to a subsequent round of funding. Furthermore, as explained in Section 4.1, our main variable of interests, $Het(Exp)_{evst}$, is available only if an entrepreneurial firm receives funding from more than one VC firm. Hence,

[24]Our results are robust to constructing the geographic proximity dummies in alternative ways. For example, we build dummies indicating if the *minimum* of distance between an entrepreneurial firm and all the investing VC firms in a syndicate is less than 50 miles (or between 50 and 100 miles). The results remain intact by using these alternative indicator measures for geographic proximity.

occurrences of switching investors, syndication, and survival may be affected by common unobservables. For example, certain characteristics of an entrepreneurial firm may lead to formation of syndication when they are seeking funding, and in the meantime, are associated with the probabilities for those entrepreneurial firms to survive to a follow-on round and then to switch VC firms. When those characteristics are not observable to econometricians, potential bias will arise in our estimation results.

To address such selection problems, we jointly estimate a system of equations that describe the occurrences of three events: (*i*) whether a syndicate is formed for funding a focal round; (*ii*) whether an entrepreneurial firm survives to receive the subsequent round after a focal funding round; and (*iii*) conditional on survival, whether an entrepreneurial firm switches VC investors in the subsequent funding round. Such system of equations is as follows:

$$\text{Switching}_{evst} = Prob(\alpha + \beta_1 Het(Exp)_{evst} + \beta_2 C_{et} + \beta_3 X_{vt} + \phi_s + \tau_t + \varepsilon_{evst}), \tag{15a}$$

$$\text{Syndicate}_{evst} = Prob(\alpha + \gamma_1 \text{Ind HHI}_{evst} + \gamma_2 C_{et} + \gamma_3 X_{vt} + \phi_s + \tau_t + \psi_{evst}), \tag{15b}$$

$$\text{Survival}_{evst} = Prob(\alpha + \eta_1 C_{et} + \eta_2 X_{vt} + \phi_s + \tau_t + \xi_{evst}). \tag{15c}$$

Note that equation (15a) is the same specification with our previous investigation regarding switching likelihoods as described in equation (14). In the meantime, equation (15b) shares specification with equation (13a) to control for selection due to receiving funding from a syndicate, and includes *Ind HHI* to satisfy exclusion restriction. To control for selection due to survivorship of the entrepreneurial firm, we rely on equation (15c), in which the dependent variable survival takes the values of one if an entrepreneurial firm survives to a follow-on round and zero otherwise. The independent variables in equation (15c) include logged deal investment size, logged company age, logged number of VC investors, logged experience of lead VC firm, entrepreneurial firm development stage dummies, entrepreneurial firm industry sector dummies, fixed effects for entrepreneurial firm state locations, and fixed effects for the year of investments.

We simultaneously estimate a multi-equation system of Probit models and allow for correlation of error terms of equations (i.e. ε, ψ, and ξ). We employ the maximum simulated likelihood method using the GHK simulator, and make use of the user-written command *cmp* in Stata (see Roodman (2011)). We report in Panel A Table 6 the average marginal effects from estimating equation (15a) for separate samples of rounds of different sequence numbers. After controlling for potential selection bias, we continue to find a positive effect from VC syndicate heterogeneity (i.e. CV and Gini) on the likelihoods of switching in the follow-on rounds. This relationship holds for rounds of different sequence numbers. However, compared to the Probit results as reported in Table 5, the effects from the two alternative heterogeneity measures are now of reduced magnitudes, suggesting an upward bias if we do not control for the selection. Taken as an example the results using first-round observations, holding all other things constant, as CV increases by one standard deviation (0.41 for the first round observations), the likelihoods for switching of all investing VC firms increase by 2.8% (column 1 Panel A of Table 6). The magnitude of such increase represents about 11% of the average switching rate for first round observations (i.e. 26%). Panel B of Table 6 reports the coefficient estimates of equations (15b) and (15c) when we jointly estimate the system of equations using alternative measures for syndicate heterogeneity (i.e. CV and Gini). The statistical tests of correlations of the error terms for the three equations are also presented in the bottom of Panel B Table 6. Selection bias is likely to arise in estimation using later round observations, as suggested by the signifiant correlations, $\rho(\psi, \varepsilon)$ and $\rho(\xi, \varepsilon)$ for the 4th-and-later rounds (columns 4 and 8). But we do not find statistically significant correlations between error terms for observations from earlier rounds.[25] Overall, the results are in support of Hypothesis 2: heterogeneity in experience of VC partners in a syndicate is positively associated with likelihoods of switching by VC firms in later rounds.

Consistent with Cumming and Dai (2013), we find a positive effect of estimated likelihood of success, *Est. Exit Prob*, on switching. However, such positive effects are statistically significant only for estimation results using observations of 4th and later rounds (see columns 4 and 8 in Table 5 and in Table 6). Furthermore, for those later rounds, the magnitudes of the positive effects of *Est. Exit Prob* on switching far outweigh the magnitudes of the effects of the corresponding syndicate heterogeneity measures: the average marginal effect (AME) of *Est. Exit Prob* is about 4 times of the AME of CV on likelihoods of switching (0.450 v.s. 0.111 in column 7 of Table 6), whereas AME of *Est. Exit Prob* is 2.4 times of the AME of Gini (0.384 v.s. 0.160 in column 8 of Table 6). Cumming and Dai (2013) suggest that entrepreneurial firms with upwardly revised quality are more likely to switch VC firms, as those entrepreneurial firms "graduate" to seek for funding from new VC firms who are likely of higher reputation than their existing investors. Our finding supports the existence of such "graduation" phenomenon. However, it appears that switching due to revised quality of entrepreneurial firms predominantly arises in later rounds of funding (i.e. 4th and later funding rounds).

[25] The only exception is a significant correlation between error terms in switching equation and syndication equation ($\rho(\psi, \varepsilon)$) for first round observations using Gini as the heterogeneity measure in the estimation.

5 Conclusion

We document and study two remarkable features of VC syndicates: (i) the VC firms that compose a syndicate often have very different levels of experience; (ii) from one round to another, a switching of VC firms is rather frequent. We show that these features can be rationalized by a theory of informational hold-up by incumbent syndicates.

An entrepreneur who seeks early round financing for his project faces a trade-off. In the early round, a syndicate of most experienced VCs can make most attractive offers, because it will interpret the information delivered by this investment round most accurately. In the follow-on round, however, the informational advantage the incumbent syndicate has over alternative lenders gives it monopoly power vis-a-vis the entrepreneur. The non-continued participation of a most experienced syndicate would send such a negative signal to alternative financiers that no other syndicate would be willing to finance the round. An incumbent syndicate of the most experienced VCs will then extract the full value of the project from the entrepreneur. We show that the early round syndicate which is most attractive to the entrepreneur has an overall level of experience that is intermediate. As a result, syndicate switching often occurs in the follow-on round.

We further show that amongst VC syndicates with the optimal intermediate overall level of experience, the entrepreneur prefers a most heterogeneous early round syndicate: one that involves a most experienced VC and a VC with markedly lower experience. The benefit of heterogeneity is that for the same probability of obtaining follow-on financing from the early round syndicate, the likelihood that the two VCs receive two negative signals is smaller. Then any non-continued participation of a heterogeneous syndicate would send a weaker negative signal to alternative financiers than that of a homogeneous syndicate. Early round syndicate heterogeneity therefore increases the willingness of alternative syndicates to finance the follow-on round. It reduces the hold-up by the lender, increasing the likelihood of syndicate switching.

We test and find empirical support for two testable predictions that emerge from such a theory: (a) there is a negative relationship between heterogeneity of VC experience in syndicates and trust in entrepreneurial firms by outside VCs; (b) there is a positive relationship between heterogeneity of VC experience in syndicates and the likelihood of switching of VC firms in the following investment round. Our empirical results are robust to correcting for selection bias.

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Appendix

Contracts:
A date-1 contract is characterized by a triple (D_1, I_1, R_1), whereby the syndicate provides funds $D_1 \geq 0$ and $I_1 \geq \gamma$ at date 1, in return for a payment $R_1 \in [0, \rho]$ at date 3, if the project is good. If the entrepreneur accepts the offer, she is contractually committed to the following usage of the funds at date 1:

- D_1 is immediately paid as a dividend to the entrepreneur;
- γ is invested in the project;
- the surplus funds $I_1 - \gamma$, are available for investment in the second round.
- If the early round syndicate does not offer follow-on financing and the entrepreneur has to seek financing from outsiders, the funds required to complete financing of the project at date 2 become only $1 - I_1$.
- In case the entrepreneur does not find alternative financing and investment in the project is not completed, the unused funds $I_1 - \gamma$ are returned to the venture capitalist.

A date-2 contract is characterized by a singleton R_2, whereby the venture capitalist provides the remaining required funds, $1 - \gamma_1$, in return for a payment $R_2 \in [0, \rho - R_1]$ at date 3, if the project is good. Offering contracts which include dividends to the entrepreneur and surplus funds serves no purpose date 2.

Game:
The sequence of events, actions and information available at each stage is as follows:

Date 1:

1. The entrepreneur seeks financing from a syndicate $(i, j) \in \mathcal{V}^2$ of its choice, where $\mathcal{V}$ is the set of VCs.
2. (i, j) makes a perfectly competitive date-1 offer (D_1, I_1, R_1) or does not make an offer.
3. If (i, j) makes a date-1 offer, the entrepreneur accepts or rejects it. If the offer is accepted, γ is invested in the project. Otherwise, the project is not financed and the game ends.
4. The entrepreneur exerts effort bearing a private cost ε, or does not exert effort. If she does not exert effort, the project generates no return and the game ends.

Date 2:

5. i and j have access to information of quality φ. i and j receive signals $s_i \in \{\overline{s}_i, \underline{s}_i\}$ and $s_j \in \{\overline{s}_j, \underline{s}_j\}$, respectively. Signal s_i is independent from signal s_j. i and j know whether the entrepreneur exerted effort or not.
   The inside VC (i, j) makes a Stackelberg leader date-2 offer R_2 to the entrepreneur, or does not make an offer.
6. If (i, j) makes a date-2 offer, the entrepreneur accepts or rejects it. If the offer is accepted, $1 - \gamma$ is invested in the project.
7. If (i, j) does not make a date-2 offer, or the offer is rejected, the entrepreneur seeks financing from an outside syndicate $(k, l) \in \mathcal{V}^2 \setminus \{i; j\}$ of its choice, or does not seek financing. If she does not, the project is not financed and the game ends.

8. k and l have access to information of quality $\varphi\,\theta$. k and l receive signals $s_k \in \{\overline{s}_k, \underline{s}_k\}$ and $s_l \in \{\overline{s}_l, \underline{s}_l\}$, respectively. Signal s_k is independent from signal s_l. Signals s_k and s_l are conditionally independent from signals s_i and s_j. k and j know the date-1 contract R_1, that the inside syndicate (i,j) did not finance the follow-on round, and whether the entrepreneur exerted effort or not. (k,j) makes a perfectly competitive date-2 offer R_2, or does not make an offer.
9. If (k,j) makes a date-2 offer, the entrepreneur accepts or rejects it. If the offer is accepted, $1-\gamma$ is invested in the project. Otherwise, the project is not financed and the game ends.

Date 3: The project's quality, G or B, and associated return, ρ or 0, is realized.

Proof of Proposition 1:
We solve the model by backwards induction. A more extended and detailed version of the proof can be found in the Internet Appendix.

Stage 9 – Acceptance of the date-2 offer made by the outside syndicate (k,l).
The entrepreneur accepts the offer of (k,l) if $R_2 < \rho - R_1$.

Stage 8 – Date-2 offer, R_2, made by the outside syndicate (k,l) to the entrepreneur.
Let $\not{ij}$ denote the set of all possible strategy profiles where either (i,j) does not make an offer (Stage 5) or where (i,j)'s offer will not be accepted (Stage 6). Let $P(G \mid s_k \cap s_l \cap \not{ij})$ be the updated belief of syndicate (k,l) that the project is good, after receiving signals s_k, s_l and $\not{ij}$, where $s_k \in \{\overline{s}_k, \underline{s}_k\}$ and $s_l \in \{\overline{s}_l, \underline{s}_l\}$. The expected payoff at date 2 of the outside syndicate (k,l), if it offers to finance the follow-on round against R_2 after receiving signals s_k, s_l and $\not{ij}$, is

$$V_{(k,l),2}(s_k \cap s_l) \;=\; -(1-I_1) \;+\; P(G \mid s_k \cap s_l \cap \not{ij})\, R_2 \;. \tag{16}$$

The competitive offer (k,l) makes solves min R_2 s.t. $V_{(k,l),2}(s_k \cap s_l) \geq 0$ and $R_2 < \rho - R_1$. This implies that an offer will only be made if $\frac{1-I_1}{\rho-R_1} \leq P(G|s_k \cap s_l \cap \not{ij})$. We conjecture that the date-1 contract (D_1, I_1, R_1) is such that $\pi < \frac{1-I_1}{\rho-R_1}$ and will later establish that this is indeed the case.

Stage 7 – Outside syndicate (k,l) chosen by the entrepreneur.
If the entrepreneur chooses to not approach any outside syndicate, her payoff at date 2 is 0. If she approaches a syndicate (k,l), her choice falls in one of three possible cases in stage 8:
– Case i: $P(G \mid \overline{s}_k \cap \underline{s}_l \cap \not{ij}) < \frac{1-I_1}{\rho-R_1} \leq P(G \mid \overline{s}_k \cap \overline{s}_l \cap \not{ij})$. The payoff of the entrepreneur at date 2 from seeking financing from (k,l) is

$$V_{e,2}^{Case\,i} \;=\; P(\overline{s}_k|G)\; P(\overline{s}_l|G)\; \pi \left(\rho - R_1 - \frac{1-I_1}{P(G|\overline{s}_k \cap \overline{s}_l \cap \not{ij})}\right) \;. \tag{17}$$

We have $\frac{\partial V_{e,2}^{Case\,i}}{\partial \alpha_k} > 0$ and $\frac{\partial V_{e,2}^{Case\,i}}{\partial \alpha_l} > 0$. If the entrepreneur seeks financing from an outside syndicate (k,l) which falls in Case i, she approaches a syndicate of VCs with highest experience $\alpha_k = 1$ and $\alpha_l = 1$. Denote $\underline{q} \;\equiv\; P(G|\overline{s}_k \cap \overline{s}_l \cap \not{ij})|_{(\alpha_k,\alpha_l)=(1,1)}$. From Bayes' rule,

$$\underline{q} \;=\; 1/[1 + \left(\frac{1-\underline{p}}{\underline{p}}\right)^2 Y]\;, \quad \text{where} \quad Y \;\equiv\; \frac{P(\not{ij}\;|B)}{P(\not{ij}\;|G)}\; \frac{(1-\pi)}{\pi}\;, \tag{18}$$

and $\underline{p} \equiv \frac{1+\varphi\,\theta}{2}$. We then obtain

$$V_{e,2}^{Case\,i} \;=\; \pi\,(\rho - R_1)\,\underline{p}^2 \;-\; \pi\,(1-I_1)\;\left(\underline{p}^2 \;+\; (1-\underline{p})^2\, Y\right)\;. \tag{19}$$

– Case ii: $P(G \mid \overline{s}_k \cap \overline{s}_l \cap i\!\!\!/j\!\!\!/) < \frac{1-I_1}{\rho-R_1}$. The follow-on round is not financed. The payoff of the entrepreneur at date 2 is $V_{e,2}^{Case\,iii} = 0$.

– Case iii: $\pi < \frac{1-I_1}{\rho-R_1} \leq P(G \mid \overline{s}_k \cap \underline{s}_l \cap i\!\!\!/j\!\!\!/)$. The payoff of the entrepreneur at date 2 is

$$V_{e,2}^{Case\,iii} \;=\; P(\overline{s}_k|G)\,\pi\,(\rho - R_1 - 1 + I_1) - \pi\,(1 - I_1)\,(1 - P(\overline{s}_k|G))\,Y\;. \tag{20}$$

We similarly obtain that if the entrepreneur seeks financing from a syndicate (k, l) which falls in Case iii, she approaches a syndicate of VCs with ability $\alpha_k = 1$ and $\alpha_l = 1$. Then,

$$V_{e,2}^{Case\,iii} \;=\; \pi\,(\rho - R_1)\,\underline{p} \,-\, \pi\,(1 - I_1)\,\left(\underline{p} \,+\, (1 - \underline{p})\,Y\right)\;. \tag{21}$$

We can write $V_{e,2}^{Case\,i} = V_{e,2}^{Case\,iii} + \pi\,\frac{1-\varphi^2\,\theta^2}{4}\,[(1 - I_1)\,(1 + Y) \,-\, (\rho - R_1)]$. Hence, given that $\pi < \frac{1-I_1}{\rho-R_1}$ and $\frac{1}{1+Y} \leq \pi$, we have $V_{e,2}^{Case\,i} > V_{e,2}^{Case\,iii}$. The entrepreneur's best choice in case iii is always dominated by the entrepreneur's best choice in case i. There are then two possibilities:

– Case 1: $\frac{1-I_1}{\rho-R_1} \in (\pi; \underline{q}]$. The entrepreneur seeks financing from a syndicate (k, l) with highest experience $\alpha_k = 1$ and $\alpha_l = 1$. If k receives a signal $\overline{s}_k$ and l receives a signal $\overline{s}_l$, the syndicate (k, l) makes a date-2 offer $R_2 = \frac{1-I_1}{\underline{q}}$. The offer is accepted by the entrepreneur and the follow-on round is financed. Otherwise, the follow-on round is not financed.

– Case 2: $\frac{1-I_1}{\rho-R_1} > \underline{q}$.

Stage 6 – Acceptance or rejection of a date-2 offer made by the inside VC (i, j).

Denote Ψ_e the probability the entrepreneur attributes to the project being good when (i, j) makes a date-2 offer. The expected payoff of the entrepreneur from accepting the date-2 offer, R_2, is $V_{e,2} = \Psi_e\,(\rho - R_1 - R_2)$. Her expected payoff of the entrepreneur from rejecting the offer and from following her reservation strategy is

$$\underline{V}_{\,e,2} \;=\begin{cases} \underline{p}^2\,\Psi_e\left(\rho - R_1 - \frac{1-I_1}{\underline{q}}\right) & \text{if } \frac{1-I_1}{\rho-R_1} \in (\pi; \underline{q}];\\ 0 & \text{if } \frac{1-I_1}{\rho-R_1} > \underline{q}\;. \end{cases} \tag{22}$$

Denote R_2^* the level of R_2 which solves $\underline{V}_{\,e,2} = V_{e,2}$. We have

$$R_2^* \;=\begin{cases} \rho - R_1 - \underline{p}^2\left(\rho - R_1 - \frac{1-I_1}{\underline{q}}\right) & \text{if } \frac{1-I_1}{\rho-R_1} \in [(\pi; \underline{q}]\,;\\ \rho - R_1 & \text{if } \frac{1-I_1}{\rho-R_1} > \underline{q}\;. \end{cases} \tag{23}$$

The entrepreneur accepts (i, j)'s offer if and only if $R_2 \leq R_2^*$.

Stage 5 – Date-2 offer, R_2, made by the inside syndicate (i, j).

The payoff at date 2 of (i, j) if it makes an offer $R_2 = R_2^*$ (most self serving offer acceptable to the entrepreneur) after receiving signals (s_i, s_j), where $s_i \in \{\underline{s}_i, \overline{s}_i\}$ and $s_j \in \{\underline{s}_j, \overline{s}_j\}$ is

$$V_{(i,j),2}(R_2^* \,|\, s_i \cap s_j) \;=\begin{cases} -(1 - I_1) + P(G|s_i \cap s_j)\left(\rho - \underline{p}^2\left(\rho - R_1 - \frac{1-I_1}{\underline{q}}\right)\right) & \text{if } \frac{1-I_1}{\rho-R_1} \in (\pi; \underline{q}];\\ -(1 - I_1) + prob(G|s_i \cap s_j)\;\rho & \text{if } \frac{1-I_1}{\rho-R_1} > \underline{q}\;. \end{cases} \tag{24}$$

If (i, j) does not make a follow-on offer, the entrepreneur seeks financing from (k, l), or not. Then, the payoff at date 2 of (i, j) if they do not make an offer after receiving signal $s_i \cap s_j$ is

$$V_{(i,j),2}(R\!\!\!/_2\,|s_i \cap s_j) = \begin{cases} [\underline{p}^2 - (1 - 2\,\underline{p}^2)\,P(G \mid s_i \cap s_j)]\,(I_1 \,-\, \gamma) & \\ \quad + \underline{p}^2\,P(G \mid s_i \cap s_j)\,R_1 & \text{if } \frac{1-I_1}{\rho-R_1} \in (\pi; \underline{q}];\\ I_1 \,-\, \gamma & \text{if } \frac{1-I_1}{\rho-R_1} > \underline{q}\;. \end{cases} \tag{25}$$

Contrasting (24) and (25), and denoting

$$Q \;\equiv\; \frac{1 - I_1 + \underline{p}^2\,(I_1 \,-\, \gamma)}{\rho - \underline{p}^2\left(\rho - \frac{1-I_1}{\underline{q}}\right) + (1-2\,\underline{p}^2)(I_1-\gamma)} \quad \text{and} \;\; Q' \;\equiv\; \frac{1-\gamma}{\rho}\;, \tag{26}$$

we obtain six cases:

– Case 1(a): $\frac{1-I_1}{\rho - R_1} \in (\pi; \underline{q}]$ and $(i,j) \in \mathcal{A}$, where $\mathcal{A} \equiv \{(i,j) \mid P(G \mid \overline{s}_i \cap \underline{s}_j) < Q \leq P(G \mid \overline{s}_i \cap \overline{s}_j)\}$. (i,j) only offers follow-on financing if it receives signal $(s_i, s_j) = (\overline{s}_i, \overline{s}_j)$.

– Case 1(b): $\frac{1-I_1}{\rho - R_1} \in (\pi; \underline{q}]$ and $(i,j) \in \mathcal{B}$, where $\mathcal{B} \equiv \{(i,j) \mid P(G \mid \overline{s}_i \cap \underline{s}_j) < Q\}$. (i,j) never offers follow-on financing.

– Case 1(c): $\frac{1-I_1}{\rho - R_1} \in (\pi; \underline{q}]$ and $(i,j) \in \mathcal{C}$, where $\mathcal{C} \equiv \{(i,j) \mid P(G \mid \overline{s}_i \cap \overline{s}_j) \leq Q\}$. (i,j) offers follow-on financing if i receives signal $s_i = \overline{s}_i$.

– Case 2(a): $\frac{1-I_1}{\rho - R_1} > \underline{q}$ and $(i,j) \in \mathcal{A}'$, where $\mathcal{A}' \equiv \{(i,j) \mid P(G \mid \overline{s}_i \cap \underline{s}_j) < Q' \leq P(G \mid \overline{s}_i \cap \overline{s}_j)\}$. (i,j) only offers follow-on financing if it receives signal $(s_i, s_j) = (\overline{s}_i, \overline{s}_j)$.

– Case 2(b): $\frac{1-I_1}{\rho - R_1} > \underline{q}$ and $(i,j) \in \mathcal{B}'$, where $\mathcal{B}' \equiv \{(i,j) \mid P(G \mid \overline{s}_i \cap \underline{s}_j) < Q'\}$. (i,j) never offers follow-on financing.

– Case 2(c): $\frac{1-I_1}{\rho - R_1} > \underline{q}$ and $(i,j) \in \mathcal{C}'$, where $\mathcal{C}' \equiv \{(i,j) \mid P(G \mid \overline{s}_i \cap \overline{s}_j) \leq Q\}$. (i,j) offers follow-on financing if i receives signal $s_i = \overline{s}_i$.

Considering in each case, the PBE consistent beliefs of (k,l) about the history of $i\!\!/\!\!j$, we obtain $\underline{q} = 1/[1 + \frac{1-P(\overline{s}_i|B)\,P(\overline{s}_j|B)}{1-P(\overline{s}_i|G)\,P(\overline{s}_j|G)}\left(\frac{1-\underline{p}}{\underline{p}}\right)^2 \frac{1-\pi}{\pi}]$ in cases 1(a) and 2(a); $\underline{q} = 1/[1 + \left(\frac{1-\underline{p}}{\underline{p}}\right)^2 \frac{1-\pi}{\pi}]$ in cases 1(b) and 2(b); $\underline{q} = 1/[1 + \frac{1-P(\overline{s}_i|B)}{1-P(\overline{s}_i|G)}\left(\frac{1-\underline{p}}{\underline{p}}\right)^2 \frac{1-\pi}{\pi}]$ in cases 1(c) and 2(c).

Stage 4 – Choice of effort by the entrepreneur.

The entrepreneur exerts effort if her continuation payoff, $V_{e,2}$, is greater than her cost of effort ε. In Cases 2(a), 2(b) and 2(c), $V_{e,2} = 0$, so she does not exert effort.

Stage 3 – Acceptance of the date-1 offer made by syndicate (i,j).

Cases 2(a), 2(b) and 2(c) cannot be an equilibrium outcome, since the value of the project would be zero. In all three cases 1(a), 1(b) and 1(c), the payoff of the entrepreneur at date 1 is

$$V_{e,1} \;=\; D_1 - (1 - I_1)\,\frac{\pi\,\underline{p}^2}{\underline{q}} \;+\; \underline{p}^2\,\pi\,(\rho - R_1) \,-\, \varepsilon\;. \tag{27}$$

The entrepreneur accepts the offer if R_1 is such that $V_{e,1} \geq 0$.

Stage 2 – Date-1 offer, (D_1, I_1, R_1), made by syndicate (i,j).

Syndicate (i,j) makes an offer (D_1, I_1, R_1) which maximizes the entrepreneur value, $V_{e,1}$, while meeting its participation constraint, $V_{(i,j),1} \geq 0$. Hence (D_1, I_1, R_1) solves

$$\max_{D_1 \geq 0, I_1 \geq \gamma, R_1 \geq 0} \; V_{e,1} \qquad \text{s.t.} \;\; V_{(i,j),1} \;\geq\; 0\;. \tag{28}$$

In case 1(a), the payoff of syndicate (i,j) at date 1 is

$$\begin{aligned} V_{(i,j),1} \;=\; & -D_1 - \gamma - (1-\gamma)\Big[P(\overline{s}_i \cap \overline{s}_j) - P(\overline{s}_i \cap \overline{s}_j \mid G)\,\frac{\pi\,\underline{p}^2}{\underline{q}}\Big] + P(\overline{s}_i \cap \overline{s}_j \mid G)\,\pi\,(1 - \underline{p}^2)\rho \\ & + \underline{p}^2\,\pi\,R_1 \;-\; \left[P(\overline{s}_i \cap \overline{s}_j \mid G)\,\frac{\pi\,\underline{p}^2}{\underline{q}} \,+\, P(\underline{s}_i \cup \underline{s}_j)\,(1 - P(\underline{s}_k \cup \underline{s}_l \mid \underline{s}_i \cup \underline{s}_j))\right](I_1 - \gamma)\;. \end{aligned} \tag{29}$$

Form the Lagrangian $\mathcal{L} = V_{e,1} + \Lambda V_{(i,j),1}$ and write the necessary Kuhn-Tucker complementary slackness conditions for a triple (D_1, I_1, R_1) to be a maximum. We obtain that $D_1 = 0$, $I_1 = \gamma$, $R_1 = 0$ and $V_{(i,j),1} = 0$ are necessary conditions for a date-1 offer, (D_1, I_1, R_1), to solve (28). When these hold, we can write (27) as $V_{e,1} = v(p_i, p_j)$ where

$$v(p_i, p_j) \equiv -\gamma - (1-\gamma)\left[P'(p_i, p_j) + P''(p_i, p_j)\right] + P'''(p_i, p_j)\,\rho - \varepsilon\,, \tag{30}$$

with $p_i \equiv P(\overline{s}_i|G) = \frac{1+\alpha_i\,\varphi}{2}$, $p_j \equiv P(\overline{s}_j|G) = \frac{1+\alpha_j\,\varphi}{2}$, $P'(p_i, p_j) \equiv P(\overline{s}_i \cap \overline{s}_j)$, $P''(p_i, p_j) \equiv P(\overline{s}_k \cap \overline{s}_l \cap i\!\!\!/j\!\!\!/)$, $P'''(p_i, p_j) \equiv P(\overline{s}_i \cap \overline{s}_j)P(G|\overline{s}_i \cap \overline{s}_j) + P(\overline{s}_k \cap \overline{s}_l \cap i\!\!\!/j\!\!\!/)P(G|\overline{s}_k \cap \overline{s}_l \cap i\!\!\!/j\!\!\!/)$. As here $i\!\!\!/j\!\!\!/ = \underline{s}_i \cup \underline{s}_j$, we can write

$$P'(p_i, p_j) \equiv p_i\,p_j\,\pi + (1-p_i)\,(1-p_j)\,(1-\pi)\,, \tag{31}$$

$$P''(p_i, p_j) \equiv \underline{p}^2\,(1-p_i\,p_j)\,\pi + (1-\underline{p})^2\,(1-(1-p_i)\,(1-p_j))\,(1-\pi)\,, \quad \text{and} \tag{32}$$

$$P'''(p_i, p_j) = \left[\underline{p}^2 + p_i\,p_j\,(1-\underline{p}^2)\right]\pi. \tag{33}$$

Note that

$$P'(p_i, p_j) + P''(p_i, p_j) = \left[\underline{p}^2 + p_i\,p_j\,(1-\underline{p}^2)\right]\pi + \left[(1-p_i)\,(1-p_j)[1-(1-\underline{p})^2] + (1-\underline{p})^2\right](1-\pi) < 1. \tag{34}$$

In Case 1(b), we obtain $V_{e,1} = -\gamma - (1-\gamma)\left[\underline{p}^2\,\pi + (1-\underline{p})^2(1-\pi)\right] + \underline{p}^2\,\pi\,\rho - \varepsilon$. In Case 1(c), we obtain $V_{e,1} = -\gamma - (1-\gamma)\left[\left[\underline{p}^2 + p_i\,(1-\underline{p}^2)\right]\pi + \left[(1-p_i)[1-(1-\underline{p})^2] + (1-\underline{p})^2\right](1-\pi)\right] + \left[\underline{p}^2 + p_i\,(1-\underline{p}^2)\right]\pi\,\rho - \varepsilon$.

Stage 1 – Syndicate (i, j) selected by the entrepreneur.

The entrepreneur obtains a higher date-1 payoff $V_{e,1}$ in case 1(a) than in cases 1(b) or 1(c). So the entrepreneur selects a syndicate $(i, j) \in \mathcal{A}$ if $V_{e,1} > 0$, where $V_{e,1} = v(p_i, p_j)$ in (30). The project is not financed otherwise. The date-1 offer, (D_1, I_1, R_1), made by the selected syndicate (i, j) is such that $D_1 = 0$, $I_1 = \gamma$, $R_1 = 0$ and $V_{(i,j),1} = 0$.

When conditions $D_1 = 0$, $I_1 = \gamma$ and $R_1 = 0$ hold, from (29), $V_{(i,j),1} = w(p_i, p_j)$, where

$$w(p_i, p_j) \equiv -\gamma - (1-\gamma)\left[P'(p_i, p_j) - P''(p_i, p_j)\,\frac{p_i\,p_j}{1-p_i\,p_j}\right] + (1-\underline{p}^2)\,p_i\,p_j\,\pi\,\rho\,, \tag{35}$$

with $P'(p_i, p_j)$ and $P''(p_i, p_j)$ given by (31) and (32). The remaining condition $V_{(i,j),1} = 0$ gives a first characterisation of (i, j):

Lemma 1 *Syndicate (i, j) belongs to the set $\mathcal{S} = \{(i, j) \mid w = 0\}$.*

The condition $w(p_i, p_j) = 0$ is insufficient to fully characterise (i, j): There are two levels, p_i and p_j, to be determined. The next Lemma completes the characterisation of (i, j):

Lemma 2 *Syndicate (i, j) belongs to $\mathcal{S}$ and is such that the difference between α_i and α_j is highest.*

Proof: Consider the function $p_i \rightarrow m(p_i)$ such that $w(p_i, m(p_i)) = 0$. Intuitively, if a VC i with experience is α_i forms a syndicate with a VC j with experience α_j such that $p_j = m(p_i)$ (where $p_i \equiv \frac{1+\alpha_i\,\varphi}{2}$ and $p_j \equiv \frac{1+\alpha_j\,\varphi}{2}$), then the syndicate (i, j) belongs to $\mathcal{S}$. Remember that i refers to the VC with the higher experience in the syndicate, i.e. $\alpha_i \geq \alpha_j$. Hence $p_i \geq m(p_i)$.

We use the "matching" function $m(p_i)$ to determine which syndicate in $\mathcal{S}$ yields the highest payoff to the entrepreneur. To prove the Lemma 2, we need to establish that the function $\Omega(p) \equiv v(p, m(p))$ is increasing in p. We have

$$\frac{\partial\,\Omega(p)}{\partial\,p} = \frac{\partial\,v(p_i, p_j)}{\partial\,p_i} + \frac{\partial\,v(p_i, p_j)}{\partial\,p_j}\,\frac{\partial\,p_j}{\partial\,p_i}\,. \tag{36}$$

Along the curve $\Omega(p)$, the following preservation law prevails: $w(p,m(p))=0$. Differentiating leads to $\frac{\partial m(p)}{\partial p}=-\frac{\partial w(p,m(p))}{\partial p_i}\left[\frac{\partial w(p,m(p))}{\partial p_j}\right]^{-1}$. Injecting back into (36) gives $\frac{\partial \Omega(p)}{\partial p}=\frac{N(p,m(p))}{D(p,m(p))}$, where $N(p_i,p_j)\equiv \frac{\partial w(p_i,p_j)}{\partial p_j}\frac{\partial v(p_i,p_j)}{\partial p_i}-\frac{\partial w(p_i,p_j)}{\partial p_i}\frac{\partial v(p_i,p_j)}{\partial p_j}$, and $D(p_i,p_j)\equiv\frac{\partial w(p_i,p_j)}{\partial p_j}$. From $w(p_i,p_j)$ in (35), $v(p_i,p_j)$ in (30), we obtain

$$N(p_i,p_j)=\frac{(1-\gamma)\,(p_i-p_j)\,(1-\pi)\,(1-\underline{p})^2}{1-p_i\,p_j}\left[\frac{(1-\gamma)(1-P'(p_i,p_j)-P''(p_i,p_j))}{1-p_i\,p_j}+(1-\underline{p})\pi\,\rho\right]\ , \quad (37)$$

$$D(p_i,p_j)=(1-\underline{p}^2)\,p_i\,\pi\,[-(1-\gamma)+\rho]+(1-\gamma)(1-\pi)[(1-p_i)+p_i(1-\underline{p})^2\,K]\ , \quad (38)$$

where $K\equiv\frac{[p_i+2p_j(1-p_i)](1-p_i\,p_j)+[1-(1-p_i)(1-p_j)]\,p_i\,p_j}{(1-p_i\,p_j)^2}$. If $p_i=p_j$ then $N(p_i,p_j)=0$; if $p_i>p_j$ then $N(p_i,p_j)>0$. So, if $p=m(p)$, then $N(p,m(p))=0$. If $p>m(p)$, then $N(p,m(p))>0$. Given that $-(1-\gamma)+\rho>0$, we have $D(p_i,p_j)>0$.
Running along the curve $\Omega(p)$ the entrepreneur payoff increases: $\Omega(p)$ is minimum when p is minimum (hence $p=m(p)$). $\Omega(p)$ is maximum when p is maximum (hence $m(p)$ is minimum). □

As $p_i\equiv\frac{1+\alpha_i\,\varphi}{2}$, the maximum possible value of p_i corresponds to the highest available level of α_i. VC i has therefore highest experience, $\alpha_i=1$. We determine α_j using the fact that (i,j) belongs to $\mathcal{S}$: VC j is such that $p_j=m(\overline{p})$, where $\overline{p}\equiv\frac{1+\varphi}{2}$. From (35), we have

$$w(\overline{p},p_j)\ \equiv\ -\gamma-(1-\gamma)\left[P'(\overline{p},p_j)\ -P''(\overline{p},p_j)\ \frac{\overline{p}\,p_j}{1-\overline{p}\,p_j}\right]+(1-\underline{p}^2)\,\overline{p}\,p_j\,\pi\,\rho\ . \quad (39)$$

Expanding (39), we can write $w(\overline{p},p_j)=\frac{F(\overline{p}\,p_j)}{1-\overline{p}\,p_j}$, where

$$F(x)\ =\ -a\,x^2\ +\ b\,x\ -\ c\ , \quad (40)$$

with a, b and c as defined in (6), (7) and (8). We have $a>0$, $b>0$ and $c>0$ (as $\rho>1-\gamma$).

The condition $w(\overline{p},p_j)=0$ can be written as the quadratic equation $F(\overline{p}\,p_i)=0$. We have $F(0)=-c<0$ and $F(1)=-a+b-c=(1-\gamma)(1-\pi)\,(1-\underline{p})^2\,[\overline{p}\,+\,(1\,-\,\overline{p})/\overline{p}]\geq 0$. Then, $F(.)$ is a concave function, with $F(0)<0$ and $F(1)\geq 0$. The solution is therefore such that $p_j=\tilde{p}$, where $\overline{p}\,\tilde{p}$ is the smallest of the two roots of $F(\overline{p}\,p_j)=0$. Hence $\tilde{p}=[b\ -\ \sqrt{b^2\ -\ 4\,a\,c}]/[2\,a\,\overline{p}]$. So the experience of the second VC j is $\alpha_j=\tilde{\alpha}$ in (5), where $\tilde{\alpha}=\frac{2\,\tilde{p}-1}{\varphi}$.

From (30), replacing $P'''(p_i,p_j)$ given in (33) and $P'(p_i,p_j)+P''(p_i,p_j)$ given in (34), we obtain that

$$\begin{aligned} v(p_i,p_j)\ =\ &-\gamma-(1-\gamma)\left[(1-p_i)\,(1-p_j)(1-(1-\underline{p})^2)+(1-\underline{p})^2\right](1-\pi) \\ &+(\rho-(1-\gamma))\left[\underline{p}^2+p_i\,p_j\,(1-\underline{p}^2)\right]\pi-\varepsilon\ . \end{aligned} \quad (41)$$

The project finds financing iif $V_{e,1}>0$. This condition can be written $v(\overline{p},\tilde{p})>0$.

Under (3), it is negative NPV for a VC i with highest level of experience $\alpha_i=1$ to invest alone in the early round. For a given VC i, investing alone is akin to investing in a syndicate where the second VC j has a level of experience $\alpha_j=0$. Then, given that early round VCs make competitive offers, restriction (3) is equivalent to $v(\overline{p},1/2)<0$: if $v(\overline{p},1/2)<0$, the project cannot find financing from one VC alone, because the aggregate value of the project to the entrepreneur and one VC alone is negative.

This concludes the proof of Proposition 1.

The following Lemma 3 is mentioned in the discussion of heterophily that follows Proposition 1. For any VC syndicate (i,j), the "prior probability" that i receives signal $s_i \in \{\overline{s}_i, \underline{s}_i\}$ and j receives signal $s_j \in \{\overline{s}_j, \underline{s}_j\}$ at date 2 is $P(s_i \cap s_j) = P(s_i|G)\,P(s_j|G)\,\pi \,+\, P(s_i|B)\,P(s_j|B)\,(1-\pi)$. Let $\mathcal{K} = \{(i,j)\,|\,\alpha_i \geq \alpha_j \,\text{and}\, P(\overline{s}_i \cap \overline{s}_j) = \kappa\}$ be the set of syndicates who have a probability of receiving two positive signals equal to a constant κ. In a syndicate (i,j), i refers again w.l.o.g to the VC with higher experience, i.e. $\alpha_i \geq \alpha_j$. To ensure that $\mathcal{K}$ is non-empty, the constant κ is restricted to the interval $[\min(\pi, 1-\pi), \max(\pi, 1-\pi)]$.

Lemma 3 *Amongst syndicates* $(i,j) \in \mathcal{K}$*,* $P(\underline{s}_i \cap \underline{s}_j)$ *decreases in* $\alpha_i - \alpha_j$*.*

Proof: Denoting $p_i \equiv P(\overline{s}_i|G) = \frac{1+\alpha_i\,\varphi}{2}$ and $p_j \equiv P(\overline{s}_j|G) = \frac{1+\alpha_j\,\varphi}{2}$, we have

$$P(\overline{s}_i \cap \overline{s}_j) \;=\; P^{++}(p_i,p_j) \;\equiv\; p_i\,p_j\,\pi \;+\; (1-p_i)\,(1-p_j)\,(1-\pi)\;, \tag{42}$$

$$P(\underline{s}_i \cap \underline{s}_j) \;=\; P^{--}(p_i,p_j) \;\equiv\; (1-p_i)\,(1-p_j)\,\pi \;+\; p_i\,p_j\,(1-\pi)\;, \tag{43}$$

$$=\; P^{++}(p_i,p_j) \;+\; (p_i+p_j-1)\,(1-2\pi)\;. \tag{44}$$

Consider the function $p_i \;\to\; n(p_i)$ such that $P^{++}(p_i, n(p_i)) = \kappa$. If a VC i with experience α_i forms a syndicate with a VC j with α_j such that $p_j = n(p_i)$, then syndicate (i,j) belongs to $\mathcal{K}$.

Let p^* be the solution to $n(p^*) = p^*$. A syndicate (i,j) with experience levels $\alpha_i = \alpha_j = \alpha^*$, where $\frac{1+\alpha^*\,\varphi}{2} = p^*$, belongs to $\mathcal{K}$ and is homogeneous. Given that $\alpha_i \geq \alpha_j$, we have $p_i \geq n(p_i)$ and $p_i \geq p^*$. From (42), p^* solves $f(p) = 0$, where $f(p) \equiv p^2 - 2\,p\,(1-\pi) + 1 - \pi - \kappa = 0$. $f(0) = 1 - \pi - \kappa$ and $f(1) = \pi - \kappa$. $\mathcal{K} \neq \emptyset$ iif $f(0)$ and $f(1)$ have opposite signs. Hence $\mathcal{K} \neq \emptyset$ iif $\kappa \geq \min(\pi, 1-\pi)$ and $\kappa \leq \max(\pi, 1-\pi)$. There are two cases:

– Case 1: $2\pi - 1 < 0$. Then $f(0) > f(1)$. p^* is then the smallest root of $f(p) = 0$. For all $p_i \geq p^*$, we have $(p_i)^2 - 2\,p_i\,(1-\pi) + 1 - \pi - \kappa \leq 0$.

– Case 2: $2\pi - 1 > 0$. Then $f(0) < f(1)$. p^* is then the largest root of $f(p) = 0$. For all $p_i \geq p^*$, we have $(p_i)^2 - 2\,p_i\,(1-\pi) + 1 - \pi - \kappa \geq 0$.

Let $\delta(p_i,p_j) \equiv \kappa + (p_i + p_j - 1)\,(1-2\pi)$. To prove the Lemma 3, we need to establish that the function $\Delta(p) \equiv \delta(p, n(p))$ is decreasing in p for $p \geq p^*$. We have $\frac{\partial\,\Delta(p)}{\partial\,p} = \frac{\partial\,\delta(p_i,p_j)}{\partial\,p_i} + \frac{\partial\,\delta(p_i,p_j)}{\partial\,p_j}\,\frac{\partial\,p_j}{\partial\,p_i}$. From (42), $n(p) = \frac{\kappa-(1-p)\,(1-\pi)}{p-(1-\pi)}$, hence $\frac{\partial\,n(p)}{\partial\,p} = \frac{\pi\,(1-\pi)-\kappa}{[p-(1-\pi)]^2}$. Therefore $\frac{\partial\,\Delta(p)}{\partial\,p} = \frac{(1-2\pi)((p_i)^2-2\,p_i\,(1-\pi)+1-\pi-\kappa)}{[p_i-(1-\pi)]^2}$. In both cases 1 and 2, $2\pi - 1$ and $(p_i)^2 - 2\,p_i\,(1-\pi) + 1 - \pi - \kappa$ have opposite signs, for all $p_i \geq p^*$. Therefore $\frac{\partial\,\Delta(p)}{\partial\,p} \leq 0$, for all $p_i \geq p^*$.

Amongst syndicates who have the same probability of receiving two positive signals $(\overline{s}_i \cap \overline{s}_j)$ at date 2, the most heterogeneous syndicate is the least likely to receive two negative signals $(\underline{s}_i \cap \underline{s}_j)$. By complement, it is also the most likely to receive only one negative signal $(\underline{s}_i \cap \overline{s}_j$ or $\overline{s}_i \cap \underline{s}_j)$.

Proof of Corollary 1:
$\tilde{\alpha} = \frac{2\,\tilde{p}-1}{\varphi}$. $\overline{p}\,\tilde{p}$ is the smallest of the two roots of $F(x) = 0$, where $F(x)$ is defined in (40). $F(.)$ is a concave function, with $F(0) < 0$ and $F(1) = (1-\gamma)(1-\pi)\,(1-\underline{p})^2\,[\overline{p} \,+\, (1 \,-\, \overline{p})/\overline{p}]$.

Given that $\varphi\,\theta < 1$, we have $\underline{p} < 1$. So $F(1) > 0$. Then $\tilde{p} < 1$. Hence $\tilde{\alpha} < 1$.

A project finds financing under (3) if $v(\overline{p}, \tilde{p}) > 0$ and $v(\overline{p}, 1/2) < 0$. So if the project finds financing, $v(\overline{p}, \tilde{p}) \,>\, v(\overline{p}, 1/2)$. From (9), $v(p_i, p_j)$ is strictly increasing in p_j. Therefore, if the project finds financing, then $1/2 < \tilde{p}$, hence $\tilde{\alpha} > 0$.

Proof of Corollary 2:
$F(x)$ in (40) depends on θ only through $\underline{p} = \frac{1+\varphi\,\theta}{2}$. We have

$$\frac{\partial F(x)}{\partial \underline{p}} \;=\; -2\,[-(1-\gamma)+\rho]\,\pi\,\underline{p}\,x\,(1-x) \;-\; 2\,(1-\gamma)(1-\pi)\,(1-\underline{p})\,[\overline{p} \,+\, (1 \,-\, \overline{p})/\overline{p}]\,x\;. \qquad (45)$$

So $\frac{\partial F(x)}{\partial \underline{p}} < 0$, for all $x \in (0;1)$ (given that $\rho > 1-\gamma$). Hence $\frac{\partial F(x)}{\partial \theta} < 0$, for all $x \in (0;1)$. $\overline{p}\,\tilde{p} \in (0;1)$ and solves $F(\overline{p}\,\tilde{p}) = 0$. Therefore $\frac{\partial \tilde{p}}{\partial \theta} > 0$. Then $\frac{\partial \tilde{\alpha}}{\partial \theta} > 0$.

Proof of Corollary 3:
In the equilibrium outcome, the probability that syndicate (k,l) finances the second round is $P(switch) = P(\overline{s}_k \cap \overline{s}_l \cap \not{i}\not{j})$, where $\not{i}\not{j}$ is the signal of non-participation of the inside syndicate. The PBE consistent beliefs of (k,l) about the history of $\not{i}\not{j}$ in the equilibrium case 1(a) is that $\not{i}\not{j}$ is equivalent to a signal $\underline{s}_i \cup \underline{s}_j$ (VC i received signal $\underline{s}_i$ or VC j received signal $\underline{s}_j$). We therefore have $P(\overline{s}_k \cap \overline{s}_l \cap \not{i}\not{j} \mid G) = P(\overline{s}_k \mid G)\,P(\overline{s}_l \mid G)\,(1 - P(\overline{s}_i \mid G)\,P(\overline{s}_j \mid G))$ and $P(\overline{s}_k \cap \overline{s}_l \cap \not{i}\not{j} \mid B) = (1 - P(\overline{s}_k \mid G))\,(1 - P(\overline{s}_l \mid G))\,(1 - (1 - P(\overline{s}_i \mid G))\,(1 - P(\overline{s}_j \mid G)))$. As $\alpha_i = 1$ and $\alpha_k = \alpha_l = 1$, $P(\overline{s}_i \mid G) = \overline{p} = \frac{1+\varphi}{2}$ and $P(\overline{s}_k \mid G) = P(\overline{s}_l \mid G) = \underline{p} = \frac{1+\varphi\,\theta}{2}$. $P(\overline{s}_j \mid G) = p_j \equiv \frac{1+\alpha_j}{2}$. So

$$P(switch) \;=\; \underline{p}^2\,(1-\overline{p}\,p_j)\,\pi \,+\, (1-\underline{p})^2\,(1-(1-\overline{p})\,(1-p_j))\,(1-\pi) \;>\; 0\;. \qquad (46)$$

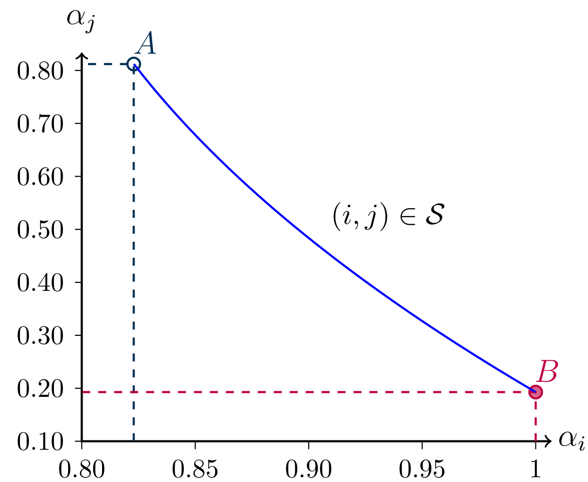
Comparison of data coverage between Thompson One and Pitchbook:
Number of distinct funding rounds raised by US entrepreneurial firms covered by Pitchook and Thomson One for each year from 2007 to 2014. Only rounds with a disclosed investment amount are considered.

Year	Thompson One	PitchBook
2007	4,244	3,338
2008	4,325	3,648
2009	2,907	3,148
2010	3,304	3,817
2011	3,553	4,916
2012	4,078	6,258
2013	4,333	7,711
2014	4,397	8,929

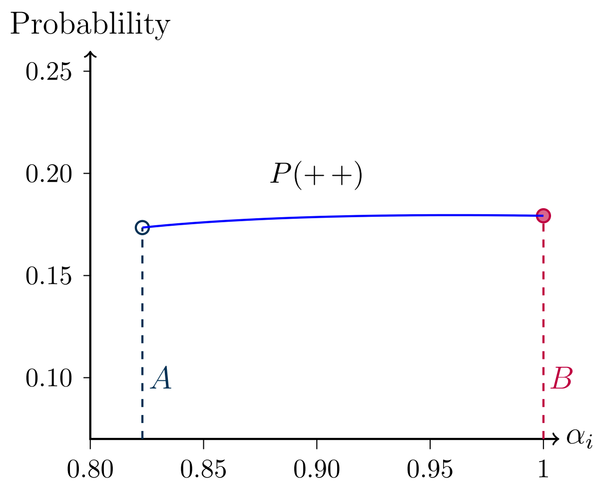
Figure 1: Early Round Heterophily

Input parameters: $\pi = 20\%$, $\gamma = 20\%$, $\rho = 3$, $\varepsilon = 0.001$, $\varphi = 90\%$, $\theta = 50\%$.

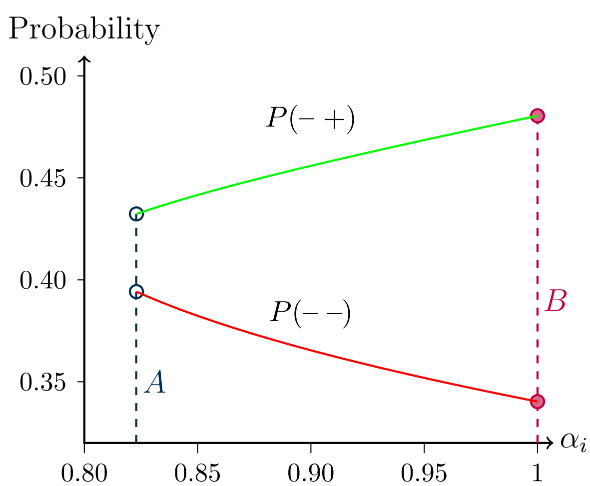
Notes: Panel (a) shows combinations of levels of VC experience such that the expected payoff at date 1 of the early round syndicate equals zero. Amongst these VC couples, couple A corresponds to a homogeneous syndicate ((α_i, α_j) where $\alpha_i = \alpha_j = 0.8229$) and couple B to a most heterogeneous syndicate ($(\alpha_i, \alpha_j) = (1, \tilde{\alpha})$ where $\tilde{\alpha} = 0.1928$). Panel (b) shows the probability an early round syndicate $(i, j) \in \mathcal{S}$ receives two positive signals, $P(++) \equiv P(\overline{s}_i \cap \overline{s}_j)$. If this occurs, (i, j) finances the follow-on round. Panel (c) shows the probability an early round syndicate $(i, j) \in \mathcal{S}$ receives one positive and one negative signal, $P(-+) \equiv P(\overline{s}_i \cap \underline{s}_j) + P(\underline{s}_i \cap \overline{s}_j)$, and the probability it receives two negative signals, $P(--) \equiv P(\underline{s}_i \cap \underline{s}_j)$. If one of these occurs, (i, j) does not finance the follow-on round. Panel (d) shows the updated probability of a most experienced outside syndicate (k, l) (such that $(\alpha_k, \alpha_l) = (1, 1)$), that the project is good, after receiving two positive signals ($\overline{s}_k$ and $\overline{s}_l$), and the negative signal of non-continued participation of the early round syndicate (i, j). This is shown for all early round syndicate $(i, j) \in \mathcal{S}$.



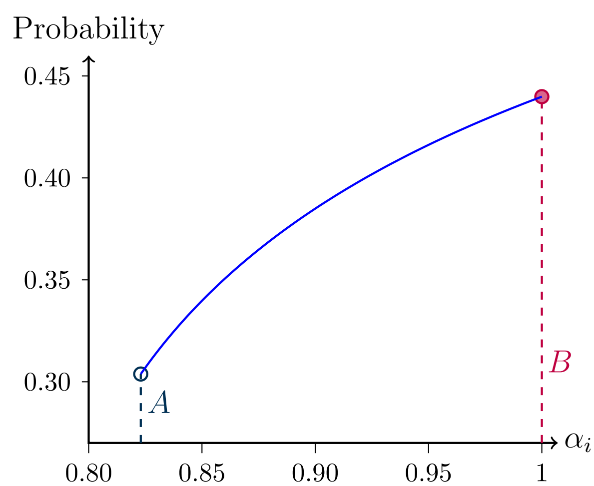
(a) Preferred couples of VC experience



(b) Inside syndicate finances the follow-on round



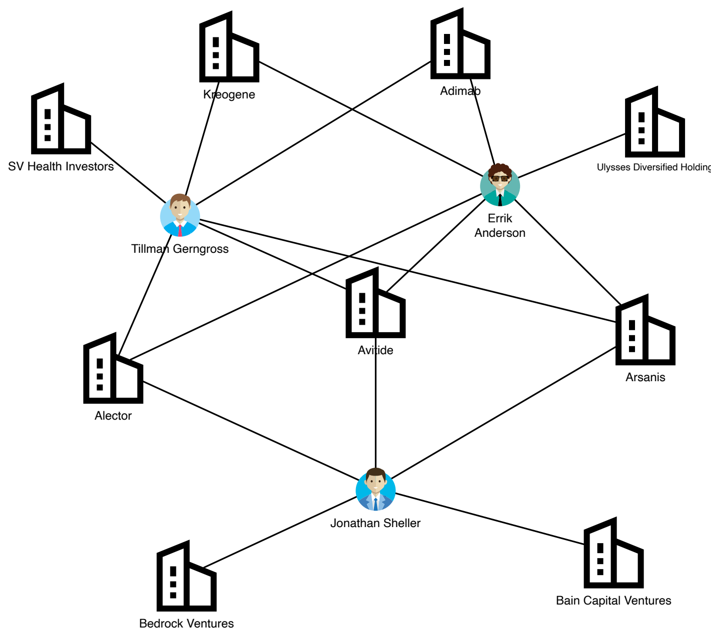
(c) Inside syndicate does not continue participating



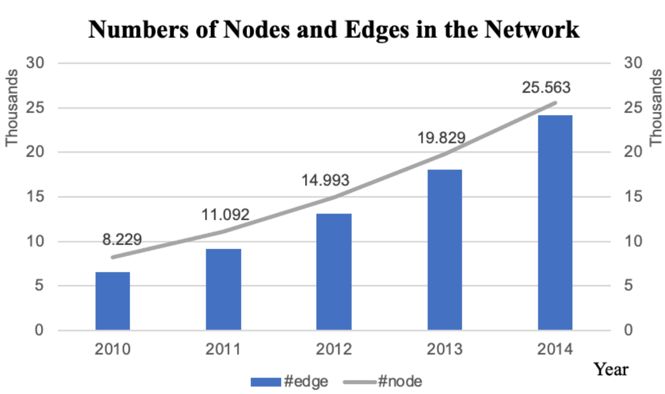
(d) Updated belief of outside syndicate

Figure 2: Description of Entrepreneurial Network

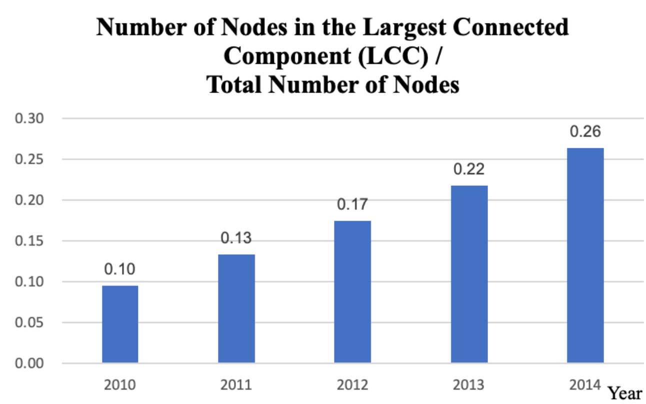
Notes: Panel A illustrates an example of the network relationships owned by the entrepreneurial firm, Avitide. Only direct ties of relationship are present. Before Avitide's first round in March 2013, one of the co-founders, Tillman Gerngross, who is a former VC investor at SV Health Investors, have founded a series of other companies, including Adimab (in 2007), Kreogene (in 2008), Arsanis (in 2010), and Alector (in January 2013). Mr. Gerngross' partners from those previously-founded ventures, namely Errik Anderson and Jonathan Sheller, also joined him in founding Avitide. In addition, Mr. Anderson himself founded Ulysses Diversified Holdings in 1994, and Mr. Sheller used to work at Bain Capital Ventures, and then left in 2011 to found Bedrock Ventures. All of those prior professional relationships owned by the key peronnel are described in the figure.
Panel B shows the number of edges and nodes in each year's network from 2010 to 2014. Panel C plots the ratio of the number of nodes in largest connected component (LCC) and the total nodes in each year's network.



Panel A



Panel B



Panel C

Table 1: Heterogeneity of VC Syndicates and Switching of VC Syndicates

Notes: Panel A presents patterns of heterogeneous VC syndicates for rounds of different sequence numbers. VC firms' experience counts the number of investment rounds a VC firm participated since 1975 to a focal round. Within each syndicated round, we calculate two alternative measures for VC experience heterogeneity: coefficient of variation (CV) and Gini coefficient.
Panel B reports the rates of all investing VC firms in a round no longer participating in any of the subsequent rounds, given an entrepreneurial firm survived to receive at least one subsequent round (i.e. Switching). Only syndicated rounds are included in the sample for generating the statistics in Panel B. For each group of rounds with a sequence number later than the first (i.e. 2nd rounds, 3rd rounds, and 4th and later rounds), we perform a mean equality test with the first-round group sample and present the p-values from such tests in Columns 4, 6, and 8.

Panel A: VC Heterogeneity in Syndicated Deals

	All Rounds		1st Round		2nd Round		3rd Round		4th and Later Round	
	mean	median	mean	median	mean	median	mean	median	mean	median
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
CV	0.73	0.68	0.76	0.73	0.74	0.70	0.71	0.66	0.71	0.65
Gini	0.68	0.72	0.68	0.75	0.68	0.72	0.67	0.70	0.68	0.72
Observations	12908		3208		3214		2359		4127	

Panel B: Switching of VC Syndicates

	All Rounds	1st Round	2nd Round		3rd Round		4th and Later Round	
	mean	mean	mean	p-value	mean	p-value	mean	p-value
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Switching	0.24	0.26	0.23	0.04	0.19	0.00	0.25	0.40
Observations	5840	1153	1439		1169		2079	

Table 2: Summary Statistics

Notes: This table presents summary statistics of variables by rounds of different sequence numbers. Panel A presents statistics related to syndicated funding rounds, whereas Panel B shows statistics for all rounds (i.e. syndicated and standalone together).

	First Round			Second Round			Third Round			4th and Later Round		
Panel A: Syndicated Deals												
	Mean	Median	S.D.	Mean	Median	S.D.	Mean	Median	S.D.	Mean	Median	S.D.
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Switching	0.26	0.00	0.44	0.23	0.00	0.42	0.19	0.00	0.40	0.25	0.00	0.43
Gini	0.67	0.75	0.29	0.68	0.73	0.25	0.67	0.70	0.24	0.68	0.71	0.23
CV	0.76	0.73	0.41	0.74	0.70	0.36	0.72	0.67	0.34	0.71	0.65	0.33
Est. Exit Prob	0.24	0.24	0.08	0.28	0.29	0.08	0.33	0.33	0.09	0.41	0.41	0.12
Closeness Centrality	0.00	0.00	0.01	0.01	0.00	0.01	0.01	0.00	0.01	0.01	0.00	0.02
Company Age	1.73	1.00	2.73	2.80	2.00	3.51	4.00	3.00	4.06	6.99	6.00	4.37
Early Stage	0.45	0.00	0.50	0.62	1.00	0.49	0.53	1.00	0.50	0.21	0.00	0.41
Seed Stage	0.51	1.00	0.50	0.29	0.00	0.45	0.14	0.00	0.35	0.04	0.00	0.21
Deal Size ($Mil)	3.76	1.50	7.57	6.64	3.00	12.02	10.81	5.80	18.41	22.44	11.00	54.38
Exp of Lead VC	248.97	57.00	518.33	277.81	78.00	509.71	321.79	87.00	584.75	338.59	94.00	594.92
Dis. to VC < 50 miles	0.77	1.00	0.42	0.75	1.00	0.43	0.73	1.00	0.44	0.70	1.00	0.46
Dis. to VC 50-100 miles	0.05	0.00	0.23	0.05	0.00	0.23	0.06	0.00	0.24	0.06	0.00	0.24
Foreign-HQ VC	0.40	0.00	0.49	0.40	0.00	0.49	0.39	0.00	0.49	0.41	0.00	0.49
Stage Mismatch	0.30	0.00	0.46	0.24	0.00	0.43	0.18	0.00	0.39	0.14	0.00	0.35
Fund size/next round size	170.74	20.15	1020.64	139.34	18.23	1363.60	112.61	17.94	720.30	116.62	15.55	956.85
No. of VCs	4.53	3.00	4.11	4.70	3.00	3.78	4.62	4.00	4.00	4.89	4.00	3.28
Panel B: All Deals												
	Mean	Median	S.D.	Mean	Median	S.D.	Mean	Median	S.D.	Mean	Median	S.D.
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Survival	0.61	1.00	0.49	0.66	1.00	0.47	0.66	1.00	0.47	0.63	1.00	0.48
Syndicate	0.56	1.00	0.50	0.69	1.00	0.46	0.72	1.00	0.45	0.74	1.00	0.44
Ind HHI	0.34	0.31	0.25	0.34	0.31	0.24	0.34	0.29	0.23	0.34	0.29	0.23

Table 3: Effects of Network Centrality on Heterogeneity of VC Syndicates

Notes: This table reports results from estimating equation (12) in OLS using all syndicated rounds raised between 2010 and 2014. Analysis is carried out by rounds of different sequence numbers (i.e. 1st, 2nd, 3rd, and 4th and later rounds). Columns 1 through 4 show results using CV as the measure for syndicate heterogeneity, whereas Columns 5 through 8 report results using Gini as the syndicate heterogeneity measure. Standard errors are clustered at entrepreneurial firm state level.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	CV	CV	CV	CV	Gini	Gini	Gini	Gini
	1st Round	2nd Round	3rd Round	4th and Later Rounds	1st Round	2nd Round	3rd Round	4th and Later Round
Closeness Centrality	-1.105***	-1.187***	-0.445	-0.512*	-0.813***	-0.818**	-0.382	-0.333
	(0.315)	(0.407)	(0.495)	(0.305)	(0.261)	(0.323)	(0.395)	(0.199)
Log(Company Age)	0.0232*	0.0162*	0.0439***	0.0125	0.0171	0.0124**	0.0282**	0.00512
	(0.0133)	(0.00836)	(0.0163)	(0.0126)	(0.0102)	(0.00596)	(0.0123)	(0.0127)
Log(DealSize)	-0.0153	-0.0283***	-0.00857	0.0175***	-0.00914	-0.0145**	0.000299	0.0139***
	(0.0122)	(0.00931)	(0.00719)	(0.00507)	(0.0103)	(0.00636)	(0.00488)	(0.00384)
Log(No. of VCs)	-0.297***	-0.277***	-0.271***	-0.309***	0.0304***	0.0507***	0.0571***	0.0375***
	(0.0146)	(0.0112)	(0.0121)	(0.0120)	(0.00746)	(0.00830)	(0.00757)	(0.00687)
Seed Stage	-0.0407	-0.0283	0.0579	0.0460	-0.0261	-0.0267	0.0294	0.0120
	(0.0462)	(0.0230)	(0.0358)	(0.0328)	(0.0356)	(0.0166)	(0.0268)	(0.0239)
Early Stage	-0.0242	-0.0195	0.0183	0.0360**	-0.00842	-0.0114	0.00858	0.0183*
	(0.0287)	(0.0174)	(0.0199)	(0.0149)	(0.0219)	(0.0121)	(0.0164)	(0.00942)
Log(Exp of Lead VC)	0.0613***	0.0386***	0.0260***	0.0212***	0.0502***	0.0306***	0.0209***	0.0161***
	(0.00292)	(0.00343)	(0.00404)	(0.00265)	(0.00236)	(0.00251)	(0.00301)	(0.00210)
Investment Year Dummies	Y	Y	Y	Y	Y	Y	Y	Y
ENT Firm State Dummies	Y	Y	Y	Y	Y	Y	Y	Y
Industry Dummies	Y	Y	Y	Y	Y	Y	Y	Y
Adjusted R^2	0.20	0.20	0.18	0.20	0.15	0.10	0.09	0.06
Observations	3208	3214	2359	4127	3208	3214	2359	4127

Standard errors in parentheses

* $p < .1$, ** $p < .05$, *** $p < .01$

Table 4: Heckman Two Stage Procedure: Effects of Network Centrality on Heterogeneity of VC Syndicates

Notes: This table reports results from two-stage Heckman regressions, using all syndicated rounds raised between 2010 and 2014. Analysis is carried out by rounds of different sequence numbers (i.e. 1st, 2nd, 3rd, and 4th and later rounds). Panel A presents results from second-stage estimation using two alternative heterogeneity measures (i.e. CV and Gini). Panel B reports coefficients from estimating the selection equation that uses *Syndicate* as the dependent variable, as shown in equation (13a). All standard errors are clustered at the entrepreneurial firm state level.

Panel A: Effects of Network Centrality on Heterogeneity of VC Syndicates

	(1) 1st Round CV	(2) 2nd Round CV	(3) 3rd Round CV	(4) 4th and Later Round CV	(5) 1st Round Gini	(6) 2nd Round Gini	(7) 3rd Round Gini	(8) 4th and Later Round Gini
Closeness Centrality	-4.899**	-1.673***	-0.714	-0.511	-4.024**	-1.231**	-0.669	-0.336
	(2.270)	(0.635)	(0.530)	(0.328)	(1.921)	(0.540)	(0.421)	(0.244)
Log(Company Age)	0.0279	0.0328**	0.0576***	0.0116	0.0210	0.0264**	0.0426***	0.00896
	(0.0347)	(0.0158)	(0.0176)	(0.0131)	(0.0294)	(0.0134)	(0.0138)	(0.00977)
Log(DealSize)	-0.170***	-0.101***	-0.0451***	0.0189*	-0.140***	-0.0764***	-0.0371***	0.00764
	(0.0563)	(0.0174)	(0.0165)	(0.0105)	(0.0476)	(0.0148)	(0.0129)	(0.00782)
Log(No. of VCs)	-0.295***	-0.278***	-0.274***	-0.309***	0.0322	0.0499***	0.0550***	0.0375***
	(0.0355)	(0.0143)	(0.0156)	(0.0112)	(0.0301)	(0.0121)	(0.0119)	(0.00829)
Log(Exp of Lead VC)	-0.0606	0.00378	0.0102	0.0218***	-0.0530	0.000940	0.00491	0.0133***
	(0.0388)	(0.00799)	(0.00722)	(0.00486)	(0.0329)	(0.00680)	(0.00563)	(0.00361)
Seed Stage	-0.618***	-0.160***	0.0222	0.0476	-0.514***	-0.139***	-0.00704	0.00465
	(0.210)	(0.0438)	(0.0332)	(0.0299)	(0.178)	(0.0373)	(0.0260)	(0.0222)
Early Stage	-0.430***	-0.0750**	0.0129	0.0363**	-0.351**	-0.0585**	0.00309	0.0168
	(0.163)	(0.0317)	(0.0186)	(0.0146)	(0.138)	(0.0269)	(0.0147)	(0.0109)
λ	-1.311***	-0.462***	-0.223***	0.00868	-1.109***	-0.393***	-0.228***	-0.0398
	(0.394)	(0.0872)	(0.0852)	(0.0589)	(0.333)	(0.0742)	(0.0657)	(0.0437)
Investment Year Dummies	Y	Y	Y	Y	Y	Y	Y	Y
ENT Firm State Dummies	Y	Y	Y	Y	Y	Y	Y	Y
Industry Dummies	Y	Y	Y	Y	Y	Y	Y	Y
Prob.> χ^2	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Observations	3208	3214	2359	4127	3208	3214	2359	4127

Standard errors in parentheses

* $p < .1$, ** $p < .05$, *** $p < .01$

Panel B: First Stage Results from Estimating Selection Equation

	(1) 1st Round Syndicate	(2) 2nd Round Syndicate	(3) 3rd Round Syndicate	(4) 4th and Later Round Syndicate
Ind HHI	0.123*	0.402***	0.258**	0.240***
	(0.0696)	(0.0859)	(0.111)	(0.0856)
Closeness Centrality	7.275***	3.854*	4.988**	0.747
	(1.978)	(2.057)	(2.343)	(1.559)
Log(Company Age)	-0.00961	-0.109***	-0.190***	-0.275***
	(0.0293)	(0.0416)	(0.0600)	(0.0502)
Log(DealSize)	0.224***	0.382***	0.415***	0.425***
	(0.0259)	(0.0283)	(0.0321)	(0.0207)
Log(Exp of Lead VC)	0.172***	0.185***	0.187***	0.193***
	(0.00908)	(0.0111)	(0.0141)	(0.0109)
Seed Stage	0.738***	0.553***	0.332***	0.433***
	(0.0904)	(0.0938)	(0.107)	(0.110)
Early Stage	0.499***	0.199**	0.0486	0.0825
	(0.0837)	(0.0780)	(0.0711)	(0.0614)
Investment Year Dummies	Y	Y	Y	Y
ENT Firm State Dummies	Y	Y	Y	Y
Industry Dummies	Y	Y	Y	Y
Observations	5721	4680	3262	5601

Standard errors in parentheses

* $p < .1$, ** $p < .05$, *** $p < .01$

Table 5: Effects of Heterogeneity of VC Syndicates on Switching

Notes: This table reports average marginal effects from estimating equation (14) in Probit, using a sample of all the funding rounds raised between year 2010 and 2014 that were backed by a syndicate and successfully received a subsequent round of funding. Analysis is carried out by rounds of different sequence numbers (i.e. 1st, 2nd, 3rd, and 4th and later rounds). The estimation results are presented by rounds of different sequence numbers. All standard errors are clustered at the state level of the entrepreneurial firm.

	(1) 1st Round Switching	(2) 2nd Round Switching	(3) 3rd Round Switching	(4) 4th and Later Round Switching	(5) 1st Round Switching	(6) 2nd Round Switching	(7) 3rd Round Switching	(8) 4th and Later Round Switching
CV	0.0918***	0.102***	0.0984***	0.179***				
	(0.0234)	(0.0259)	(0.0320)	(0.0276)				
Gini					0.184***	0.153***	0.167***	0.264***
					(0.0388)	(0.0417)	(0.0500)	(0.0468)
Est. Exit Prob	-0.115	-0.0950	0.00294	0.616***	-0.151	-0.166	-0.0467	0.519***
	(0.248)	(0.176)	(0.209)	(0.106)	(0.238)	(0.171)	(0.202)	(0.105)
Log(Max VC Exp)	-0.0382***	-0.0388***	-0.0294***	-0.0427***	-0.0433***	-0.0427***	-0.0336***	-0.0502***
	(0.00679)	(0.00612)	(0.00756)	(0.00652)	(0.00740)	(0.00643)	(0.00793)	(0.00692)
Dis. to VC<50 miles	-0.0211	-0.0578***	-0.0276	-0.0321*	-0.0301*	-0.0655***	-0.0351	-0.0423**
	(0.0168)	(0.0181)	(0.0219)	(0.0186)	(0.0168)	(0.0180)	(0.0217)	(0.0185)
Dis. to VC 50-100 miles	-0.0246	0.0751**	0.0263	-0.0455	-0.0295	0.0684**	0.0238	-0.0530
	(0.0573)	(0.0325)	(0.0382)	(0.0396)	(0.0579)	(0.0323)	(0.0380)	(0.0400)
Foreign-HQ VC	0.00601	0.0143	-0.00762	0.0169	-0.0123	0.000888	-0.0222	-0.000925
	(0.0191)	(0.0173)	(0.0192)	(0.0169)	(0.0171)	(0.0178)	(0.0195)	(0.0172)
Stage Mismatch	0.0488**	0.0354*	0.0625***	0.0441*	0.0458**	0.0314	0.0590**	0.0460*
	(0.0212)	(0.0200)	(0.0242)	(0.0263)	(0.0203)	(0.0201)	(0.0241)	(0.0265)
Log(Fund size/next round size)	0.0133***	0.0131**	0.0159**	0.0310***	0.0134***	0.0132**	0.0167***	0.0322***
	(0.00417)	(0.00536)	(0.00625)	(0.00534)	(0.00413)	(0.00531)	(0.00626)	(0.00539)
Investment Year Dummies	Y	Y	Y	Y	Y	Y	Y	Y
ENT Firm State Dummies	Y	Y	Y	Y	Y	Y	Y	Y
Industry Dummies	Y	Y	Y	Y	Y	Y	Y	Y
Pseudo R^2	0.11	0.15	0.08	0.09	0.11	0.15	0.09	0.09
Observations	1153	1439	1169	2079	1153	1439	1169	2079

Standard errors in parentheses

* $p < .1$, ** $p < .05$, *** $p < .01$

Table 6: Effects of Heterogeneity of VC Syndicates on Switching (Selection Corrected)

Notes: This table reports results from correcting for selection by jointly estimating equations (15a), (15b), and (15c) using observations of rounds raised between 2010 and 2014. Analysis is carried out by rounds of different sequence numbers (i.e. 1st, 2nd, 3rd, and 4th and later rounds). In Panel A, average marginal effects on the likelihoods of switching VCs in the subsequent rounds are presented. Panel B reports coefficients from two other jointly estimated equations in the system that describe the formation of a syndicate and survival to a subsequent round, respectively. All standard errors are clustered at the entrepreneurial firm state level.

Panel A: Effects of Heterogeneity of VC Syndicates on Switching

	(1) 1st Round Switching	(2) 2nd Round Switching	(3) 3rd Round Switching	(4) 4th and Later Round Switching	(5) 1st Round Switching	(6) 2nd Round Switching	(7) 3rd Round Switching	(8) 4th and Later Round Switching
CV	0.0671**	0.0577***	0.0969*	0.111***				
	(0.0340)	(0.0211)	(0.0543)	(0.0263)				
Gini					0.113***	0.0877**	0.151***	0.160***
					(0.0291)	(0.0344)	(0.0495)	(0.0413)
Est. Exit Prob	-0.124	-0.0768	-0.0204	0.450***	-0.127	-0.118	-0.0937	0.384***
	(0.196)	(0.118)	(0.235)	(0.0896)	(0.153)	(0.111)	(0.212)	(0.0725)
Log(Max VC Exp)	-0.0185***	-0.0192**	-0.0314**	-0.0212***	-0.0198***	-0.0208*	-0.0340***	-0.0252***
	(0.00591)	(0.00887)	(0.0153)	(0.00574)	(0.00513)	(0.0108)	(0.0116)	(0.00612)
Dis. to VC<50 miles	-0.0136	-0.0372***	-0.0258	-0.0203	-0.0177	-0.0407***	-0.0272	-0.0256**
	(0.0131)	(0.0125)	(0.0254)	(0.0125)	(0.0118)	(0.0133)	(0.0214)	(0.0119)
Dis. to VC 50-100 miles	-0.0189	0.0433**	0.0261	-0.0316	-0.0201	0.0387**	0.0202	-0.0354
	(0.0412)	(0.0173)	(0.0308)	(0.0292)	(0.0359)	(0.0162)	(0.0260)	(0.0285)
Foreign-HQ VC	0.00345	0.0118	-0.00608	0.0120	-0.00458	0.00415	-0.0166	0.00125
	(0.0129)	(0.0118)	(0.0106)	(0.0110)	(0.00936)	(0.0118)	(0.0117)	(0.0122)
Stage Mismatch	0.0338**	0.0228*	0.0615**	0.0304*	0.0296**	0.0200	0.0516***	0.0308*
	(0.0133)	(0.0132)	(0.0271)	(0.0158)	(0.0128)	(0.0131)	(0.0151)	(0.0161)
Log(Fund size/next round size)	0.00866***	0.00762*	0.0155	0.0189***	0.00804***	0.00747	0.0143**	0.0193***
	(0.00324)	(0.00434)	(0.00947)	(0.00424)	(0.00292)	(0.00478)	(0.00568)	(0.00425)
Investment Year Dummies	Y	Y	Y	Y	Y	Y	Y	Y
ENT Firm State Dummies	Y	Y	Y	Y	Y	Y	Y	Y
Industry Dummies	Y	Y	Y	Y	Y	Y	Y	Y
Prob > χ^2	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Observations	1153	1439	1169	2079	1153	1439	1169	2079

Standard errors in parentheses

* $p < .1$, ** $p < .05$, *** $p < .01$

Panel B: Results for Syndication and Survival Equations

	(1) 1st Round	(2) 2nd Round	(3) 3rd Round	(4) 4th and Later Round	(5) 1st Round	(6) 2nd Round	(7) 3rd Round	(8) 4th and Later Round
Heterogeneity Measure Used	CV	CV	CV	CV	Gini	Gini	Gini	Gini
Results for Equation (15b)	Syndicate	Syndicate	Syndicate	Syndicate	Syndicate	Syndicate	Syndicate	Syndicate
Ind HHI	0.124**	0.410***	0.273***	0.247***	0.125**	0.411***	0.268***	0.248***
	(0.0541)	(0.0642)	(0.0900)	(0.0672)	(0.0539)	(0.0648)	(0.0914)	(0.0678)
Log(Deal Size)	0.240***	0.391***	0.414***	0.427***	0.239***	0.391***	0.414***	0.428***
	(0.0390)	(0.0233)	(0.0306)	(0.0236)	(0.0387)	(0.0233)	(0.0306)	(0.0235)
Early Stage	0.511***	0.201***	0.0424	0.0757	0.513***	0.202***	0.0368	0.0769
	(0.0779)	(0.0694)	(0.0587)	(0.0653)	(0.0771)	(0.0695)	(0.0600)	(0.0651)
Seed Stage	0.745***	0.550***	0.321**	0.423***	0.749***	0.551***	0.326***	0.425***
	(0.101)	(0.0944)	(0.125)	(0.130)	(0.0960)	(0.0949)	(0.122)	(0.130)
Log(Company Age)	-0.0213	-0.114**	-0.198***	-0.279***	-0.0199	-0.114**	-0.196***	-0.279***
	(0.0337)	(0.0460)	(0.0609)	(0.0807)	(0.0315)	(0.0460)	(0.0609)	(0.0808)
Log(Exp of Lead VC)	0.174***	0.186***	0.190***	0.193***	0.174***	0.186***	0.189***	0.193***
	(0.00949)	(0.0118)	(0.0139)	(0.0155)	(0.00930)	(0.0118)	(0.0143)	(0.0155)
Investment Year Dummies	Y	Y	Y	Y	Y	Y	Y	Y
ENT Firm State Dummies	Y	Y	Y	Y	Y	Y	Y	Y
Industry Dummies	Y	Y	Y	Y	Y	Y	Y	Y
Results for Equation (15c)	Survival	Survival	Survival	Survival	Survival	Survival	Survival	Survival
Log(No. of VCs)	0.275***	0.102	0.137*	-0.0122	0.272***	0.109*	0.139**	0.00204
	(0.0361)	(0.0673)	(0.0807)	(0.0452)	(0.0325)	(0.0657)	(0.0662)	(0.0466)
Log(Deal Size)	0.118***	0.183***	0.207***	0.173***	0.121***	0.182***	0.206***	0.169***
	(0.0317)	(0.0282)	(0.0490)	(0.0228)	(0.0305)	(0.0281)	(0.0460)	(0.0224)
Early Stage	-0.112*	-0.342***	0.119*	0.102***	-0.109*	-0.342***	0.126**	0.103***
	(0.0629)	(0.0526)	(0.0614)	(0.0386)	(0.0627)	(0.0529)	(0.0512)	(0.0385)
Seed Stage	0.0136	-0.201***	0.357***	0.188**	0.0167	-0.202**	0.347***	0.186**
	(0.0743)	(0.0781)	(0.0823)	(0.0871)	(0.0750)	(0.0786)	(0.0777)	(0.0877)
Log(Company Age)	-0.158***	-0.398***	-0.275***	-0.442***	-0.159***	-0.398***	-0.278***	-0.440***
	(0.0316)	(0.0265)	(0.0696)	(0.0278)	(0.0308)	(0.0264)	(0.0640)	(0.0280)
Log(Exp of Lead VC)	0.0298***	0.0331***	0.00666	0.0272***	0.0296***	0.0322***	0.00675	0.0254***
	(0.0106)	(0.00946)	(0.0112)	(0.00845)	(0.0105)	(0.00953)	(0.0112)	(0.00863)
Investment Year Dummies	Y	Y	Y	Y	Y	Y	Y	Y
ENT Firm State Dummies	Y	Y	Y	Y	Y	Y	Y	Y
Industry Dummies	Y	Y	Y	Y	Y	Y	Y	Y
atanh($\rho(\psi, \xi)$)	-0.0279	0.0549	0.0230	0.0738	-0.0248	0.0501	0.0215	0.0631
	(0.0216)	(0.0395)	(0.0821)	(0.0496)	(0.0205)	(0.0388)	(0.0721)	(0.0515)
atanh($\rho(\psi, \varepsilon)$)	1.199	0.362	-0.205	0.357*	0.826**	0.384	-0.380	0.339*
	(1.745)	(0.344)	(0.432)	(0.200)	(0.374)	(0.430)	(0.379)	(0.182)
atanh($\rho(\xi, \varepsilon)$)	-0.115	0.712	0.128	0.654***	0.133	0.761	0.551	0.722***
	(0.405)	(0.654)	(1.084)	(0.178)	(0.188)	(0.689)	(0.737)	(0.171)
Observations	5720	4677	3272	5596	5720	4677	3272	5596

Standard errors in parentheses

* $p < .1$, ** $p < .05$, *** $p < .01$