Organizational Decision-Making and Information: Angel Investments by Venture Capital Partners

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Abstract: We study information aggregation in organizational decision-making for the financing of entrepreneurial ventures. We introduce a formal model of voting where agents face costly tacit information to improve their decision quality. Equilibrium outcomes suggest a theoretical tension for group decision-making between the benefits of information aggregation and a cost from the participation of uninformed agents, and this tension presents a boundary condition for when a group decision is superior to an individual decision.

We test the implications of the model for a particular phenomenon in venture capital: private angel investments by the partners outside of their employer, which represent investments passed on by the employer. Venture capital partners, acting independently with their personal funds, make investments into younger firms with less educated and younger founding teams than their employing VC firms, but these investments perform financially similarly or better on some metrics even when controlling for investment size, stage, and industry. Geographic distance and technological inexperience by the VC increase the probability the investment is taken up by a partner and not the VC. This work contributes to an emerging stream of literature on information aggregation in organizations and the established literatures on resource allocation and incumbent spin-outs.

Keywords: Entrepreneurial Finance, Venture Capital, Angel Investors, Organization Design, Information, Voting, Group Decision-Making

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1 Introduction

Why do we trust groups to make some of our most important decisions? US criminal cases are determined by the unanimous vote of a jury, and a board of directors has the power to hire and fire the CEO by a majority vote. Why not one juror or one director? When preferences are aligned, groups can deliver superior decision quality relative to that of a single agent (de Condorcet, 1785) because of their ability to aggregate information across agents. Information aggregation represents an important differentiating capability for organizations (Cyert and March, 1963; Gavetti et al., 2007), and it is thus relevant to understand the optimal organizational structures that enable this capability and their associated boundary conditions (Csaszar, 2012).

In the setting of entrepreneurial finance, optimally aggregating information is especially crucial for financial intermediaries because information is low and at a premium. Entrepreneurial ventures lack any of the capital assets or organizational infrastructure present in larger incumbent firms, and thus they are difficult to value using straightforward explicit information: these ventures may have unproven management teams, enter new and undefined market segments, and develop cutting edge but untested technology products (Aldrich and Fiol, 1994). As a result, non-traditional tacit information, such as "gut feel" about an entrepreneur or industry, play a large and pivotal role in the decision-making process in entrepreneurial finance (Huang and Knight, 2015; Huang and Pearce, 2015). To facilitate capital investments into these entrepreneurial firms, we have dedicated financial institutions, such as venture capital firms, angel investors, crowdfunding platforms, and accelerators, which seek to address these information problems and invest in high risk, high reward ventures. These institutions specialize in identifying investment opportunities from a vague choice set, acquiring and aggregating external information to evaluate and execute investments, and monitoring their investments ex post.

We study two particular organizational forms in entrepreneurial finance, venture capital firms and angel investors, which differ starkly in their decision-making structures. Venture capital firms are administrated by a general partnership. The partners individually source investments and collect intimate information about those investments through due diligence, which they then bring to the whole partnership for consideration. The venture capital partnership then makes decisions by committee through a formal or informal vote on the deals brought in. Angel investors also individually source investments and collect information, but unlike a venture capital firm, they make the investment decisions by themselves. Basic voting theory suggests that committees can more effectively aggregate information among informed parties than the parties acting individually (de Condorcet, 1785), so all else equal, we might expect a group decision-making process to outperform an individual decision-making process.

We examine a particular phenomenon where the information aggregation advantage of the venture capital organization may break down: individual angel investments by partners of venture capital firms. Partners of some venture capital firms make their own angel investments into ventures their firm ultimately chooses not to invest in. As a requirement of employment with the venture capital firm, the partners have a fiduciary duty, a *duty of loyalty*, to the venture capital firm. As such, the venture capital firm must always have the right of first refusal on any possible deal, and the partners can only invest in deals that the firm would not do. Thus, we observe angel investments made by the venture capital partners that were necessarily rejected or "passed over" by the firm decision-making criterion while meeting the partner's personal criterion for an investment. Between 2005 and 2013, over 500 US venture capital firms have partners who made such angel investments on the side. We ask why an individual partner would still pursue a deal when her colleagues, whose opinion she presumably respects, voted against it. It is a paradox and open question as to why a partner would take on substantially more personal financial risk to pursue her own investment.

To explain this phenomenon, we argue that there is a tradeoff in group decision-making between the benefits of information aggregation and the cost from the participation of uninformed agents, driven by a disincentive to acquire costly tacit information about the venture among the individual agents. This tension presents a fundamental boundary condition for group decision-making, namely that in some cases of heterogeneous information, the group decision underperforms an individual decision.

We offer a stylized formal model to explain the observed phenomenon. A committee of agents with homogenous utility functions must make a dichotomous choice about whether to invest in a particular project that can turn out to be good or bad. A sourcing agent receives a costless private signal, representing tacit information, which is costly to the other members of a committee. The agents all share a public signal component representing explicit information. The other agents have the option to acquire the private signal at cost; this decision is endogenous to the model. The committee then engages in a voting process with a pre-determined threshold. For the model, we find there is no pure strategy equilibrium where all agents acquire the costly private signal, but we find there is an equilibrium where some or no agents acquire the costly private signal. The comparative statics of the model generate a number of testable empirical hypotheses to test. First, projects funded by an angel investor will exhibit weaker explicit characteristics than those funded by the VC. Second, projects funded by the angel investor will have a higher associated cost to acquire the necessary tacit information. Third, projects funded by the angel investor will have less informative tacit information.

We test our theory on a large sample of investments made by venture capital partners, in the form of individual angel investments, and their employing firms, in the form of traditional venture capital investments. We find that the venture capital partners, acting independently, make investments into younger firms with less educated, less experienced, and younger founding teams, but these investments perform similarly or better on some financial metrics even when controlling for investment size, stage, and industry. Geographic distance and VC inexperience in an industry category increase the probability the investment is taken up by a partner and not the VC.

This project makes a number of contributions across the strategy and finance literature. This work is the first to document the investment patterns of venture capital affiliated angel investors, and it also contributes to the still relatively small literature on angel investors, who normally represent a heterogeneous and difficult group to study. Second, we are among the first large sample empirical studies of committee decision-making, with prior work conducted in the lab (Kotha et al., 2015) and through simulation (Csaszar, 2012). Third, we contribute to an emerging stream of work studying specialized decision-making structures as part of a "behaviorally plausible, decision-centered perspective on organizations" (Gavetti et al., 2007). Finally, the particular empirical setting at hand in this study is thematically related to work on spin-outs, companies founded by former employees of incumbent firms (e.g. Klepper, 2001), which we will discuss in the conclusion.

2 Stylized Model

A primary purpose of the firm is to acquire, integrate, and then apply information for its productive use in the form of knowledge (Grant, 1996).[1] In the setting of venture capital, nearly all venture capital firms have a formal or informal mechanism, usually a vote, held for aggregating information from its partners when evaluating a possible deal. This information aggregation structure has direct implications for the ability of the organization to receive knowledge, in other words, its absorptive capacity (Cohen and Levinthal, 1990).

A key challenge for the organizational use of information is the transferability of said information. *Explicit information* is easily and credibly transferable, functioning as a public good. Explicit information can be costlessly aggregated by the organization since it is easily transferable. Examples of explicit knowledge relevant to the venture investor include educational characteristics and work experience of the founding team and the prior financial performance of the startup and its chosen market (e.g. Bernstein et al., 2016b), facts that would be easy to record and communicate. Entrepreneurs create business plans and financial statements for the purposes of communicating this explicit knowledge to investors, and investors can share these documents amongst themselves to communicate this explicit knowledge with each other.

On the other hand, *tacit information*[2] (Polanyi, 1966) cannot be codified and is only revealed by its application, and thus its transfer between people is costly (Kogut and Zander, 1992). Tacit information plays a key role in the decision process for venture investors (Huang and Knight, 2015). The social psychology literature has focused on intuition—affectively charged judgements that arise through rapid and non-conscious associations between different ideas—as a major component of decision-making at the individual level. For example, Huang and Pearce (2015) show that "gut feel," a blend of analysis and intuition derived from the interpersonal relationship between the individual investor and the entrepreneur, has a tangible effect on investor decision-making. Indeed, the investor's intuitive assessment of the entrepreneur and future market trends, along with other informal channels of information often make up the most salient component of the investor's decision-making process, more so than the formal business plan (Huang and Pearce, 2015;

[1] Information is often thought of as the antecedent to knowledge ("all that is known"), where knowledge is information in a useful cognitive representational form, such as a mental model, schema, rules, constraints, etc.

[2] Tacit information is also known as *implicit information*. We use tacit information as an umbrella construct spanning both cognitive and affective domains. Polanyi (1966) argues for the existence of tacit information by noting that "individuals know more than they can explain."

Kirsch et al., 2009). Symbolic actions by the entrepreneur such as professionalism (Zott and Huy, 2007) and other factors gleaned through personal interaction such as optimism (Dushnitsky, 2010), trustworthiness (Maxwell and Lévesque, 2014), passion, and preparedness (Chen et al., 2009) play a deep role in venture investor decision processes. These tacit characteristics can then be combined into a shortcut decision-making heuristic (Åstebro and Elhedhli, 2006; Maxwell et al., 2011). Thus, an important component of the information used by investors to evaluate early stage ventures is captured in a tacit information component, and the ability to utilize this tacit information is a key source of competitive advantage for venture investors who are able to optimally utilize it.

This distinction in transferability of information presents a key inefficiency in simple group decision-making processes like voting. When all information is explicit, information can be shared among all participants and thus participants will be informed when they vote. When there is tacit information, some of the agents in a group may not acquire that information because the information acquisition process is individually costly to each agent. In a standard voting mechanism with no abstentions, agents who have not acquired the costly tacit information will still vote but vote in an uninformed fashion, making their vote worse than useless as they dilute the quality of the group decision that would have occurred without them. We henceforth refer to the explicit information as being *public*, since it can and is shared by all agents, and we refer to the tacit information as being *private*, since it is private to each agent and not shared. This choice of terminology is made to better align with norms in game theoretic formal modeling.

We propose a formal model to elucidate on the boundary conditions of group decision-making through a voting mechanism when some information is heterogeneous or costly to individual agents. For a committee voting by majority rule, where the voters are equally informed (all information is public), the Condorcet jury theorem says that adding more voters asymptotically increases the probability the decision will be correct (de Condorcet, 1785). However, we consider the case where there is heterogeneity in information available to the members of the committee by modeling the tacit component of information as an endogenous outcome of the model (Persico, 2004). We represent shared explicit information through a public signal, and the non-sharable tacit information is represented by a private signal.[3] The committee decision then notably deviates from efficiency and optimality. The primary channel by which agents can credibly express their opinion in a voting environment is through their vote. In most settings, every agent's opinion counts equally, but not every agent voting may be informed. This challenge sets up the primary theoretical tension at the heart of our theory: the benefit of aggregating information across the agents of the group versus the cost of participation of uninformed agents. We propose that this tension, driven by the introduction of costly private (tacit) information into the model, results in the VC partner angel investing phenomenon. We proceed with our model to show the existence of equilibria demonstrating this trade-off and to derive a set of comparative statics for the purposes of empirical testing.

[3]The term *signal* has a different meaning here than in the labor market literature such as in Spence's 1973 work. The information content of the signal is only known to the focal agent.

2.1 Model Setup

We model a committee of three agents $i \in \{1, 2, 3\}$ who together represent the venture capital (VC) firm. The VC firm is responsible for making a dichotomous investment decision $x \in$ {Not Invest (0), Invest (1)}, on a project brought to the firm by agent $i = 1$, who is referred to as the *sourcing agent*. There are two states of the world for the outcome of the investment, $s \in$ {Unprofitable (0), Profitable (1)}, unknown to the agents. Each agent i casts an equally weighted vote $v_i \in \{\text{No } (0), \text{Yes } (1)\}$ against or in favor of the project. The committee requires a majority—at least 2 votes in favor—to invest in the project. If the committee does not invest in the project, then the sourcing agent can choose to invest in the project as an angel investor and independent of the VC firm.

1. **Sourcing** An agent belonging to the organization sources a possible investment and receives a public signal and a private signal, representing explicit information and tacit information respectively.

2. **Sharing** The sourcing agent brings the project to the organization if the combination of the public and private signal merits such, and the sourcing agent shares the public signal with the other agents.

3. **Acquiring Costly Information** Each of the other non-sourcing agents in the organization decides whether to acquire a private signal at a cost to them. This decision is conditional on the public signal brought by the sourcing agent.

4. **Voting** The agents vote. If the vote passes the predetermined majority voting rule, the organization invests in the project.

5. **Individual Decision** If the organization does not vote to approve the project, then the sourcing agent decides whether to individually invest in the project as an independent angel investor.

In evaluating a project and casting their votes, all agents have identical preferences, reflected by voting for the project if and only if their information is favorable. If the project is not funded, then each agent's payoff is 0, independent of state.[4] If the project is funded and the eventual state is s, each agent receives a payoff of $U(s)$ where $U(0) < 0 < U(1)$. These payoffs are prior to subtracting any cost of acquiring information. For notational simplicity, we assume the payoff for the sourcing agent is also $U(s)$ when she makes an individual investment.[5]

Our model follows the setup and many assumptions of the jury voting literature (e.g. de Condorcet, 1785), and we use the notation as set out in Gerling et al. (2005). As is common in voting

[4] We assume there is no regret or loss aversion (Kahneman and Tversky, 1979) if the non-funded project is eventually funded by some other investor and proves successful.

[5] If the VC firm does not fund the project but the sourcing agent does, then the latter's payoff is $\omega U(s)$ for some $\omega > 0$. $\frac{1}{\omega}$ can be interpreted as the proportion of the carry that is paid out to an investment partner at a VC firm for deals conducted through the firm. Given that theoretical results are robust to ω if utility is invariant to linear transformations, we can set $\omega = 1$ for the sake of reducing the amount of notation.

model literature and for all practical considerations, we only consider pure strategy Nash equilibrium and not probabilistic mixed strategy equilibrium. The extensive form representation of the model is shown in Figure 1.

——————Insert Figure 1——————

2.2 Information: Public and Private

Agents have two sources of information, explicit and tacit, represented in the model by a public signal and a private signal respectively. By definition, a public signal encompasses information that can be shared among the members of the VC firm, while the private signal contains information that cannot be shared. The public signal that the sourcing agent brings to the VC firm is embodied in the prior probability that the project will prove profitable: $\pi = Pr(s = 1)$. If agent i has a private signal, it is denoted $\sigma_i \in \{\text{Bad } (B),\ \text{Good } (G),\ \text{Terrific } (T)\}$. To deliver the main hypotheses for the empirical analysis, the information space needs to be more rich than the voting space; in other words, there must be more information than can be fully expressed by the voting mechanism. Since an agent has only two choices in voting $v_i \in \{0, 1\}$, it is sufficient to have three possible private signals.

We define two of those signals as "favorable," where a signal is "favorable" if it increases the likelihood attached to $s = 1$ (investment in the project will prove profitable) and is "unfavorable" if it decreases the likelihood that $s = 1$. Signal B is unfavorable and both signals G and T are favorable. What distinguishes signals G and T is that G is not a sufficiently positive signal that, by itself, an agent would believe the project is worthy, while signal T is sufficient by itself for an agent to draw that conclusion.

The private signal σ_i has the following properties captured by the parameters q, θ, and β, which together with π define the information environment. q is the probability that the signal is favorable, $\sigma_i \in \{G, T\}$, when in the profitable state $s = 1$; q is also the probability that the signal is unfavorable, $\sigma_i = B$, when the state is unprofitable $s = 0$. Conditional on $s = 1$, θ is the probability that the signal is terrific $\sigma_i = T$ given the signal is favorable, $\sigma_i \in \{G, T\}$; analogously, conditional on $s = 0$, β is the probability that $\sigma_i = T$ given $\sigma_i \in \{G, T\}$.

In order for signals G and T to be favorable and B to be unfavorable, it is assumed that the favorable signals G, T are more likely when $s = 1$ than when $s = 0$ and the reverse is true for the unfavorable signal B:[6]

$$\begin{aligned}
Pr(\sigma = G|s = 1) > Pr(\sigma = G|s = 0) \quad &\Leftrightarrow \quad (1 - \theta)q > (1 - \beta)(1 - q) \\
Pr(\sigma = T|s = 1) > Pr(\sigma = T|s = 0) \quad &\Leftrightarrow \quad \theta q > \beta(1 - q) \\
Pr(\sigma = B|s = 1) < Pr(\sigma = B|s = 0) \quad &\Leftrightarrow \quad 0 < 1 - q < q < 1
\end{aligned}$$

It is assumed that $0 < \beta < \theta < 1$: conditional on a favorable signal, the signal is more likely $\sigma_i = T$ when the state is 1 than when it is 0. We have assumed symmetry in the signal, $Pr(\sigma \in \{G, T\}|s =$

[6] This assumption is equivalent to the monotone likelihood ratio property if the private signal were continuous.

$1) = Pr(\sigma = B|s = 0) = q$, so the signal provides the same information content about the state of the world in the profitable state and the unprofitable state. Finally, conditional on the state, agents' signals are assumed to be independent of each other.

2.3 Agent Voting and Information

The sourcing agent, denoted as agent 1, is assumed to already have the public and private signal and brings the project to the VC firm if and only if the private signal is favorable $\sigma_1 \in \{G, T\}$. If agent 1 brings the project to the VC firm, then the other two agents will infer $\sigma_1 \in \{G, T\}$. Our model makes this assumption about the sourcing agent's signal to better reflect the realities of the deal flow process in a venture capital firm. In a venture capital firm, the partners of the firm are themselves responsible for sourcing deal flow for consideration by the firm. Beyond just the search process for possible investments, the partner conducts a due diligence process to assess the quality of the process, i.e. acquire the costly private signal. If a partner brought a project of poor quality, that would hurt the partner's reputation and waste the time and resources of the whole firm.

The initial information of agents 2 and 3 is just the public signal, represented by the prior probability $\pi = Pr(s = 1)$, and the knowledge that the sourcing agent has a favorable signal $\sigma_1 \in \{G, T\}$, although they do not know whether that favorable private signal is good or terrific. They will independently decide whether to acquire a private signal at a cost c which is born by the agent and not the VC firm. If agent 2 (or 3) acquires a signal and the project is not funded then her payoff is $-c$, and if it is funded and the state is s then her payoff is $U(s) - c$.[7] This costly information acquisition setup follows from Persico (2004).

After acquiring any private signals, the three agents simultaneously vote. The agents are not allowed to abstain.[8] It is assumed that agent $i \in \{1, 2, 3\}$ votes in favor of funding the project if and only if:

1. she acquired a signal and the signal is favorable $\sigma_i \in \{G, T\}$;[9]

2. she did not acquire a signal and based on her current beliefs she expects the project to be profitable.[10]

We can now define a set of expected utility conditions that will characterize the Nash equilibria for the information acquisition phase.

[7]Presumably, agent 1 also faces the information acquisition cost, but it is assumed to be a sunk cost outside of this model.

[8]Allowing for abstentions is not a realistic assumption for the present setting, nor would it change the general findings.

[9]For this voting rule, an agent may vote for a project even if her current information does not indicate the project is profitable, merely that it has met the rule for being favorable. This action is perfectly reasonable given that the purpose of voting is to aggregate information, so there are cases where the group will find a project to be profitable even when the individual agent did not. This possibility is only feasible if those with favorable signals vote in support of the project.

[10]We assume that the project is never profitable in expectation without having acquired the private signal.

2.4 Expected Utility Conditions

To ensure the existence of an equilibrium, we make the following assumptions with regards to the expected utility for the individual agents of the VC firm. The following assumptions ensure that the sourcing agent 1 brings projects to the committee for which she receives a signal $\sigma_1 \in \{G, T\}$, because they have a non-zero probability of being approved by the group, and that she would still pursue the project independently when she receives a signal of $\sigma_1 = T$. The full expression of the conditions is available in Appendix A.1

1. $\mathbf{E[U] < 0}$ Without a private signal, the expected value of a project is negative. Hence, the prior probability that the project is worthy of funding must be sufficiently small. Given that the vast majority of ideas that come to a VC firm are not funded, this is a descriptively realistic assumption. For example, Andreessen Horowitz, a well-known venture capital firm, reviews over three thousand startups a year, and ultimately invests in fifteen.[11]

2. $\mathbf{E[U|\sigma = B] < E[U]}$ Signal B reduces the expected utility from funding the project. This assumption justifies an agent voting against the project if an agent receives signal B. This parametric assumption was already made in the model setup to ensure the private signal has informational value.

3. $\mathbf{E[U|\sigma = G] > E[U]}$ Signal G is favorable in that the expected utility is higher after having received this signal. This assumption justifies voting in support of the project if an agent receives signal G. Note that this parametric assumption has also already been made.

4. $\mathbf{E[U|\sigma = T] > 0}$ Signal T is sufficiently positive that the expected utility of the project is positive. This assumption justifies the sourcing agent funding the project if her only information is signal T.

5. $\mathbf{E[U|\sigma \in \{G, T\}] < 0}$ If an agent only knows a signal is favorable, but not whether it is G or T, then she will believe the project is not worthy of funding. Prior to deciding whether to acquire a signal, agents 2 and 3 have their prior beliefs and the knowledge that agent 1 received a favorable signal by virtue of having brought the project to the VC firm. At that moment, agents 2 and 3 have expected utility of $E[U|\sigma \in \{G, T\}]$ from funding the project. This assumption then implies that if they do not acquire the signal, they vote no.

6. $\mathbf{E[U|\sigma = G] < 0 < E[U|\sigma_i = G, \sigma_j = G]}$ By this condition, one good signal is insufficient to conclude the expected utility from the project is positive but two good signals are sufficient to reach that conclusion. Note that $E[U|\sigma = G] < 0$ (Assumption 6a) is implied by the preceding two assumptions: $E[U|\sigma = T] > 0 > E[U|\sigma \in \{G, T\}]$. We then just need to ensure $E[U|\sigma_i = G, \sigma_j = G] > 0$ (Assumption 6b). This condition provides motivation for the existence of the decision-making organization in the first place and the use of a voting rule to aggregate information. If a single G signal was sufficient to conclude the project is worthy

[11] *The New Yorker* May 18, 2015 issue.

then there would be no need to bring it to a committee for a vote and no need for agents to make their decisions as part of the organization in the first place. Thus, the organization would not need to exist.

The addition of Assumptions 1 through 6 are sufficient to characterize the equilibrium. We can further add an additional assumption for $E[U|\sigma_i = T, \sigma_j = B] < 0$ to cover all cases of voting by the organization and to cover the scenario where agent 1 receives a signal of $\sigma_1 = T$ and agent 2 acquires signal but receives $\sigma_2 = B$. This additional assumption implies that agent 1 would not pursue the deal on her own, but this assumption is not necessary for the model or its empirical predictions. Combined with the original assumptions on the parameters in the model setup, we can identify the parameter space for which the model holds; the derivation of the parameter space is presented in Appendix A.2.

2.5 Theorems

This stylized model shows that the information aggregation benefits of voting in a committee can be offset by including endogenous individual costly information acquisition since uninformed agents continue to vote. Our voting rule and expected utility conditions leads us to Theorem 1 and Theorem 2, and their full proofs are presented in Appendix A.3 and Appendix A.4 respectively.

Theorem 1 $\exists \widehat{c} > 0$ *s.t.*
a) If $c > \widehat{c}$, the Nash equilibrium has agents 2 and 3 not acquire signals.
b) If $c < \widehat{c}$, the Nash equilibrium has agent 2 (or 3) acquire the signal.

$\widehat{c}$ is the acceptable threshold for each individual partner of the cost of acquisition of the private information. When the cost of individual information acquisition is high, then the other agents without the endowed private signal are not incentivized to acquire the private information. When the cost of individual information acquisition is low, then one of the other agents will acquire the tacit information. Agents 2 and 3 simultaneously decide whether to acquire a private signal at cost c. Once any signals have been acquired, the three agents vote. While it is not directly revealed whether agent 2 and/or 3 are informed, the sourcing agent does knows whether the other non-sourcing agents are informed, because she is aware of the parameters forming the cost of information acquisition.

Under Theorem 1a, the VC does not fund the investment, and the angel investor will fund it if $\sigma_1 = T$. Under Theorem 1b, the VC funds it when $\sigma_2 \in \{G, T\}$, and then angel investor does not fund it.

The voting rule forms a symmetric Bayes-Nash equilibrium. For these equilibira, the voting rule is optimal and the agents vote sincerely (Austen-Smith and Banks, 1996; Persico, 2004), and the proof of the voting rule optimality is presented in Appendix A.5.

Theorem 2 $\nexists$ *an equilibrium in which both agents 2 and 3 acquire the private signal.*

Informally, there is no equilibrium where both agents 2 and 3 acquire the private signal because you only need as many informed agents as there are votes needed to reach the predetermined voting threshold. This particular theorem has no implications for our empirical study, but it is a matter of theoretical interest.

2.6 Empirical Hypotheses

Focusing on the critical threshold $\widehat{c}$ for the cost of acquiring information, we produce three testable empirical hypotheses.

First, we look at how $\widehat{c}$ changes relative to different levels of the public information π. We analytically show in Appendix A.6 that the comparative statics of $\widehat{c}$ imply

$$\frac{d\widehat{c}}{d\pi} > 0$$

For larger π, there is a higher acceptable cost threshold $\hat{c}$. In other words, the acceptable cost of acquiring the private signal is increasing in the public information, or the baseline probability of a profitable investment. It is thus more likely that agents 2 or 3 will acquire the private signal and thus make it more probable that they would vote for the possible project. If we take the public signal representing explicit information to be characteristics observable to the econometrician, this result leads to the following hypothesis.

Hypothesis 1 *Projects funded by an angel investor will have lower π than projects funded by the VC. They will on average appear worse on observable characteristics of the startup firm and its founding team.*

Observable characteristics include types of information that can be easily and credibly transferred between parties.[12] In our setting, we will interpret that as easily observable characteristics of the startup firm and its founding team, such as the pedigree of the founders and the age of the firm.

Second, consider the relationship between c and $\widehat{c}$. Recall that if the cost c exceeds $\widehat{c}$, then none of the non-sourcing agents engage in costly information acquisition. In that case, the organization is certain to reject the project. When instead the cost of a signal is less than $\widehat{c}$, then it is still possible that the project may be funded.

Hypothesis 2 *Projects funded by an angel investor will have higher c than projects funded by the VC. They will on average have a higher cost of information acquisition, as measured by geographic distance between the VC and startup.*

As noted before, tacit information is more costly (harder) to acquire than explicit information since it requires experiential contact between the investor and entrepreneur. We will use geographic

[12] In the finance literature, this might be thought of as "hard" information, which is generally taken to mean quantitative type information (Petersen, 2004).

distance between the investor and the entrepreneur as a proxy for the cost of information acquisition because information about potential investment opportunities generally circulates more within proximate geographic spaces (Sorenson and Stuart, 2001) and the cost of travel has an effect on the information exchange between an investor and the entrepreneur (Bernstein et al., 2016a). There is extensive work in the innovation (e.g. Alcácer and Chung, 2007), teams (e.g. Clark and Wheelwright, 1992) and multinational (e.g. Ahearne et al., 2004) literature showing that distance increases the cost of information exchange. In our setting, the other partners of the VC organization will be less likely to acquire costly tacit information since it is more costly for the non-sourcing agents to visit the physical office and meet the full team of the venture, which only the sourcing agent would have already. Thus, they would be less likely to be informed and then less likely to invest as suggested by the model.[13]

Figure 2 presents the the implication of the public signal content and information cost for investment vehicle outcome as discussed in Hypothesis 1 and Hypothesis 2. For $\hat{c}(\pi)$ where $\frac{d\widehat{c}}{d\pi} > 0$, there is an equivalent relation $\hat{\pi}^{-1}(c)$. If $\pi > \hat{\pi}^{-1}$ then the VC invests. If $\pi < \hat{\pi}^{-1}$, then the angel investor invests.

——————Insert Figure 2——————

Third, the comparative statics presented in Appendix A.6 also produce the result that

$$\frac{d\widehat{c}}{dq} > 0$$

For larger q, there is a higher acceptable cost threshold $\hat{c}$. In other words, the acceptable cost of acquiring the private signal is increasing in the information content of the private signal. It is thus more likely that agents 2 or 3 will acquire the private signal if the private signal is more informative.

Hypothesis 3 *Projects funded by an angel investor will have lower q than projects funded by the VC. There will be less information content in the private signal in investments done by the angel relative to those done by the VC, as measured by the VC's investment experience in that category.*

This result should be fairly intuitive, but unfortunately it is difficult to test in the data, since there is no clear empirical measure for a private signal, which is presumably private to the researcher.[14] Empirically, we use a proxy variable of the employing VC firm's experience in a given category (business model, technology method, or technology platform). Since tacit knowledge, represented by the private signal, is developed through experience (e.g. Lam, 2000), then it will be more informative for the other non-sourcing agents of the firm to evaluate the deal if they are already experienced in that category. For example, imagine an investor evaluating a deal in the business model category of Software as a Service (SaaS). There are specialized aspects to evaluating that type of business that are developed experientially, such as predicting the product-market

[13] There are also a number of cognitive and behavioral measures that may drive up the cost of information acquisition that we cannot currently empirically measure.

[14] Tacit to the partners is still tacit to the econometrician!

fit, knowing the optimal management style, and understanding key performance indicators[15] (e.g. annual recurring revenue, bookings, churn). These are all things that would be developed and honed through practical experience working with and investing in SaaS businesses, and thus tacit information would be more informative when an agent evaluates a future deal in the space.[16]

These are the three main hypotheses we will test empirically. We make no predictions about the distribution of financial performance between the angel investor and their employing VC, but we document performance metrics as a matter of empirical interest.

3 Organizational Forms in Entrepreneurial Finance

We focus our study on two organizational forms tailored to entrepreneurial finance, venture capital and individual angel investors.

3.1 Venture Capital Firms

Venture capital (VC) is a subset of private equity that originated in the 20$^{\text{th}}$ century designed to provide financing, usually equity financing, to early stage, high potential startup businesses. There is an extensive literature on the subject spanning the last three decades (e.g. MacMillan et al., 1986; Sahlman, 1990; Bygrave and Timmons, 1992; Hsu, 2004). Like private equity more broadly, venture capital firms in the United States are a financial intermediary most commonly structured as a *general partnership*[17] composed of *general partners* who are of utmost important to the performance of the VC firm: Ewens and Rhodes-Kropf (2015) argue that the partners' human capital is two to five times more important than the VC firm's organizational capital. *Limited partners*, such as public pension funds and family offices, invest in discrete funds with a limited lifespan before the money is returned to the outside investors. The general partners have complete control over the day to day management of the limited partner fund. The general partners are paid through a *management fee*, a set proportion of the funds under management, and the *carry*, a percent of the profits, which are conventionally set at 2% and 20% respectively. In addition, the general partners have their own capital invested in the fund, usually representing around 1% of the fund.

As a result of the partnership system, VC firms have relatively flat structures in which final investment decisions are made jointly by the partners while deal sourcing duties are divided among the individual partners. VC firms are small, with small numbers of partners and support staff. Some subset of the partners, if not all of them, are investment partners individually responsible for

[15] The reason that the key performance indicators for SaaS would not necessarily fall into costless information in the public signal is that the metrics are not actually true financial metrics (revenue, profit), but are meant to be taken as a whole and interpreted qualitatively.

[16] A primary endogeneity issue with this proxy is that if a VC firm is experienced in a given category, then they would also be more prepared to add value to the investment ex post via mentoring and advising. This effect would bias the results towards more venture capital investments and away from angel investments.

[17] By the time of the internet boom of the 2000s, nearly all U.S. domestic venture capital firms were structured as general partnerships.

contributing to the firm's deal flow by finding and bringing in possible investment opportunities. The partners are assisted by more junior associates in larger firms, but a deal coming into the firm is generally associated with a particular partner. The partners source potential deals in a variety of ways, including introductions from their personal networks (Hallen, 2008; Rider, 2012), open solicitations, and public news (Hoyt et al., 2012; Shane and Cable, 2002). From the set of all investment opportunities she sees, the partner then pre-screens for the highest quality investments based upon her due diligence to select the set she would like to bring up for consideration by the full partnership. The sourcing partner invites the entrepreneur to present to the firm at the regularly occurring partnership meeting, which customarily occurs on Mondays. The sourcing partner will also share her information with the rest of the firm and argue in favor of the investment. Since the perceived quality of the deal has career and financial implications for the sourcing partner, the sourcing partner will normally speak in favor of the potential deal as she will get pecuniary and reputational credit for it if the investment turns out to be a good one; on the other hand, since the other partners know that the individual partner will benefit from having her own deals executed, there may be some discounting of the partner's information, and the other partners will have to acquire their own information to make a fully informed judgment.

The partners then jointly make a decision on whether or not to act on the investment opportunity. The decision is generally made in a mostly non-hierarchically committee. The final decision-making process resembles a voting process in nearly all cases. We confirm and document the existence and role of this group decision-making stage through semi-structured interviews conducted with employees of 19 venture capital firms; a limited discussion of these interviews is presented in Appendix B.1. The partners may vote against the potential deal if their beliefs differ from those of the sponsoring partner, who clearly believed the deal had merit.

If the VC investment is made, the sourcing partner will take a board seat or advisory role in the startup, where they will presumably add value to their investments through official channels such as board membership or unofficially through mentorship and advice, with the eventual goal of bringing the investment to an exit opportunity, namely an acquisition (M&A) or initial public offering (IPO) event.

3.2 Angel Investors

At the other end of the spectrum of organizational sophistication in entrepreneurial finance, there are individual investors, known as angels. There is a growing but relatively limited academic literature focusing on the performance of this form of financing.[18] Angel investors take on all the roles of the venture capitalist, including deal sourcing, pre-screening, evaluation, and then the final decision, all rolled up into one person. These angel investors are generally affluent, as they must be

[18] For example, Kerr et al. (2014) find in a discontinuity analysis that ventures backed by angels in syndicates have improved survival, exits, employment, patenting, Web traffic, and financing than those not backed. Hellmann and Thiele (2014) study the interaction between angel and venture capital markets. Goldfarb et al. (2013) find that deals with more angel investors have weaker cash flow and control rights, and experience longer times to resolution than those with VC investors.

accredited by the securities commission of their home country: in the United States, an accredited investor must have a net worth of at least $1 million, not including the value of their primary residence, or they can have an income over $200,000 each year for the last two years (in other words, they have to have enough money such that they can afford to lose their money on their risky investments). Angels generally make equity or convertible debt investments, just like venture capitalists. Angel investors come from various backgrounds: many are current and former executives and entrepreneurs, while a smaller subset are pure full-time angel investors. Since angel investors use their own funds to make investments, they have less access to capital than a venture capital firm and make smaller investments; smaller investments happen earlier in a startup's lifecycle, so they often invest earlier than VCs (Lerner, 1998).[19]

In this paper, we focus on a particular kind of angel investor: partners of venture capital firms. We refer to these individual investors as *angel partners*. By focusing on this subset of angel investors, we get around one of the empirical challenges with studying angel investors: angel investors in general are highly heterogenous along the dimensions of skill, background, and personal motivation, and angel partners are more homogenous. There are substantial differences between the partners of venture capital firms and angel investors with other backgrounds. First, angel partners presumably still have access to the skills and professional network that they use while employed as a full-time venture capitalist. These skills can include deal evaluation (e.g. more experience looking at startups), deal execution (e.g. familiarity and access to the legal documents used by their employing firm), and post-deal value add (e.g. hiring support). Second, they see a lot more possible deals than a part-time angel investor, as they are compensated to look at deals full time. Thus, they have a larger pool of deals to choose from, even conditional on some of those deals going to their employer. Third, given their full-time employment in financial services, many of these angel partners are of ultra-high net worth and can make larger angel investments approximating a smaller venture investment in the seed, series A, or series B rounds.[20]

The partners of venture capital firms are more sophisticated than the average angel investor on nearly all dimensions and comparable in process and performance to a venture capital firm. In Figure 3, we provide basic descriptive information generated from the Crunchbase data about that difference. VC affiliated angels, as compared to non-VC affiliated angels, make more investments, make larger investments, and participate in later funding rounds, but participate in similarly sized investment syndicates. In other words, angel partners make investments closer to and in the territory of venture capital firms.

[19]The term "angel round" has entered the parlance and is used to mean what might also be referred to as a seed round, which happens before a series A round. However, this terminology does not mean that angel investors do not participate in venture rounds, and they may also make venture sized investments.

[20]Since an angel partner is likely wealthier than the average angel, she is also more capable of defending her fractional ownership share of the startup by using a contractual *pro rata* right to invest more funds in the next round of financing to maintain her original proportion of ownership.

4 Empirical Setting: Angel Investments by Venture Capital Partners

C. Richard "Dick" Kramlich founded the venture capital firm New Enterprise Associates (NEA) in 1978 after leaving Arthur Rock and Co., where he began his career. An entrepreneur named Rob Campbell sought additional venture funds for his computer software company, Forethought, Inc, which developed a new program called Presenter which generated text and graphics for overhead transparencies. A variety of issues troubled the company: the engineering on its product was delayed, its largest distributor went into Chapter 7 bankruptcy, and it was running out of investment money fast. Campbell approached NEA for additional funds. The partners of NEA disagreed on whether to invest in Forethought—they were concerned about the problems plaguing the company, and they did not like Campbell much either—and they ultimately decided not to invest. Dick wasn't ready to let it go so easily. He believed there was something special about the firm and its product, beyond what the current observable state of the firm would suggest. He asked his partners if he could pursue the investment on his own, with his own money. Since the investment was not in conflict with anything in the existing portfolio, they gave him the go ahead. He called his wife and said, "Pam, stop work on the house. I'm going to fund this company myself."

The company survived. In April 1987, they renamed their main product "PowerPoint". Just four months later, Microsoft acquired ForeThought for $14m USD cash (1987 value), a lucrative exit for everyone involved. Microsoft eventually integrated PowerPoint into its Office suite of desktop applications, and the rest is history (Goldfine and Geller, 2011).

4.1 Conditions on Angel Investments by Partners

The identification of individual vs. group investment decisions comes from the phenomenon of venture capital firm partners and other employees who also make angel investments on the side with their own funds. As a requirement of employment with the venture capital firm, the partners have a fiduciary duty to the venture capital firm first. In legal terms, the partners owe a *duty of loyalty* to the partnership, and this duty requires all partners to disclose any potential opportunity that the partnership entity would potentially be interested in taking. They then have to wait until the partnership passes on the opportunity before they can personally engage on it.

Accordingly, the venture capital firm must always have right of first refusal on any possible deal, and the employee can only invest in deals that the firm would not do. In addition, the deal cannot be in conflict (i.e. competing) with any current investments already in the venture capital firm's portfolio and any probable future firm investments. We should also note that not all venture capital firms allow their partners to make outside investments of their own,[21] so we do not include the universe of venture capital firms. We only study venture capital firms that have partners who make angel investments, which still represents a substantive proportion of venture capital firms.

We can observe investments made by the venture capital firm and those rejected by the venture

[21] Bill Bowes at US Venture Partners has stated that they do not allow this (Goldfine and Geller, 2011).

capital firm and invested in by its partners through an angel investment. This empirical strategy partially addresses the risk set problem facing empirical work in venture capital: we normally cannot know what investments were rejected by the venture capital firm, and now we can observe at least a portion of them. As noted before, since there is so much heterogeneity among the general category angel investors, the sample gives us a better composed set of angel investors, who are skilled and have access to the same information and resources as VCs, and can be then directly compared to venture capital firms.

Our study still faces the two-sided matching challenges in much of the literature: we cannot officially discern whether the entrepreneur had any choice in whether to take the partner's personal angel investment or the VC firm's, but it is assumed that the entrepreneur would have to take the venture capital investment if offered, because the partner is not allowed to make a competing angel investment cross-bid.

4.2 Alternative Scenarios

There are plausible alternative stories for the partner angel investments phenomenon that do not represent substantive challenges to the scope of implications for the present project.

Information Withholding. Partners could theoretically withhold information on potential deals from their firm. In the most extreme case, the partner may withhold and hide potential investments from their employing firm or in a lesser form, she may intentionally undersell the quality of a deal if there is a certain "home run" investment opportunity and the partner wants to fully capitalize on the gains. If the investment opportunity is withheld, the venture capital firm does not have a chance to consider the investment, but our interviews with venture capital partners suggest this is highly unlikely. A partner acting otherwise would face the consequences of legal action by the firm and its limited partners (outside investors). Beyond direct legal consequences, there would be significant reputational costs that translate directly into future financial costs in an industry based heavily on network connections and syndication activity. The network of investors and entrepreneurs is fairly small and geographically concentrated, and secrecy would be difficult to maintain; additionally, the sample we study is only of publicly known investment events. While there is a possibility of incentive compatibility issues, both the formal legal barriers and reputational costs of hiding possible investments suggest it is highly unlikely and would not be a dominating factor driving the observed phenomenon.

In a weaker version of the withholding story, a partner may disclose but intentionally undersell the quality of an investment so that the VC firm will then pass on it and the partner can capture it for herself. We cannot empirically rule out this possibility, but this story is still consistent with the theory we have proposed in Section II. A partner that is underselling the quality of a deal does so by making the available public signal π artificially low by failing to disclose relevant explicit information to her partners. Hypothesis 1 states that a potential investment with lower π is more likely to be passed on by the VC firm and then be taken up by an angel partner.

Return Proportionality. Our theoretical model is agnostic to return proportionality: if a partner takes a deal on their own, then they stand to have more exposure to both the upside and downside of a potential deal since they capitalized on all the returns and not just the carry compensation from their VC firm. This proportionality does not change the sign of the risk-adjusted net present value of a possible investment. However, one could make an argument about the differential need for risk-return levels in a VC vs. an individual. For example, the VC firm may seek high-risk high-return type investments, while angels can live with low-risk low-return type investments. The empirical results presented in Section VII do not support this story, as the angel partners invest in deals that are observably weaker, and presumably riskier.

Anticipated VC Decision. In another case, the partner may fail to bring a potential investment to their employing firm if she does not believe that the firm will act on the potential investment. The partner may have prior information that suggests to her that the venture partners will likely vote no regardless and that bringing the investment up to a vote would be a waste of time and reflect poorly on her sourcing skills. For example, the VC firm may have an *investment thesis*[22] proscribing a number of target investment characteristics for the VC firm in terms of investment size, investment stage, industry, geography, and management team profiles.

In practice, the investment thesis is non-binding for the firm,[23] but let us assume for the sake of argument that the partner correctly assumes that the venture capital firm would not act on the investment based on the existing VC investment thesis.

In the context of our theoretical model, this circumstance would not affect the mechanisms of the model and its accompanying empirical predictions. For example, if the investment does not fit the industry or management team scope stated in the investment thesis, we could conceptualize the partners as sharing a low public signal, and the partners would not expend the cost of private information to make the deal happen. As another example, deals that are "too small" for the VC investment thesis, i.e. need only a small amount of capital, may not merit a full discussion by the firm and would be passed upon immediately as being not capital efficient by the firm. The possible profit from the small deal is small and would not justify the component of cognitive and financial cost of conducting due diligence on a deal (the cost of acquiring the private signal) that is invariant to deal size.

Regardless, it is more empirically interesting to compare deals that are clearly within the purview of the venture capital firm and the angel investor. We introduce a number of industry, investment size, and round characteristics to control for this, and we also estimate a matching

[22]The *investment thesis* is a formal or informal statement that represents the firm's ex ante plan about the types of businesses they want to invest in, based upon what the partners believe to be the best path towards reaching the ideal level of risk and return for their portfolio.

[23]An investment thesis is generally not legally binding, either to the general partnership entity or to any of its limited partnership funds. Thus, the VC firm can freely invest outside of the bounds of the thesis, and the majority of firms will do so. For example, Union Square Ventures's investment thesis states that they seek to invest in "large networks of engaged users, differentiated through user experience, and defensible through network effects," as described on the Union Square Ventures company page in 2016. They have invested in a number of startups that are only peripherally related or unrelated to that thesis, including enterprise drones and financial technology. The investment thesis is based only upon the information known to the firm when the thesis is written, and it represents an aspirational goal—and indeed the majority of the portfolio is related to the stated thesis–but it is by no means a requirement for venture capital firms.

model that directly addresses this issue.

5 Data

5.1 Sample Construction

The main dataset is constructed from the universe of venture capital and angel investment rounds from January 1st, 2005 to December 31st, 2013, as identified in CrunchBase (e.g. Block and Sandner, 2009; Alexy et al., 2012; Wal et al., 2016; Howell, 2016). This set contains firms founded before and during the observation window, as long as they raised a round in our observation window. CrunchBase is a database of startup firms and affiliated people (employees, board members, etc.), financial organizations, and service providers. The database is operated by TechCrunch, a news website and AOL Inc. subsidiary focused on firms in the information technology sector; accordingly, the data oversamples firms in the IT sector relative to biotechnology and other industries. Much of the data, particularly on investment events, is entered by TechCrunch staff based upon their own reporting and SEC Form D filings. A large component of the data is *crowdsourced*: registered members of the public may make submissions to the database which are then reviewed individually by moderators working for TechCrunch. During this study, CrunchBase is also synced up with AngelList, a website for matching between startups and angel investors, giving us additional coverage of angel investments.

CrunchBase has superior coverage of angel investment events relative to the more traditional venture capital database of VentureXpert/Venture Economics (now part of ThomsonOne) used in much of the earlier venture capital literature (e.g. Bygrave, 1988; Gompers and Lerner, 2004). To check the coverage of CrunchBase data, Block and Sandner (2009) compared a sample of CrunchBase data with statistics published by the National Venture Capital Association (NVCA), and they find that the number of investment events in the CrunchBase data accounts for about 97% of the Internet-related deals as reported by NVCA (amounting to about 21% of all VC deals).

We identified all individual angel investors whose primary occupation is in a financial organization that has made an investment into a startup in our sample. We include investors even if they were employed at their financial organization for only a portion of our observation period, but this represents only a minimal portion of the sample. We only retain firms that were identified as either a venture capital, private equity, or angel stage investment firm, but we refer to these collectively as venture capital. The final full sample consists of 879 unique individuals making investments out of 726 venture capital organizations into 8342 different startups. We construct the data at the investment-level, so each observation represents an investment by either the VC or the angel partner. Additional details about the construction of the sample are available in Appendix C.1.

5.2 Entrepreneurial Venture: Observable Characteristics

To study the distribution of observable characteristics that make up the public signal in our theoretical model and thus test Hypothesis 1, we construct a number of entrepreneurial firm characteristics at the time of the investment event, primarily based upon characteristics of the founding team. The age of the startup at the funding round is taken as the number of days between the founding date and the investment round; a younger age is considered riskier because there is less of an explicit financial track record to evaluate the startup on. To identify the founding team, we identify individuals formally associated with the startup and who have listed themselves as a founder in their job title. Firms in about half our sample, for both venture capital investments and partner investments, disclose this information. For each founding team member, we build educational characteristics using CrunchBase profiles supplemented with public LinkedIn information to identify whether they have an MBA, a PhD, a regular masters degree, and if they attended an "elite" institution,[24] and whether or not they studied engineering. We then aggregate this to the firm level by identifying whether or not the founding team has at least one founder with a given educational characteristic and averaging the number of founders with a given education characteristic. We construct a measure of founder age by averaging over the imputed age of the founders.[25] We also study whether any of the founders have prior entrepreneurial experience and measure the count of previous startups the founding team established that received any equity financing.[26]

5.3 Entrepreneurial Venture: Financial Performance

While we make no predictions about financial performance, differences in financial performance of investments by angel investors vs. venture capital firms is certainly of empirical interest and included for such reason. We construct a number of outcome variables to evaluate investment performance as commonly used in the entrepreneurial finance literature. We use future funding rounds as a proxy for firm survival, with measures of whether or not the firm achieves any future funding rounds and the count of future funding rounds. We gauge financial performance with dichotomous variables on the achievement of a merger and acquisition (M&A) event or an initial public offering (IPO). We also have exit valuations for all firms which underwent an IPO and for some of the firms undergoing an acquisition, i.e. for any case where the final exit valuation was publicly reported.

5.4 Controls

There are a number of controls and matching criteria that need to be implemented. First, angel investors tend to make smaller investments than venture capital firms, due primarily to liquidity constraints (the individual partner has less access to capital than his employing venture capital firm which has raised money from outside limited partners) but also due to both risk aversion

[24] We identify "elite" educational institutions as those in the top 25 US national universities and the remaining top 25 non-US universities that were not in the US list, as defined by US News & World Report in 2015.

[25] Ages are assigned by assuming the founder is a certain age at the graduation year of the lowest degree they list. We assume a founder is the following age at graduation: high school is 18, bachelors degree is 22, master degree is 24, JD is 25, MD is 26, PhD is 27, and MBA is 30. All ages are calculated for the year 2010, which is acceptable because we include year fixed effects in all empirical models.

[26] We have limited data on the founding team characteristics, with data for about half the sample. We also include founding team size as a placebo test. A test of missing data on founding team characteristics is presented in Appendix C.3.

(an individual angel investor faces full exposure to the loss). For a given amount of funds raised, a round composed of only angels tends to have more participants in the syndicate than a round composed only of venture capital investors. Thus, we need to control for the size of the investment being made and the number of participants in the round. Unfortunately, the size of the investment of each participant in a syndicate is not available for most observations: we accordingly control for the size of the total round as a proxy for the size of the individual investment. Second, angel investors traditionally make investments into earlier stages of the venture lifecycle, so we introduce round fixed effects controlling for the particular stage of financing (seed, series A, series B, etc.). Third, we would like to broadly control for across-industry heterogeneity, so we classify each firm into a two digit North American Industry Classification System (NAICS) and introduce industry fixed effects. Fourth, venture capital activity tends to follow the business cycle (e.g. Gompers et al., 2008), so we introduce year fixed effects.

5.5 Information Acquisition Cost: Geographic Distance

In a test of Hypothesis 2, we measure the cost of information acquisition using the geographic distance between investments and their investors. We calculate geographic distance between venture capital firms and their investments by calculating the geodesic distance in kilometers between the two, i.e. the length of the shortest curve between two points along the surface of a mathematical model of the earth (Vincenty, 1975). Addresses of the venture capital firms and startups were collected from CrunchBase and their public facing websites. For the majority of firms, we only have either their zip code or their city, state, and country available: we assume they are located at the geographic center of the most specific address we have. Since at the within city level, our locations are only approximate, we left-censor distances less than 1 km to 1 km. In the case of firms that have multiple offices, we took the distance between the two closest offices, on the assumption that the closest offices are likely the ones interacting. In our analysis, we take the natural logarithm of the distance since the baseline distance measures are heavily skewed, and the resulting logged distance distribution is substantially closer to normal.

5.6 Tacit Information: VC Experience

To measure the information content of the other VC partner's private (tacit) information and test Hypothesis 3, we take the experience of the venture capital firm in specific categories. On CrunchBase, each startup can self-designate itself into a number of keywords. We then focus on keywords placed into broad two digit NAICS codes which contain software, internet, and information technology firms. Each of these self-descriptive keywords were classified into categories by business model, technology method, and technology platform. The categorizations are not mutually exclusive: a firm can fit into multiple categories if they list keywords that fit into multiple categories, but each keyword is filled into an exclusive category. Additional details about this categorization are in Appendix C.2.

For a given VC-venture or angel partner-venture investment round, an experience measure is constructed for the investing or employing VC by taking the count of investments executed by the VC prior to the date of the focal investment round in the category of the startup that is receiving investment. For ventures that fall into more than one category, we take the value of the category for which the VC has the most experience.[27]

5.7 Descriptive Statistics

Descriptive statistics for investment level data are presented in Table 1. We have a much larger sample of investments by the venture capital firms than we do for angel investments by their partners. Not unexpectedly, venture capital firms are on average making larger investments in older firms, at an average round size of $13.17 million and firm age of 1193 days while the angel partners invest at an average round size of $4.04 million and firm age of 569 days. However, the difference in the round number is smaller than expected: angel partners invest in an average round of 1.40 and the VC firms invest at an average round of 1.53. This difference is small for a couple reasons. First, the nature of the startup firm lifecycle is that there is a high death rate from round to round, so there are compositionally many more early round investments than later round investments by the VCs. Second, there are many venture capital firms that only do early stage investments, and these are usually the smaller VC firms which actually represent most of the sample of VCs. Thus, the high average round size and later firm age for the VC investments is driven by the presence of relatively few outlier large and late stage investments made by the VCs, which the angel partners cannot execute because they lack the financial capital to do so.

——————Insert Table 1——————

6 Empirical Strategy

In the following empirical models, we document the compositional differences between angel investments by VC partners and investments by their employing VC firm and provide evidence in support of the empirical hypotheses suggested by our theoretical model. The analysis is conducted at the investment-level, for investments i by the firm or affiliated partner j at time t. $Angel_{ijt}$ is an indicator for whether the investment was taken by the partner (1) or the firm (0). $\bar{X}_{ijt}$ represents a vector of controls for the size of the funding round and the count of the investors in the syndicate. α_j represents a fixed effect for the affiliated VC organization of the investment. δ_t represents a year fixed effect to control for the business cycle. ρ_i represents a round number fixed effect. τ_i represents an industry fixed effect, where industry is defined by the 2 digit NAICS code.

6.1 Main Model

To test Hypothesis 1 and to document differences in financial performance, we run an ordinary least squares (OLS) model with organization fixed effects and year fixed effects on the sample of

[27] Empirical results are robust to taking the average experience over multiple categories for when the venture falls into multiple categories, instead of the maximum.

investments we study. The organization fixed effects control for time-invariant effects common to the members of the venture capital organization and to the venture capital organization itself; the identification assumption being made here is that the angel investor and their parent organization share the same mean investment preferences and performance.[28] We can conceptualize that preference as skill to select investments that is now being controlled. We use robust standard errors clustered by VC organizational affiliation. This full sample is where we choose to test our moderators. β is the coefficient of interest showing the average compositional difference in the dependent variable DV_{ijt} between investments by a given VC and its angel partners, controlling for year, round, industry, round size, and syndicate size.

$$DV_{ijt} = \beta Angel_{ijt} + \gamma \bar{X}_{ijt} + \alpha_j + \delta_t + \rho_i + \tau_i + \epsilon_{ijt} \quad \text{(Main Model)}$$

We begin with the full set of angel investments by individual investors whose primary occupation is in a financial organization and the set of venture capital investments by the venture capital firms that employ these individuals.

6.2 Matching Model

To address possible confounding compositional differences between the angel partner and VC investments, such as differences in stage and industry, we introduce a matching model where we match each angel investment one-to-one with a venture capital investment made by their parent firm to further explore Hypothesis 1 and financial performance. Starting with the full sample of angel partner investments, we match each angel investment with the venture capital investment that is in the same 2 digit NAICS class and closest in total round size and then round date, with a maximum difference of \$1 million in round size. We drop angel investments that do not have a match: these are cases where the venture capital firm makes very large investments relative to the size of the angel investments made by their employees, which are general venture capital firms making mezzanine or growth equity investments, which are closer to what is generally classified as private equity. We run a similar investment-level OLS regression as the full sample, and we use robust standard errors clustered by VC organizational affiliation.

For investment i by matched pair $p \in P$ and at time t, we regress the dependent variable of interest on $Angel_{ipt}$ and the fixed effects and controls. Matched pair fixed effects can also be included, but it is unnecessary since the sample is balanced. Results are similar with the inclusion of matched pair fixed effects.

$$DV_{ipt} = \beta Angel_{ipt} + \gamma \bar{X}_{ipt} + \delta_t + \rho_i + \epsilon_{ipt} \quad \text{(Matching Model)}$$

The summary statistics for the matching model are presented in Table 2.

——————**Insert Table 2**——————

[28]This assumption may not universally hold if we believe that there is persistent heterogeneity in information access or skill by the partners, such as documented in Ewens and Rhodes-Kropf (2015).

Both the Main Model and the Matching Model analysis are meant to be descriptive and intended only to describe the compositional differences in characteristics and performance between venture capital investments and angel investments made their partners. By construction, the main independent variable of *Angel* is not causal in nature.

6.3 Geography Model

To test Hypothesis 2, we present a variation of the Main Model where the dependent variable is now whether the investment goes to the angel partner or stays within the VC, defined before as $Angel_{ijt}$. $\ln(D_{ij})$ represents the log distance (km) between the VC firm and the venture, and it is logged because the distances are heavily skewed and the log transformation makes it more appropriate for use in an OLS model. After preliminary tests, the non-monotonicity of the effect of geographic distance became obvious (see Figure 4 for a visual presentation), and accordingly a piecewise analysis of distance was deemed more informative. The pattern of non-monotonicity in spatial effects has been observed in a number of settings, such as patent citations (Alcácer and Gittelman, 2006). The effect is driven by the shape and distribution of economic activity in the United States; entrepreneurial activity and investment is highly agglomerated, particularly along specific portions of the east and west coast.

$D_{ij}^{[L,R)}$ is an indicator variable for whether the investment is between L kilometers and R kilometers away from the VC; indicators are created for the bounds $[100, 1000)$, $[1000, 10000)$, and $[10000, 100000)$. This model is still estimated in OLS clustered at the organizational level, but it is robust to other functional forms (probit and logit). These indicators are interacted with $\ln(D_{ij})$ to illustrate the effect of distance for each range of distance. The same controls and fixed effects as the Main Model are included.

$$
\begin{aligned}
Angel_{ijt} = &\beta_1 \ln(D_{ij}) + \beta_2 D_{ij}^{[100,1000)} + \beta_3 \ln(D_{ij})\, D_{ij}^{[100,1000)} \\
&+ \beta_4 D_{ij}^{[1000,10000)} + \beta_5 \ln(D_{ij})\, D_{ij}^{[1000,10000)} + \beta_6 D_{ij}^{[10000,100000)} + \beta_7 \ln(D_{ij})\, D_{ij}^{[1000,100000)} \\
&+ \gamma \bar{X}_{ijt} + \alpha_j + \delta_t + \rho_i + \tau_i + \epsilon_{ijt} \qquad \text{(Geography Model)}
\end{aligned}
$$

6.4 Category Experience Model

To test Hypothesis 3, we present a model similar to the Geography Model. $BusModel_{ijt}$, $TechMethod_{ijt}$, and $TechPlatform_{ijt}$ represent the experience of the parent VC in the category of the investment as described in the data section. The other controls and fixed effects are the same as in Geography Model, with the exclusion of the industry fixed effects ρ_i; the model is robust to the inclusion of industry fixed effects.

$$
\begin{aligned}
Angel_{ijt} = &\beta_1 BusModel_{ijt} + \beta_2 TechMethod_{ijt} + \beta_2 TechPlatform_{ijt} \\
&+ \gamma \bar{X}_{ijt} + \alpha_j + \delta_t + \rho_i + \epsilon_{ijt} \qquad \text{(Category Model)}
\end{aligned}
$$

We test this model with both the full sample and a sample only containing investments for which the affiliated venture capital firm has non-zero experience in the respective category, to address concerns about the bounds of an investment thesis.

7 Results

7.1 Hypothesis 1: Explicit Information

We find evidence in favor of Hypothesis 1. Table 3 and Table 4 present the results on the analysis on observable venture characteristics with the Main Model and Matching Model respectively. We focus here on the discussion of the results of the main specification, but similar results follow in all samples. Coefficient signs generally hold throughout the models, but statistical significance suffers as we lose power in some of the subsample based models (round 1 and 2, matching).

——————Insert Table 3——————

——————Insert Table 4——————

We find that individual partners invest in firms at a younger firm age controlling for round stage, ranging from 348 days younger than their parent VC firm in specification (2-1) and 129 days younger in specification (4-1). They invest in founding teams that are statistically indistinguishable in size, which we made no prior prediction about. The individual partners invest in founding teams that are significantly younger, 1.07 years younger in specification (2-4) to .90 years younger in specification (2-5); we do not find a significant coefficient in (4-2). The founders have less prior entrepreneurial experience, with .24 less firms founded that received venture investment in their history in specification (2-1); the results on entrepreneurial experience are robust across all specifications. Across the education metrics, the founding teams that the individual partners choose to invest in have less formal education: fewer founding teams have founders with graduate degrees, MBAs, PhDs, and training in engineering, although statistical significance varies across specifications. For example, the angel partners invest in founding teams that are 5.8 percentage points less likely to have any graduate degree in specification (2-13). We find no significant results on the analysis of graduation from elite ranked institutions. We find broad support for Hypothesis 1.

7.2 Hypothesis 2: Cost of Tacit Information Acquisition

Table 5 and Figure 4 show the results of our analysis of the effect of geographic distance on investment uptake between the partner and the firm, as a test of Hypothesis 2. Table 5 is estimated using the Geography Model. There is a stark non-linearity in the results. Up to about 1000km,[29] greater distance is associated with a higher probability of the investment being taken by the partner than the firm. After 1000km, more distance has a statistically insignificant effect. While further work has to be done to explore the consequences of this, one possibility is related to the limits of

[29] 1000 kilometers is about 621 miles. The distance between San Francisco, CA and Seattle, WA is 1095km (681 miles). The distance between Boston, MA and San Francisco, CA is 4350km (2703 miles).

forms of transportation. Up to 1000km, it is feasible that the partner would make a land-based trip via car or train to visit the potential investment, and as that distance increases and approaches 1000km, it is less likely that non-sourcing partners would come to visit that investment opportunity to acquire their own private signal. After 1000km, we would imagine that the partners would predominately fly to visit their investments, minimizing the cost in effort to acquire information. Moreover, beyond we might think that VC firms have a particular advantage over individual investors in structuring geographically disparate investments: for example, international investments face alternative legal and coordination barriers that the VC firm may have the resources to tackle.

——————Insert Table 5——————

——————Insert Figure 4——————

7.3 Hypothesis 3: Tacit Information

Table 6 and Figure 5 show the results of our analysis of VC experience, measured by a count of prior investments, in a particular business model, technology method, or technology platform as implemented by the startup, as a test of Hypothesis 3. Table 6 is estimated with the Category Model. Across all categorizations and specifications, the increased experience by the VC is associated with a greater likelihood that the investment would be picked up by the VC and not by the partner on her own. VCs with greater experience in a particular category likely have a more informative private signal across the partners to understand a new investment in the same category since they have already done so before. Specification (6-1) includes the full sample of firms that were categorized. One concern with the first specification is that the firm might have a pre-specified investment thesis stated to the limited partner outside investors that is contractually or implicitly binding and limits the scope of investments able to be executed by the firm. Specification (6-2) only looks at investments for which the VC has any experience in the category, and thus it is within the scope of any possible investment thesis.

——————Insert Table 6——————

——————Insert Figure 5——————

7.4 Venture Financial Performance

As a matter of general empirical interest, we present the results of the descriptive analysis of venture financial performance in Table 7 and Table 8 estimated with the Main Model and Matching Model respectively. Nevertheless, we find inconclusive results regarding the financial performance differences. In all specifications about future funding rounds (7-1 through 7-6, 8-1 through 8-2), we do not find evidence of statistically significant difference. In specifications (7-7) through (7-9), investments backed by the angel partner are around 3 percentage points more likely to reach an acquisition exit, but this effect does not appear in the matching model (8-3). In the main model, they are around .5 percentage points less likely to reach an IPO exit in specifications 7-10 through

7-12), but this effect does not appear in the matching model (8-4). It is difficult to directly compare the aggregate financial value of the acquisitions and IPOs together, and the limited data available on the exit valuations[30] creates some doubt around the specifications (7-16) through (7-18) and (8-6).

As a cautionary note, there are significant omitted variables that differentially affect investment performance between the angel partner and the employing VC. First, the angel partner may have received a different investment contract structure than their employing firm would have received, such as weaker cash flow and control rights (Goldfarb et al., 2013), impacting the performance of the startup firm. Second, post-investment value add through advising and monitoring can be contributed by both the VC firm (Hsu, 2004; Sørensen, 2007) and the angel (Kerr et al., 2014), but there is no data on the sign or the scale of the possible difference in these value add effects. Initial intuition suggests that VC organizations would likely be able to contribute a greater value add. The venture capital firm has a formal capability to advise and monitor the investment: many VC firms maintain a number of resources, including formal contact lists (the "Rolodex"), executive and technology recruiting staff, legal support, as well as known reputations that signal the quality of the venture. For example, First Round Capital, based in Philadelphia, maintains an internal database of advisers and potential executive and technical hires for use by its portfolio companies. However, the individual partners of the venture capital firm may have access to many of the same resources that the firm itself would have, particularly those like their professional network, the use of which can't be constrained by the firm.

Thus, the implications of the financial performance differences between individual vs. VC investments documented in this analysis are limited in scope. However, if the venture capital investments do not clearly outperform the angel partner investments, coupled with the assumption that the VC organization has more ability to add value to the investment than an individual angel partner, then the angel partner investments may reflect compositionally ex ante stronger investments in the presence of analysis suggesting they are similar, but evidence for this is limited in the present research.

Insert Table 7

Insert Table 8

8 Conclusion

We study the role of information in organizational decision making for financing of entrepreneurial ventures. We formally model an organization of one or more agents who must make a dichotomous choice about whether or not to allocate resources to a particular project with an unknown outcome. The agents vote strategically and decide whether to acquire costly external

[30] There are small sample sizes on the exit valuation, because most M&A transactions do not disclose it and M&A transactions are by far the most common exit outcome.

information to improve their decision quality. We test our theoretical predictions in the setting of venture capital partnerships, where venture capital partners invest on their own outside of their employing firms. We find that the venture capital partners, acting independently, exhibit a number of different investment behaviors than their employing venture capital firm. They make investments into younger firms with less educated and younger founding teams, but these investments perform better on some metrics (future funding rounds, exit events) even when controlling for investment size and stage.

Our findings link to the broader literature of organization design, especially the core concepts of *incentive alignment* (e.g. Jensen and Meckling, 1976) and the *provision of information* (e.g. Schelling, 1980). In particular, it contributes to a growing literature on committee decision-making and information aggregation, which has long been overlooked by the organization design literature (Csaszar and Eggers, 2013), despite being one of the original but "forgotten pillars" (Gavetti et al., 2007) of the Carnegie tradition (Cyert and March, 1963). In a notable related work, Csaszar (2012) tests the predictions of the Sah and Stiglitz (1991) model of committee decision-making in a related setting, mutual fund managers, and he finds the organizational structure has significant effects on the rate of omission and commission errors in the setting of mutual fund stock picking.

Beyond decision-making and information, our work also fits thematically into the discussion on resource allocation in organizations. Leaders of organizations, whether they be a singular manager or a team of managers, must allocate resources to the most productive activities to maximize organizational performance (Baldwin and Clark, 1994; Bower, 1986; Cyert and March, 1963). This complex process involves the division, allocation, incentive alignment, and knowledge questions core to organizational design. An organization with a singular manager allocating resources can be thought of as *centralized*, while an organization with managers jointly allocating resources can be thought of as *decentralized* (Sah and Stiglitz, 1991). The venture capital partnership engages in a centralized decision-making process, while the angel partners acting independently could be thought of as engaging in a decentralized form of decision-making. The design choice between centralized and decentralized structures has tradeoffs for the organizations productivity, because they lead to different choices of resource allocation and thus different aggregate organizational performance.

Our theoretical model and empirical strategy can also lend itself to addressing the phenomenon of spin-outs, entrepreneurial ventures of ex-employees of large firms. There are competing theories explaining their origins. On one hand, agency models suggest an intrinsic conflict of interest between the employees and the firm as valuable discoveries arise that can be brought to market (e.g. Wiggins, 1995; Anton and Yao, 1995). On the other hand, incumbent firms may lack the organizational capabilities to recognize and take advantage of new opportunities (e.g. Christensen, 1993). Applying our findings to the setting of spin-outs, our work suggests that spin-outs can emerge even when incentives are aligned between the employee and the firm, as a consequence of the organizational form limiting access to information in the incumbent firm. In more recent work, Agarwal et al. (2004) find that spin-outs occur when incumbent firms lack both technological and market know-how. In other words, the organization is not structured to take advantage of new opportunities sourced by its employees. The resource allocation process may be set up such that the firm leaders lack the information or decision-making structure to recognize the opportunities in the first place. Any hierarchy involving teams must ultimately involve a decision-making process, leading to the age-old tension between individual vs. group decision-making which we study in a very specific setting.

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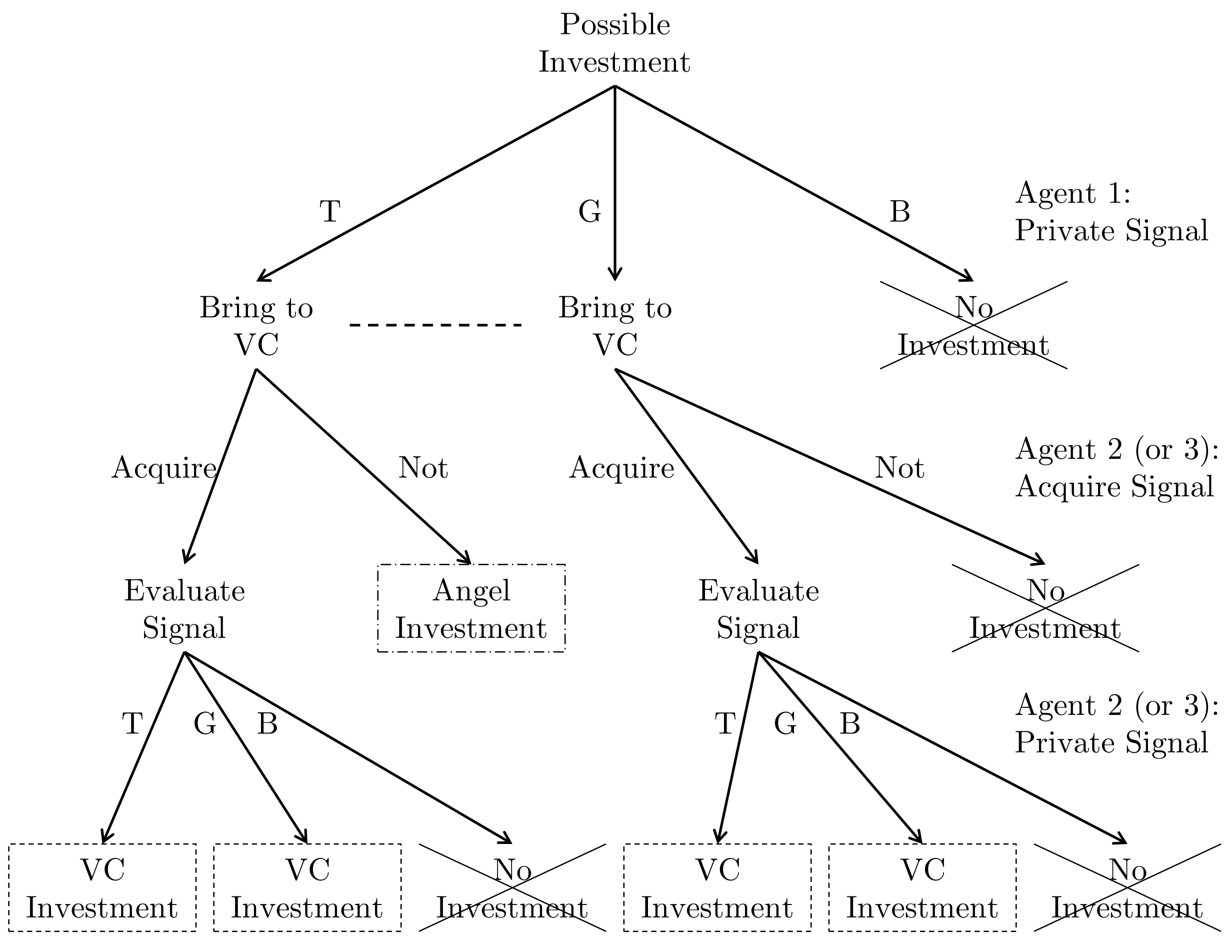

Figure 1: **Extensive Form Game**. This figure is the extensive form representation of the model in Section II. T (terrific), G (good), B (bad) represent the information content of the private signal known to the respective agent but not directly known to the other agents. The dashed line shows that the other agents would not be able to distinguish between whether Agent 1 had a T or G private signal. *Angel Investment* means that the agent would take the investment herself. *VC Investment* means the investment is retained by the firm. *No Investment* means both the VC firm and the individual agent reject the investment.

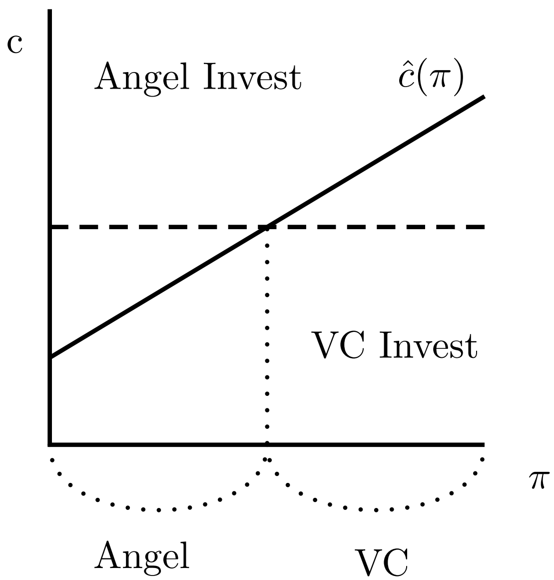

Figure 2: **VC vs. Angel Investment as Function of the Public Signal and Cost of Information**. This figure presents the implication of public signal π and information cost c on the investment vehicle outcome for the model in Section II. π presents the information content of the public signal, c represents the cost of information acquisition, and $\widehat{c}(\pi)$ represents the threshold cost function for an agent to acquire the private signal. An investment with π and c placing it above the solid line representing $\widehat{c}(\pi)$ would be taken up by the individual angel investor if she has a private signal of T, and if it is below the line then it would be taken up by the VC if another agent has a favorable signal G or T. The horizontal dotted line shows the outcomes for a given level of c.

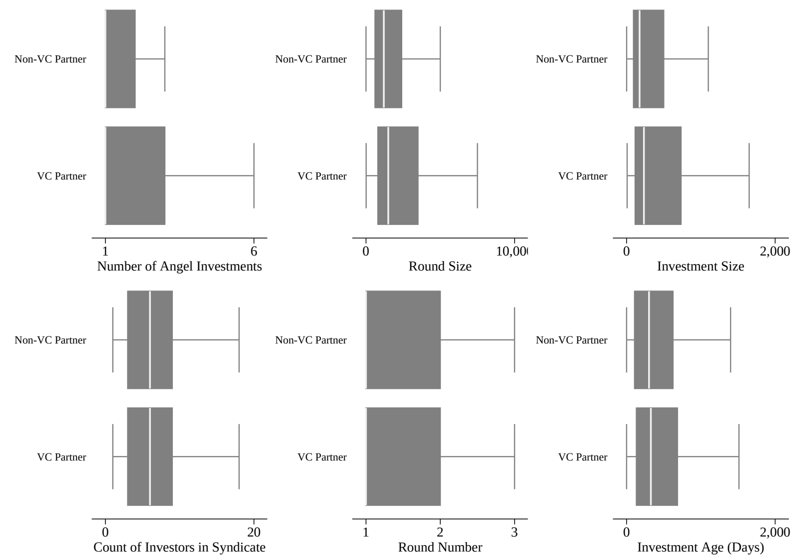

Figure 3: **VC Partner vs. Non-VC Affiliated Angels**. These box plots illustrate the compositional differences between angels who are full-time venture capital partners and not. The box itself represents the 25$^{\text{th}}$ and 75$^{\text{th}}$ percentile, the vertical white line is the median, and the adjacent lines represent $\frac{3}{2}$ times the inter-quartile range. Outliners beyond the adjacent lines were omitted for presentation. *Round Size* and *Investment Size* are in units of thousands of USD. The *Investment Size* was imputed by dividing the total size of the investment round for which an angel participated in by the number of investors in the syndicate. Only *Number of Angel Investments*, *Round Size*, and *Investment Size* have a statistically significant difference (at beyond the 0.1% level) and the others do not have a significant difference. Source: Crunchbase 2005 to 2013.

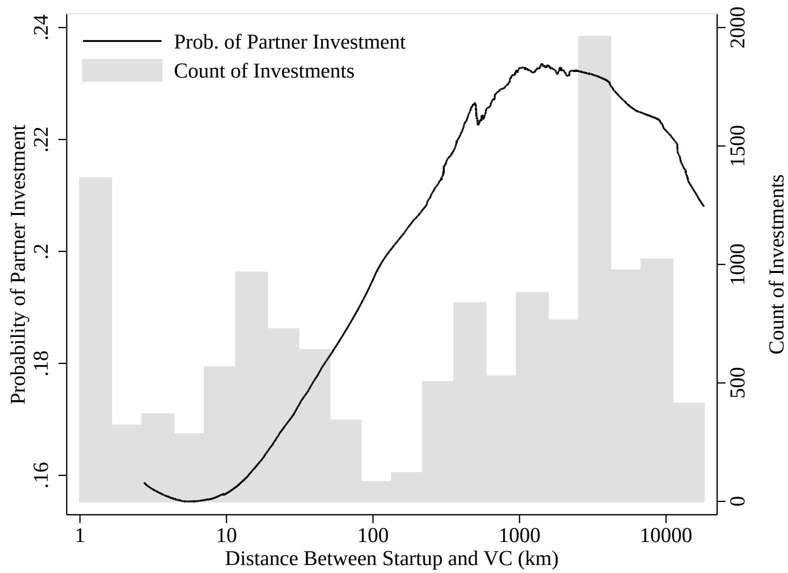

Figure 4: **Geographic Distance Between Venture and VC Offices**. This figure presents the relationship between geographic distance between the new venture and the offices of the venture capitalist and the investment vehicle outcome, in support of Hypothesis 2. The X-axis represents geodesic distance in kilometers between the main office of a startup and the closest office of the the VC making the investment or the employing VC of the angel partner who made the investment. Note that the X-axis is presented in a logarithmic scale. The left Y-axis and black line represents the probability that the investment is taken by an angel partner and not the employing VC. The right Y-axis and grey area represent a frequency histogram of investments at each distance. The figure was constructed with local linear smoothing (Cleveland, 1979). Source: Crunchbase 2005 to 2013.

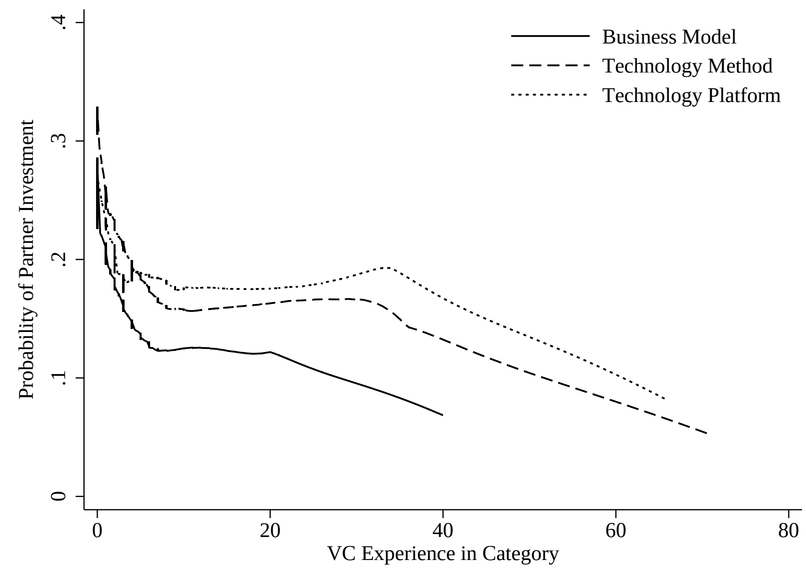

Figure 5: **VC Experience in Category**. This figure presents the relationship between a venture capital firm's experience in a category and the investment vehicle outcome, in support of Hypothesis 3. The X-axis represents the number of investments executed by the VC or the VC who employs the angel partner prior to the date of the investment in a given *Business Model*, *Technology Method*, or *Technology Platform* category. The Y-axis represents the probability that the investment is taken by an angel partner and not the employing VC. The figure was constructed with local linear smoothing (Cleveland, 1979). Source: Crunchbase 2005 to 2013.

Table 1: **Summary Statistics**. Summary statistics are presented for the partner angel investments and VC firm investments composing the full sample, grouped by: dependent variables for observable venture characteristics; dependent variables for venture financial performance; control variables; and independent variables used to measure geographic distance and category experience.

	Partner Angel Investments		**VC Firm Investments**		**Full Sample**		
	Mean	**S.D.**	**Mean**	**S.D.**	**Min**	**Max**	**Obs.**
Age at Funding Round (in Days)	569.35	2302.72	1192.96	1920.45	0	62212	15766
Size of Founding Team	2.70	1.54	2.63	1.70	1	18	13254
Average Age of Founders	33.25	7.38	35.86	8.32	20	75	6583
Max Prior Number of Firms Founded	0.94	1.45	1.13	1.57	0	14	7754
At Least One Founder with Graduate Degree	0.61	0.49	0.66	0.47	0	1	8487
At Least One Founder with MBA	0.38	0.48	0.41	0.49	0	1	8487
At Least One Founder with Ph.D.	0.08	0.26	0.11	0.31	0	1	8487
At Least One Founder with Elite Institution	0.59	0.49	0.59	0.49	0	1	8487
At Least One Founder with Engineering	0.18	0.38	0.22	0.42	0	1	8487
Future Funding Round	0.48	0.50	0.48	0.50	0	1	18227
Number of Future Funding Rounds	0.85	1.17	0.87	1.22	0	9	18227
Acquisition Exit	0.21	0.41	0.18	0.38	0	1	18227
Exit (IPO/M&A)	0.22	0.41	0.20	0.40	0	1	18227
Exit Valuation (MM USD)	657	6,086	1,505	10,210	0	104,200	1360
IPO Exit	0.00	0.07	0.02	0.13	0	1	18227
Round Size (MM USD)	4.04	13.70	13.17	35.55	0.01	1500	16467
Syndicate Size	6.84	4.95	3.91	3.06	1	27	18073
Round Number	1.40	0.74	1.53	0.95	1	11	18227
Round Year	2010.08	2.10	2009.40	2.49	2005	2013	20993
Distance (km)	2344.34	3231.57	2196.08	3208.96	0	18106.05	13662
VC Exp. in Business Model	0.32	1.76	0.79	2.86	0	40	17318
VC Exp. in Technology Method	1.31	3.61	2.41	4.94	0	71	17318
VC Exp. in Technology Platform	1.03	3.74	1.68	5.01	0	66	17318
Observations	5107		15897				

Table 2: **Summary Statistics: Matching Model**. This table presents the data used for the Matching Model. Starting with the full sample of angel partner investments, we match each angel investment with the venture capital investment that is in the same 2 digit NAICS class and closest in total round size and then round date, with a maximum of $1 million different in round size. We drop angel investments that do not have a match.

	Angel Partner Investment		**VC Firm Investment**	
	Mean	**SD**	**Mean**	**SD**
Age at Funding Round (in Days)	510.58	1943.77	678.93	1564.45
Size of Founding Team	2.71	1.47	2.75	1.61
Average Age of Founders	33.40	7.29	33.16	7.65
Max Prior Number of Firms Founded	0.94	1.30	1.01	1.49
At Least One Founder with Graduate Degree	0.58	0.49	0.62	0.49
At Least One Founder with MBA	0.37	0.48	0.39	0.49
At Least One Founder with Ph.D.	0.07	0.25	0.08	0.27
At Least One Founder with Elite Institution	0.59	0.49	0.63	0.48
At Least One Founder with Engineering	0.17	0.38	0.20	0.40
Future Funding Round	0.48	0.50	0.45	0.50
Number of Future Funding Rounds	0.83	1.11	0.73	1.06
Acquisition Exit	0.20	0.40	0.17	0.37
Exit (IPO/M&A)	0.20	0.40	0.17	0.38
Exit Valuation (MM USD)	393.22	1757.44	137.03	228.27
IPO Exit	0.00	0.05	0.00	0.05
Round Size (MM USD)	2.41	3.61	2.43	3.59
Syndicate Size	7.29	4.95	4.67	3.86
Round Number	1.41	0.74	1.43	0.70
Round Year	2009.89	1.94	2010.00	1.98
Observations	2458		2458	

Table 3: **Main Model: Venture Characteristics**. This table presents a descriptive multivariate analysis for Hypothesis 1 with various dependent variables for favorable observable venture characteristics, estimated with OLS. The first two models for each dependent variable are estimated with the full sample, and the third is estimated with the subsample of the first and second rounds of investment. Statistical significance is represented by $*p < 0.10$, $**\ p < 0.05$, and $***p < 0.01$. Robust standard errors clustered at the VC organizational level are shown in parentheses.

	Firm Age			**Founder Age**			**Team Size**		
	(2-1)	(2-2)	(2-3)	(2-4)	(2-5)	(2-6)	(2-7)	(2-8)	(2-9)
Angel Investor	-347.776***	-279.923***	-228.309***	-1.072***	-0.900***	-0.980***	-0.048	-0.076	-0.056
	(70.27)	(74.49)	(83.75)	(0.29)	(0.29)	(0.32)	(0.05)	(0.05)	(0.05)
Round Size	4.562***	4.033***	15.426***	0.047***	0.043***	0.070***	-0.002***	-0.001***	-0.002
	(1.08)	(1.01)	(1.99)	(0.01)	(0.01)	(0.01)	(0.00)	(0.00)	(0.00)
Syndicate Size	-3.332	-4.968	-3.027	-0.241***	-0.218***	-0.207***	0.028***	0.029***	0.032***
	(4.80)	(4.81)	(5.11)	(0.03)	(0.03)	(0.03)	(0.00)	(0.00)	(0.01)
Observations	14179	13129	11310	5195	4879	4137	10332	9708	8311
	Prior Entrepreneurial Exp			**Education: Graduate Degree**			**Education: MBA**		
	(2-10)	(2-11)	(2-12)	(2-13)	(2-14)	(2-15)	(2-16)	(2-17)	(2-18)
Angel Investor	-0.235**	-0.246**	-0.192*	-0.058***	-0.058***	-0.027	-0.029*	-0.021	0.00
	(0.10)	(0.10)	(0.11)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)
Round Size	-0.001*	0.00	0.004**	0.00	0.00	0.002***	0.00	0.00	0.00
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Syndicate Size	0.016*	0.020**	0.016*	-0.002	-0.001	-0.002	0.005***	0.005***	0.003*
	(0.01)	(0.01)	(0.01)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Observations	6147	5807	4844	6688	6305	5315	6688	6305	5315
	Education: PhD			**Education: Elite Institution**			**Education: Engineering**		
	(2-19)	(2-20)	(2-21)	(2-22)	(2-23)	(2-24)	(2-25)	(2-26)	(2-27)
Angel Investor	-0.034***	-0.030***	-0.019*	0.007	0.001	-0.01	-0.040**	-0.032**	-0.027
	(0.01)	(0.01)	(0.01)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)
Round Size	0.00	0.00	0.002***	-0.000*	0.00	0.001	0.00	0.00	0.001
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Syndicate Size	-0.002**	-0.002*	-0.001	0.001	0.003	0.002	0.001	0.001	0.001
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Observations	6688	6305	5315	6688	6305	5315	6688	6305	5315
Sample	Full	Full	Rnd 1&2	Full	Full	Rnd 1 &2	Full	Full	Rnd 1&2
Org. FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Round FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry FE	No	Yes	Yes	No	Yes	Yes	No	Yes	Yes

Table 4: **Matching Model: Venture Characteristics**. This table presents the results of the Matching Model analysis for Hypothesis 1 with various dependent variables for favorable observable venture characteristics, estimated with OLS. Statistical significance is represented by $*p < 0.10$, $**\ p < 0.05$, and $***p < 0.01$. Robust standard errors clustered at the VC organizational level are shown in parentheses.

	Firm Age	**Founder Age**	**Team Size**	**Prior Entrep.**	**Education: Graduate**	**MBA**	**PhD**	**Elite**	**Eng.**
	(4-1)	(4-2)	(4-3)	(4-4)	(4-5)	(4-6)	(4-7)	(4-8)	(4-9)
Angel Investor	-128.659**	0.279	-0.122**	-0.200*	-0.043**	-0.034*	-0.017	-0.032	-0.050***
	(56.65)	(0.34)	(0.05)	(0.10)	(0.02)	(0.02)	(0.01)	(0.02)	(0.02)
Round Size	110.311***	0.336***	0.042***	0.065***	0.015***	0.011***	0.001	0.012***	0.004
	(8.71)	(0.05)	(0.01)	(0.02)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Syndicate Size	-12.629*	-0.265***	0.042***	0.029**	-0.004*	-0.002	-0.001	0.003	0.005***
	(6.67)	(0.04)	(0.01)	(0.01)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Organization FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Round FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	4298	2065	3735	2332	2538	2538	2538	2538	2538

Table 5: **Geography Model**. This table presents the results of the Geography Model analysis for Hypothesis 2, estimated with OLS. Statistical significance is represented by $*p < 0.10$, $**\ p < 0.05$, and $***p < 0.01$. Robust standard errors clustered at the VC organizational level are shown in parentheses.

	Angel Investor
	(5-1)
ln(Distance)	0.002
	(0.005)
Distance (100–1000km)	-0.172**
	(0.084)
ln(Distance) × Distance (100–1000km)	0.028*
	(0.014)
Distance (1000–10000km)	-0.011
	(0.085)
ln(Distance) × Distance (1000–10000km)	0.001
	(0.011)
Distance (10000–100000km)	1.843
	(1.419)
ln(Distance) × Distance (10000–100000km)	-0.196
	(0.150)
Round Size	-0.001***
	(0.000)
Syndicate Size	0.028***
	(0.002)
Organization FE	Yes
Year FE	Yes
Round FE	Yes
Industry FE	Yes
Observations	11719

Table 6: **Category Experience Model**. This table presents the results of the Category Model analysis for Hypothesis 3, estimated with OLS. The *Full* sample contains all firms for which we were able to categorize. The *Experience* sample limits the angel investments to those for which the VC has any experience in the category, and thus it is within the scope of any possible investment thesis. Statistical significance is represented by $*p < 0.10$, $**\ p < 0.05$, and $***p < 0.01$. Robust standard errors clustered at the VC organizational level are shown in parentheses.

	Angel Investor	
	(6-1)	(6-2)
VC Exp. in Business Model	-0.008***	-0.007***
	(0.00)	(0.00)
VC Exp. in Technology Method	-0.008***	-0.007***
	(0.00)	(0.00)
VC Exp. in Technology Platform	-0.004***	-0.004***
	(0.00)	(0.00)
Round Size	-0.001***	-0.001***
	(0.00)	(0.00)
Syndicate Size	0.026***	0.027***
	(0.00)	(0.00)
Sample	Full	Experience
Year FE	Yes	Yes
Round FE	Yes	Yes
Observations	10620	9201

Table 7: **Main Model: Venture Financial Performance**. This table presents the results of the analysis of financial performance with various dependent variables for venture financial performance. The Main Model is estimated with OLS. Statistical significance is represented by $*p < 0.10$, $**\ p < 0.05$, and $***p < 0.01$. Robust standard errors clustered at the organizational level are shown in parentheses.

	Future Funding Round			**Number of Future Rounds**		
	(7-1)	(7-2)	(7-3)	(7-4)	(7-5)	(7-6)
Angel Investor	0.011	-0.007	-0.005	0.043	0.005	0.003
	(0.01)	(0.01)	(0.01)	(0.03)	(0.03)	(0.03)
Round Size	0.00	-0.00	-0.001***	0.00	0.00	-0.003***
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Syndicate Size	0.005***	0.006***	0.006***	0.008**	0.010***	0.010***
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Observations	16339	15059	13174	16339	15059	13174
	Acquisition Exit			**IPO Exit**		
	(7-7)	(7-8)	(7-9)	(7-10)	(7-11)	(7-12)
Angel Investor	0.038***	0.031***	0.028**	-0.004*	-0.005**	-0.005**
	(0.01)	(0.01)	(0.01)	(0.00)	(0.00)	(0.00)
Round Size	0.000**	0.000***	0.00	0.001***	0.001***	0.001***
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Syndicate Size	0.006***	0.006***	0.006***	0.001	0.001*	0.001**
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Observations	16339	15059	13174	16339	15059	13174
	Exit (IPO/M&A)			**Exit Valuation**		
	(7-13)	(7-14)	(7-15)	(7-16)	(7-17)	(7-18)
Angel Investor	0.030***	0.023**	0.022**	-657.098	-236.653	-77.885
	(0.01)	(0.01)	(0.01)	(552)	(278)	(69)
Round Size	0.001***	0.001***	0.001**	12.307***	11.764***	-3.242
	(0.00)	(0.00)	(0.00)	(1.75)	(1.10)	(3.68))
Syndicate Size	0.007***	0.007***	0.007***	-35.40	29.18	2.84
	(0.00)	(0.00)	(0.00)	(39.23)	(38.12)	(20.34)
Observations	16339	15059	13174	1229	1150	943
Sample	Full	Full	Rnd 1&2	Full	Full	Rnd 1 &2
Org. FE	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Round FE	Yes	Yes	Yes	Yes	Yes	Yes
Industry FE	No	Yes	Yes	No	Yes	Yes

Table 8: **Matching Model: Venture Financial Performance**. This table presents the results of the Matching Model analysis of financial performance with various dependent variables for venture financial performance. The Matching Model is estimated with OLS. Statistical significance is represented by $*p < 0.10$, $**\ p < 0.05$, and $***p < 0.01$. Robust standard errors clustered at the VC organizational level are shown in parentheses.

	Future Round	**# Future Rounds**	**Acq. Exit.**	**IPO Exit**	**Exit**	**Exit Valuation**
	(8-1)	(8-2)	(8-3)	(8-4)	(8-5)	(8-6)
Angel Investor	-0.008	0.024	0.004	0.000	0.003	44.76
	(0.01)	(0.03)	(0.01)	(0.00)	(0.01)	(39.96)
Round Size	-0.004**	-0.001	0.001	0.001***	0.001	16.327***
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(2.93)
Syndicate Size	0.009***	0.016***	0.006***	0.00	0.007***	-20.096***
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(6.01)
Organization FE	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Round FE	Yes	Yes	Yes	Yes	Yes	Yes
Observations	4862	4862	4862	4862	4862	287

Online Appendix *Not intended for publication.*

A Appendix: Stylized Model

A.1 Expected Utility Conditions

1. $\mathbf{E[U] < 0}$ Recall that $U(1) > 0 > U(0)$.

$$E[U] = \pi U(1) + (1-\pi)U(0) < 0 \Leftrightarrow \pi < \frac{-U(0)}{U(1) - U(0)},$$

2. $\mathbf{E[U|\sigma = B] < E[U]}$

$$\begin{aligned} E[U|\sigma = B] < E[U] \Leftrightarrow & \frac{\pi(1-q)U(1) + (1-\pi)qU(0)}{\pi(1-q) + (1-\pi)q} \\ & < \pi U(1) + (1-\pi)U(0) \\ \Leftrightarrow & q > \frac{1}{2} \end{aligned}$$

3. $\mathbf{E[U|\sigma = G] > E[U]}$

$$\begin{aligned} E[U|\sigma = G] > E[U] \Leftrightarrow & \frac{\pi q(1-\theta)U(1) + (1-\pi)(1-q)(1-\beta)U(0)}{\pi q(1-\theta) + (1-\pi)(1-q)(1-\beta)} \\ & > \pi U(1) + (1-\pi)U(0) \\ \Leftrightarrow & q(1-\theta) > (1-q)(1-\beta) \end{aligned}$$

4. $\mathbf{E[U|\sigma = T] > 0}$

$$E[U|\sigma = T] > 0 \Leftrightarrow \frac{\pi q\theta U(1) + (1-\pi)(1-q)\beta U(0)}{\pi q\theta + (1-\pi)(1-q)\beta} > 0.$$

5. $\mathbf{E[U|\sigma \in \{G, T\}] < 0}$

$$E[U|\sigma \in \{G, T\}] < 0 \Leftrightarrow \frac{\pi qU(1) + (1-\pi)(1-q)U(0)}{\pi q + (1-\pi)(1-q)} < 0.$$

6. $\mathbf{E[U|\sigma = G] < 0 < E[U|\sigma_i = G, \sigma_j = G]}$ Note that $E[U|\sigma = G] < 0$ (Assumption 6a) is implied by the preceding two assumptions: $E[U|\sigma = T] > 0 > E[U|\sigma \in \{G, T\}]$. To ensure $E[U|\sigma_i = G, \sigma_j = G] > 0$ (Assumption 6b), it is assumed:

$$E[U|\sigma_1 = G, \sigma_2 = G] > 0 \Leftrightarrow \frac{\pi q^2(1-\theta)^2U(1) + (1-\pi)(1-q)^2(1-\beta)^2U(0)}{\pi q^2(1-\theta)^2 + (1-\pi)(1-q)^2(1-\beta)^2} > 0$$

A.2 Parameter Restrictions

The original assumptions on the parameters are: $\pi \in (0,1), q \in (\frac{1}{2},1), 0 < \beta < \theta < 1$, and $q(1-\theta) > (1-q)(1-\beta)$. Augmenting these original assumptions with the additional restrictions from the six conditions just derived from our expected utility assumptions, we derive the parameter space for which the model holds.

Assumption 2 and Assumption 3 are satisfied automatically from the original assumptions.[31]

$$\begin{aligned}\underbrace{E[U|\sigma = B] < E[U]}_{\text{Assumption 2}} &\Leftrightarrow q > \frac{1}{2}\\ \underbrace{E[U|\sigma = G] > E[U]}_{\text{Assumption 3}} &\Leftrightarrow q(1-\theta) > (1-q)(1-\beta)\\ &\Leftrightarrow \frac{1-q}{q} < \frac{1-\theta}{1-\beta}\end{aligned}$$

Assumption 4, Assumption 6, and Assumption 6b hold if and only if the following conditions are met[32]:

$$\begin{aligned}\underbrace{E[U|\sigma = T] > 0}_{\text{Assumption 4}} &\Leftrightarrow \pi q\theta U(1) + (1-\pi)(1-q)\beta U(0) > 0\\ &\Leftrightarrow \frac{1-q}{q} < \left(\frac{\theta}{\beta}\right)\left(\frac{\pi}{1-\pi}\right)\left(-\frac{U(1)}{U(0)}\right)\\ \underbrace{E[U|\sigma \in \{G,T\}] < 0}_{\text{Assumption 5}} &\Leftrightarrow \pi q U(1) + (1-\pi)(1-q)U(0) < 0\\ &\Leftrightarrow \frac{1-q}{q} > \left(\frac{\pi}{1-\pi}\right)\left(-\frac{U(1)}{U(0)}\right)\\ \underbrace{E[U|\sigma_i = G, \sigma_j = G] > 0}_{\text{Assumption 6b}} &\Leftrightarrow \pi q^2(1-\theta)^2 U(1) + (1-\pi)(1-q)^2(1-\beta)^2 U(0) > 0\\ &\Leftrightarrow \frac{1-q}{q} < \sqrt{\left(\frac{\pi}{1-\pi}\right)\left(-\frac{U(1)}{U(0)}\right)}\end{aligned}$$

Given Assumption 5, the original parameter restrictions imply Assumption 1 and Assumption 6a.

$$\underbrace{E[U|\sigma \in \{G,T\}] < 0}_{\text{Assumption 5}} \Rightarrow \underbrace{E[U|\sigma = G] < 0}_{\text{Assumption 6a}} \Rightarrow \underbrace{E[U] < 0}_{\text{Assumption 1}}.$$

Assumptions 1 through 6 are sufficient to characterize the equilibrium. We can further add an additional assumption for $E[U|\sigma_i = T, \sigma_j = B]$ to cover all cases of voting by the organization. This case would represent the scenario where agent 1 receives a signal of $\sigma_1 = T$ and agent 2 acquires

[31] Assumption 3 holds as long as θ is not that much larger than β, given $q \in (\frac{1}{2}, 1)$.

[32] Assumption 4 is sure to be satisfied as $\theta/\beta \to +\infty$. When θ/β is large, the terrific signal, $\sigma = T$, is far more likely for the profitable state ($s = 1$) than for the unprofitable state ($s = 0$), conditional on receiving a favorable signal (i.e., $\sigma \in \{G,T\}$).

signal but receives $\sigma_2 = B$. We assume that agent 1 would not pursue the deal on her own, but this assumption is not necessary for the model or its empirical predictions.

$$\begin{aligned} E[U|\sigma_i = T, \sigma_j = B] < 0 &\Leftrightarrow \frac{\pi q\theta(1-q)U(1) + (1-\pi)(1-q)}{\pi\theta(1-q) + (1-\pi)(1-q)\beta q} < 0 \\ &\Leftrightarrow \left(\frac{\pi}{1-\pi}\right)\left(-\frac{U(1)}{U(0)}\right) < \frac{\beta}{\theta} \\ &\Leftrightarrow \phi_\pi \phi_U < \frac{\beta}{\theta} \end{aligned}$$

Given that $\pi \in (0,1)$, $U(0) < 0 < U(1)$, and $q \in (\frac{1}{2}, 1)$, let $\phi_\pi = \frac{\pi}{1-\pi} \in (0, \infty)$, $\phi_U = -\frac{U(1)}{U(0)} \in (0, \infty)$, and $\phi_q = \frac{1-q}{q} \in (0,1)$. In conclusion, our expected utility conditions require the following parameter restriction:

$$\phi_\pi \phi_U < \phi_q < \begin{cases} \dfrac{1-\theta}{1-\beta} \\ \dfrac{\theta}{\beta}\phi_\pi\phi_U \\ \sqrt{\phi_\pi\phi_U} \end{cases}$$

The conditions containing θ, β are then satisfied when $\theta, \beta \longrightarrow 0$ and $\frac{\theta}{\beta} \longrightarrow +\infty$. In other words, the probability of receiving a terrific signal (under either state of the world) needs to be small, but the probability of terrific signal needs to be far greater in the profitable state than in the unprofitable state. An omitted computational simulation finds a broad set of parameters for which the identified equilibria will hold.

A.3 Equilibrium with One Agent or No Agents Acquiring a Signal

There does exist an equilibrium for which one or no agents acquire the private signal.

A.3.1 Intuition

Consider a strategy pair in which agent 2 acquires a signal and agent 3 does not acquire a signal. For agent 3, we know from the preceding analysis that she will prefer not to acquire a signal, so her strategy is optimal. By the voting rule, she will vote against the project because she has expected utility of $E_3[U|\sigma_1 \in \{G, T\}]$ which is assumed to be negative.

Agent 2 expects agent 1 to vote for the project—agent 1 brought the project to the firm so he can assume that $\sigma_1 \in \{G, T\}$—and agent 3 to vote against it. Thus, agent 2 is the pivotal voter. If he does not acquire a signal then, like agent 3, he will vote against the project and, therefore, his payoff is zero. If he acquires a signal, his expected utility is

$$\begin{aligned}&\Pr(\sigma_2 \in \{G,T\}|\sigma_1 \in \{G,T\})E[U|\sigma_1 \in \{G,T\}, \sigma_2 \in \{G,T\}]\\&\quad + \Pr(\sigma_2 = B|\sigma_1 \in \{G,T\}) \times 0\\&= \Pr(\sigma_2 \in \{G,T\}|\sigma_1 \in \{G,T\})E[U|\sigma_1 \in \{G,T\}, \sigma_2 \in \{G,T\}].\end{aligned}$$

Thus, acquisition of the signal is optimal if and only if the cost of information acquisition c is less than a critical threshold $\widehat{c}$ equivalent to the above expression, which is derived in full in below.

$$\Pr(\sigma_2 \in \{G,T\}|\sigma_1 \in \{G,T\})E[U|\sigma_1 \in \{G,T\}, \sigma_2 \in \{G,T\}] \geq c$$

$$\Leftrightarrow \widehat{c} \equiv \frac{\pi q^2 U(1) + (1-\pi)(1-q)^2 U(0)}{\pi q + (1-\pi)(1-q)} \geq c$$

If $c \leq \widehat{c}$, then it is optimal for agent 2 to acquire a signal given agent 3 does not. We already showed that for all values of c, it is optimal for agent 3 not to acquire a signal given agent 2 does. In summary, if $c < \widehat{c}$, then it is a unique Nash equilibrium for one of those two agents to acquire a signal and the other not to acquire a signal. If instead $c > \widehat{c}$, then it is optimal for agent 2 to not acquire a signal given agent 3 does not. By symmetry, we conclude that if $c > \widehat{c}$, it is the unique Nash equilibrium for both agents not to acquire signals.

For this equilibrium, the voting rule is optimal and the agents vote sincerely (Austen-Smith and Banks, 1996; Persico, 2004).

A.3.2 Derivation of $\widehat{c}$

The acquisition of the signal is optimal if and only if

$$\Pr(\sigma_2 \in \{G,T\}|\sigma_1 \in \{G,T\})E[U|\sigma_1 \in \{G,T\}, \sigma_2 \in \{G,T\}] \geq c$$

Expanding the left-hand side expression,

$$\begin{aligned}&\Pr(\sigma_2 \in \{G,T\}|\sigma_1 \in \{G,T\})E[U|\sigma_1 \in \{G,T\}, \sigma_2 \in \{G,T\}]\\&= \Pr(\sigma_2 \in \{G,T\}|\sigma_1 \in \{G,T\}) \times \left[\sum_{s\in 0,1} \Pr(s\,|\sigma_1 \in \{G,T\}, \sigma_2 \in \{G,T\})U(s)\right]\\&= \left(\frac{\Pr(\sigma_1 \in \{G,T\}, \sigma_2 \in \{G,T\})}{Pr(\sigma_1 \in \{G,T\})}\right) \times \left[\sum_{s\in 0,1}\left(\frac{\Pr(s, \sigma_1 \in \{G,T\}, \sigma_2 \in \{G,T\})}{\Pr(\sigma_1 \in \{G,T\}, \sigma_2 \in \{G,T\})}\right)U(s)\right]\\&= \left(\frac{\Pr(s=1, \sigma_1 \in \{G,T\}, \sigma_2 \in \{G,T\})}{Pr(\sigma_1 \in \{G,T\})}\right)U(1)\\&\quad + \left(\frac{\Pr(s=0, \sigma_1 \in \{G,T\}, \sigma_2 \in \{G,T\})}{Pr(\sigma_1 \in \{G,T\})}\right)U(0)\end{aligned}$$

The probabilities in the expression are

$$
\begin{aligned}
&\frac{\Pr(s=1,\sigma_1\in\{G,T\},\sigma_2\in\{G,T\})}{\Pr(\sigma_1\in\{G,T\})}\\
&=\frac{\Pr(s=1)\Pr(\sigma_1\in\{G,T\}\,|s=1\,)\Pr(\sigma_2\in\{G,T\}\,|s=1\,)}{\Pr(s=1)\Pr(\sigma_1\in\{G,T\}\,|s=1\,)+\Pr(s=0)\Pr(\sigma_1\in\{G,T\}\,|s=0\,)}\\
&=\frac{\pi q^2}{\pi q+(1-\pi)(1-q)}\\
&\frac{\Pr(s=0,\sigma_1\in\{G,T\},\sigma_2\in\{G,T\})}{Pr(\sigma_1\in\{G,T\})}\\
&=\frac{\Pr(s=0)\Pr(\sigma_1\in\{G,T\}\,|s=0\,)\Pr(\sigma_2\in\{G,T\}\,|s=0\,)}{\Pr(s=1)\Pr(\sigma_1\in\{G,T\}\,|s=1\,)+\Pr(s=0)\Pr(\sigma_1\in\{G,T\}\,|s=0\,)}\\
&=\frac{(1-\pi)(1-q)^2}{\pi q+(1-\pi)(1-q)}
\end{aligned}
$$

Hence,

$$\Pr(\sigma_2\in\{G,T\}|\sigma_1\in\{G,T\})E[U|\sigma_1\in\{G,T\},\sigma_2\in\{G,T\}]\geq c$$

$$\Leftrightarrow \widehat{c}\equiv\frac{\pi q^2U(1)+(1-\pi)(1-q)^2U(0)}{\pi q+(1-\pi)(1-q)}\geq c$$

A.4 No Equilibrium with Both Agents Acquiring a Signal

There is no Nash equilibrium in which both agents 2 and 3 acquire the costly private signal. We first discuss the intuition for this, and then provide the analytic proof.

A.4.1 Intuition

We show that it is not optimal for agent 3 to also acquire a signal if agent 3 anticipates agent 2 acquiring a signal. By the specified voting rule, agent 3 anticipates agent 1 voting for the project (as agent 1 would not have brought the project to the VC firm unless $\sigma_1\in\{G,T\}$ and by the voting rule, an agent with a favorable private signal votes in support of the project) and anticipates agent 2 voting for the project if and only if $\sigma_2\in\{G,T\}$. If it turns out agent 2 has a favorable signal, both agents 1 and 2 will vote in support in which case the project will be funded irrespective of agent 3's vote. If instead $\sigma_2=B$, then agent 1 will vote for and agent 2 will vote against and, in that situation, agent 3 is the *pivotal* vote.

Given agents 1 and 2 acquire signals, agent 3's vote is pivotal only when the other two agents split their votes, i.e. one received a favorable signal and the other an unfavorable signal. Given that signals are independent and the symmetry in the model, the beliefs of agent 3, conditional on agents 1 and 2 splitting their votes, are just her beliefs prior to any information acquisition. Given that it is assumed a single favorable signal is insufficient to find the project worthy of funding, for agent 3 to acquire a signal and then voting in favor when the signal is favorable could only result in funding a project that is not worthy. We conclude there are no equilibria where both agent 2 and agent 3 acquire the private signal.[33]

A.4.2 Analytic Proof

If agent 3 does not acquire a signal, given her current expectation $E[U|\sigma_1 \in \{G,T\}] < 0$, then she will vote against the project, giving her expected utility of

$$\underbrace{\Pr(\sigma_2 \in \{G,T\}\,|\sigma_1 \in \{G,T\}\,)E[U|\sigma_1 \in \{G,T\}, \sigma_2 \in \{G,T\}]}_{\text{Agent 2 Favorable Signal}}$$
$$+\underbrace{\Pr(\sigma_2 = B\,|\sigma_1 \in \{G,T\}\,) \times 0}_{\text{Agent 2 Unfavorable Signal}}.$$

If agent 3 instead acquires a signal, she will vote for the project when $\sigma_3 \in \{G,T\}$–in which case it will be funded as there will be at least two votes in support–and vote against it when $\sigma_3 = B$–in which case it will be funded if and only if $\sigma_2 \in \{G,T\}$. The associated expected utility to agent 3 (after netting out the cost of the signal) is:

$$\underbrace{\begin{bmatrix} \Pr(\sigma_2 \in \{G,T\}\,|\sigma_1 \in \{G,T\}\,) \\ \times E[U|\sigma_1 \in \{G,T\}, \sigma_2 \in \{G,T\}] \end{bmatrix}}_{\text{Agent 2 Favorable Signal}}$$
$$+\underbrace{\begin{bmatrix} \Pr(\sigma_2 = B\,|\sigma_1 \in \{G,T\}\,)\Pr(\sigma_3 \in \{G,T\}\,|\sigma_1 \in \{G,T\}, \sigma_2 = B\,) \\ \times E[U|\sigma_1 \in \{G,T\}, \sigma_2 = B, \sigma_3 \in \{G,T\}] \end{bmatrix}}_{\text{Agent 2 Unfavorable Signal, Agent 3 Favorable Signal}}$$
$$+\underbrace{[\Pr(\sigma_2 = B\,|\sigma_1 \in \{G,T\}\,)\Pr(\sigma_3 = B\,|\sigma_1 \in \{G,T\}, \sigma_2 = B\,) \times 0]}_{\text{Agents 2 \& 3 Unfavorable Signal}} - c$$

The expected utility of agent 3 acquiring the signal exceeds the expected utility of agent 3 not acquiring the signal when:

$$\Pr(\sigma_2 = B\,|\sigma_1 \in \{G,T\}\,)\Pr(\sigma_3 \in \{G,T\}\,|\sigma_1 \in \{G,T\}, \sigma_2 = B\,)$$
$$\times E[U|\sigma_1 \in \{G,T\}, \sigma_2 = B, \sigma_3 \in \{G,T\}] > c.$$

If this condition could be met, then agent 3 would acquire the signal. We will show that this condition cannot hold because $E[U|\sigma_1 \in \{G,T\}, \sigma_2 = B, \sigma_3 \in \{G,T\}] < 0$. When agent 3's vote is pivotal and she receives a favorable signal (and votes for it), the expected utility of funding the

[33] Consequently, a larger group does not necessarily translate into a more efficient decision, because when the voting rule is a number less than the group size, the remaining agents beyond the voting rule threshold may choose to remain uninformed.

project is negative.

$$
\begin{aligned}
&E[U|\sigma_1 \in \{G,T\}, \sigma_2 = B, \sigma_3 \in \{G,T\}] \\
&= \Pr(s=1\,|\sigma_1 \in \{G,T\}, \sigma_2 = B, \sigma_3 \in \{G,T\}\,)U(1) \\
&\quad + \Pr(s=0\,|\sigma_1 \in \{G,T\}, \sigma_2 = B, \sigma_3 \in \{G,T\}\,)U(0).
\end{aligned}
$$

To solve for this, we solve to the probabilities in the expected utility expression.

$\Pr(s=0\,|\sigma_1 \in \{G,T\}, \sigma_2 = B, \sigma_3 \in \{G,T\}\,)$ follows similarly.

$$
\begin{aligned}
&\Pr(s=1\,|\sigma_1 \in \{G,T\}, \sigma_2 = B, \sigma_3 \in \{G,T\}\,) \\
&= \frac{\Pr(s=1, \sigma_1 \in \{G,T\}, \sigma_2 = B, \sigma_3 \in \{G,T\})}{\Pr(\sigma_1 \in \{G,T\}, \sigma_2 = B, \sigma_3 \in \{G,T\})} \\
&= \frac{\Pr(s=1, \sigma_1 \in \{G,T\}, \sigma_2 = B, \sigma_3 \in \{G,T\})}{\sum\limits_{s\in 0,1} \Pr(s, \sigma_1 \in \{G,T\}, \sigma_2 = B, \sigma_3 \in \{G,T\})}
\end{aligned}
$$

By the conditional independence of agents' signals,

$$
\begin{aligned}
&\Pr(s=1, \sigma_1 \in \{G,T\}, \sigma_2 = B, \sigma_3 \in \{G,T\}) \\
&= \Pr(s=1)\Pr(\sigma_1 \in \{G,T\}\,|s=1\,)\Pr(\sigma_2 = B\,|s=1\,)\Pr(\sigma_3 \in \{G,T\}\,|s=1\,) \\
&= \pi q(1-q)q = \pi q^2(1-q) \\
&\Pr(s=0, \sigma_1 \in \{G,T\}, \sigma_2 = B, \sigma_3 \in \{G,T\}) \\
&= \Pr(s=0)\Pr(\sigma_1 \in \{G,T\}\,|s=0\,)\Pr(\sigma_2 = B\,|s=0\,)\Pr(\sigma_3 \in \{G,T\}\,|s=0\,) \\
&= (1-\pi)(1-q)q(1-q) = (1-\pi)q(1-q)^2
\end{aligned}
$$

Combining these expressions, we find an equivalence between the condition probability of the state with only one favorable signal and two favorable signals and an unfavorable signal.

$$
\begin{aligned}
&\Pr(s=1\,|\sigma_1 \in \{G,T\}, \sigma_2 = B, \sigma_3 \in \{G,T\}\,) \\
&= \frac{\pi q^2(1-q)}{\pi q^2(1-q) + (1-\pi)q(1-q)^2} \\
&= \frac{\pi q}{\pi q + (1-\pi)(1-q)} \\
&= \Pr(s=1\,|\sigma_1 \in \{G,T\}\,)
\end{aligned}
$$

$\Pr(s=1\,|\sigma_1 \in \{G,T\}, \sigma_2 = B, \sigma_3 \in \{G,T\}\,) = \Pr(s=1\,|\sigma_1 \in \{G,T\}\,)$ follows similarly.

Putting this back into our original expression for $E[U|\sigma_1 \in \{G,T\}, \sigma_2 = B, \sigma_3 \in \{G,T\}]$, we find

$$
E[U|\sigma_1 \in \{G,T\}, \sigma_2 = B, \sigma_3 \in \{G,T\}] = E[U|\sigma_1 \in \{G,T\}]
$$

which is assumed to be negative from Assumption 5.

Since $E[U(\sigma_1, \sigma_2, \sigma_3)|\sigma_1 \in \{G, T\}, \sigma_2 = B] < 0$, then the condition $E[U(\sigma_1, \sigma_2, \sigma_3)|\sigma_1 \in \{G, T\}, \sigma_2 = B] > 0$ cannot hold, which means it cannot be optimal for agent 3 to acquire a signal given agent 2 does acquire the signal. [34]

A.5 Optimality of Voting Rule

We assumed that an agent's voting rule has her vote in support of the project if and only if:

1. she acquired a signal and the signal is favorable, $\sigma_i \in \{G, T\}$;

2. she did not acquire a signal and based on her current beliefs she expects the project to be profitable.

For the equilibria characterized above, we will now show that this voting rule is optimal and the agents vote sincerely (Austen-Smith and Banks, 1996; Persico, 2004).

Consider the equilibrium in which agents 2 and 3 do not acquire signals. As both of those agents will vote against the project, agent 1 is not pivotal in which case voting for the project (as prescribed by agent 1's voting rule) is trivially optimal. Turning to agent 2, she expects agent 1 to vote for the project and agent 3 to vote against it (because agent 2 expects agent 3 not to acquire a signal). As agent 2 is pivotal, the project is not funded if agent 2 votes against it, in which case her payoff is zero, and the project is funded if she votes for it and that yields expected utility of $E[U|\sigma_1 \in \{G, T\}]$ which is negative. Hence, it is optimal for agent 2 not to vote for the project. By symmetry, the same argument applies to agent 3. We conclude that the voting rule is optimal for the equilibrium in which agents 2 and 3 do not acquire signals.

Next consider the equilibrium in which agent 2 acquires a signals and agent 3 does not. Beginning with agent 1, he is pivotal if and only if agent 2 receives a favorable signal, $\sigma_2 \in \{G, T\}$, and thus votes in favor of funding to project and that offsets agent 3's vote in opposition. It is optimal for agent 1 to vote for the project when $\sigma_1 \in \{G, T\}$ if $E[U|\sigma_1, \sigma_2 \in \{G, T\}]$ for $\sigma_1 \in \{G, T\}$. This expected utility is assumed to be positive by Assumption 6 on the expected utility, and thus agent 1's voting rule is optimal. Given agent 1 is expected to vote for and agent 3 against, agent 2 is pivotal in which case voting for the project if and only if agent 2's signal is favorable is optimal when

$$E[U|\sigma_1 \in \{G, T\}, \sigma_2] > 0 > E[U|\sigma_1 \in \{G, T\}, \sigma_2 = B], \ \sigma_2 \in \{G, T\}$$

or

$$E[U|\sigma_1 \in \{G, T\}, \sigma_2 = G] > 0 > E[U|\sigma_1 \in \{G, T\}, \sigma_2 = B].$$

This condition follow from prior assumptions that

$$E[U|\sigma_1 = G, \sigma_2 = G] > 0 > E[U|\sigma_1 \in \{G, T\}].$$

[34] The lack of an equilibrium with both agents 2 and 3 acquiring signals is predicated upon a voting rule in which an agent votes yes if and only if her signal is G or T. However, that voting rule need not be optimal when both agents acquire signals. This raises the question of whether an equilibrium exists in which both agents 2 and 3 acquire signals and agents vote yes if and only if her signal is T.

Agent 2's voting rule is then optimal. Finally, agent 3's vote is pivotal only when $\sigma_2 = B$ in which case the expected utility of the project is $E[U|\sigma_1 \in \{G, T\}, \sigma_2 = B] < 0$; given that it is negative, it is optimal for agent 3 to vote against it. We conclude that the symmetric voting rule forms an equilibrium.

A.6 Empirical Hypotheses

We explore the comparative statics of $\hat{c}$ with respect to π and q.

$$
\begin{aligned}
\frac{d\widehat{c}}{d\pi} =& [\pi q(1-\pi)(1-q)][2\pi q U(1) - 2(1-\pi)(1-q)U(0)] \\
& - [\pi q^2 U(1) + (1-\pi)(1-q)^2 U(0)][\pi - 1 + \pi] \\
=& 2\pi^2 q^2 U(1) - 2(1-\pi)(1-q)U(0)\pi q \\
& + 2\pi(1-\pi)(1-q)qU(1) - 2(1-\pi)^2(1-q)^2 U(0) \\
& + \pi q^2 U(1) + (1-\pi)(1-q)^2 U(0) \\
& - 2\pi^2 q^2 U(1) - 2\pi(1-\pi)(1-q)^2 U(0) \\
=& 2\pi(1-\pi)(1-q)q(U(1) - U(0)) + \pi q^2 U(1) \\
& + (1-\pi)(1-q)^2 U(0)[-2(1-\pi) + 1 - 2\pi] \\
=& 2\pi(1-\pi)(1-q)q(U(1) - U(0)) + \pi q^2 U(1) - (1-\pi)(1-q)^2 U(0) > 0
\end{aligned}
$$

$$
\begin{aligned}
\frac{d\widehat{c}}{dq} =& [2\pi q u_1 - 2(1-\pi)(1-q)u_0][\pi q + (1-\pi)(1-q)] \\
& - [\pi q^2 u_1 + (1-\pi)(1-q)2u_0](2\pi - 1) \\
=& 2\pi^2 q^2 u_1 + 2\pi(1-\pi)q(1-q)u_1 - 2\pi(1-\pi)q(1-q)u_0 - 2(1-\pi)^2(1-q)^2 u_0 \\
& - 2\pi^2 q^2 u_1 + \pi q^2 u_1 - 2\pi(1-\pi)(1-q)^2 u_0 + (1-\pi)(1-q)^2 u_0 \\
=& 2\pi(1-\pi)q(1-q)(u_1 - u_0) - 2(1-\pi)(1-q)^2 u_0 + \pi q^2 u_1 + (1-\pi)(1-q)^2 u_0 \\
=& 2\pi(1-\pi)q(1-q)(u_1 - u_0) - (1-\pi)(1-q)^2 u_0 + \pi q^2 u_1 > 0
\end{aligned}
$$

B Appendix: Organizational Forms in Entrepreneurial Finance

B.1 Interviews with Venture Capital Firms

We conducted semi-structured interviews with current and former investment team members at 19 venture capital firms. The purpose of these interviews was to better understand the functional nature of the organizational decision-making process within venture capital firms. We contacted 113 alumni of a mid-Atlantic university, predominantly graduates of its highly ranked business and engineering programs, and we were able to set up interviews with 22 individuals. The individuals spanned all levels of seniority within their organizations, ranging from associate up to senior general partner. Some individuals had worked at more than one venture capital firm during the course of their career, and they were thus able to speak about more than one firm. In some cases, we interviewed multiple employees of the same firm.

Interviews took place over June and July 2014, and each interview was approximately 30 minutes long. Informants were ensured anonymity of themselves and their firms. The interview data was supplemented with data available from CrunchBase, the Investment Advisor Public Disclosure (IAPD) database, Thomson ONE, and company websites.

The main finding of the interviews is that all venture capital firms have an organizational routine for integrating information from its employees and evaluating deals sourced by those employees. There is unanimously a group stage that requires some or all of the other partners to vote and confirm the deal before it is executed. However, there is tremendous heterogeneity about how the information is integrated and how group voting processes work, particularly in the degree of formality used. Firms ranged from allowing partners to individually execute investments with relative little oversight by the other partners besides a brief discussion at the partner meeting, to having a formal and tracked voting process requiring a specific number, majority, or unanimous vote of the partners. There is also heterogeneity in who is allowed to vote: some firms allow all people with the title of partner to vote, and other firms have a specialized investment committee involving a subset of the partners to vote. At the extreme, one firm requires all deals proposed by partners to be voted upon by only one specific partner which is not a sourcing partner.

In all cases, informants confirmed the existence of angel partner investments in the industry. Most of firms do all angel partner investments, although a few firms have rules explicitly banning the practice.

C Appendix: Data

C.1 Sample Construction

We classified each of these financial organizations into venture capital, private equity, corporate venture capital, angel investment firm, seed accelerator/business incubator, or a family office. The classification was made using information from the website of the respective firm. Venture capital firms were defined as those who have the stated strategy of investing in early-stage, growth startups and who manage money on behalf of outside investors (limited partners). Private equity firms were distinguished from venture capital firms as those that also made leveraged buyout, mezzanine capital, distressed, and secondary investments, although they could have also made traditional venture capital investments in our time period. Corporate venture capital is a venture capital firm making investments on behalf of a corporation that is not primarily engaged in investment. Angel investment firms specialize in making seed stage investments, either with funds directly held by the firm or by an outside limited partnership as in traditional venture capital. Seed accelerators and business incubators make fixed size investments and also offer participation in a fixed-term cohort-based program which may include office space and mentorship (in almost all cases). Family investment firms are those firms that primarily make investments on behalf of a single individual or family and are also managed by that individual or family.

We also constructed a dataset that restricts the set of investments made by venture capital firms to those that are confirmed to be "approved" by the individual investors in our data. We identified "individually approved" investments by identifying investments where the focal investor "led" the investment into the venture and thus holds a board or executive position in the startup. Unfortunately, this sample was omitted from the paper because a large amount of data was missing in a systemic way as to introduce bias: we cannot observe cases where the focal investor led the investment for the venture capital firm but did not take a position in the startup or did not publicly disclose it. We suspect that the public disclosure of the board member is a non-random choice by the investors.

C.2 Tacit Information: VC Experience

The main NAICS codes containing software, internet, and information technology firms are 33 Manufacturing, 42 Wholesale Trade, 44 45 Retail Trade, 51 Information, 54 Professional, Scientific, and Technical Services, and 61 Educational services.

Self-descriptive keywords for each startup firm were classified into categories by business model, technology method, and technology platform. The business models are business-to-business (B2B), business-to-consumer (B2C), crowdsourcing, freemium, infrastructure as a service (IAAS), lead generation, licensing, machine-to-machine (M2M), open source, peer to peer (P2P), platform as a service (PAAS), and software as a service (SAAS). The technology methods are advertising, information aggregation, data analytics, artificial intelligence, big data, content management, crowdfunding, cyber security, e-commerce, gamification, gaming, local, media streaming, modeling, operating system, payment, productivity, sharing, and social media. The technology platforms are application, browser, cloud, mobile, package, and website.

C.3 Missing Data

To test whether we should be concerned about the missing data on founding teams, we conduct a basic test of missing data. There is a weak, mostly insignificant correlation between the team data missing, and the variables that we do have for the full sample (round age, future rounds, exit events), exhibiting a pattern consistent with data that is missing at random (MAR).

Table 9: **Missing Data**. This table presents the correlations between an indicator for missing founding team data and various variables that we have for the full sample.

Correlation with Missing Data Indicator	
Angel Investor	-0.20
Age at Funding Round (in Days)	0.15
Future Funding Round	-0.09
Number of Future Funding Rounds	-0.09
Acquisition Exit	-0.03
Exit (IPO/M&A)	-0.03
Exit Valuation (IPO/M&A)	-0.07
IPO Exit	0.00
Funding Round Amount	0.06
Count of Investors in Syndicate	-0.19
Round Number	-0.12
Round Year	-0.16