

## ABSTRACT

Title of Document:

DOES NETWORK DENSITY MATTER:  
ESSAYS ON INTER-FIRM GROUP  
FORMATION AND PERFORMANCE  
IMPLICATION

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This dissertation studies inter-firm network formation and performance implication. Different from current network formation literature that focuses on the *actor* or *dyad level*, this dissertation examines network formation and its performance implication at the *group level*. Specifically, I examine: 1) How do inter-firm groups with different levels of density form? 2) When is a firm more likely to participate in a group with mostly unfamiliar firms? and 3) How do group internal and external network structures influence task performances? Using Venture Capital (VC) investments as the research context, I develop novel empirical designs to quantitatively test my theory. In Essay I, to investigate how groups with different levels of density form, I emphasize the path-dependence effect of previous ties among

*all* potential group members and simultaneously examine the formation of *all* ties in a group. I find that both anticipated environmental adaptation and anticipated internal cooperation are important considerations in a group formation. Taking a firm-focused group perspective, Essay II studies when a firm participates in a group with mostly unfamiliar firms. The empirical results show that the group participation of an unfamiliar firm depends not only on the uncertainty it brings in value creation but also on the uncertainty in value appropriation. Essay III examines the impact of syndicate density and structural holes and finds that both have impacts on the startup company performance. This dissertation enhances our understanding of network formation by bringing in a brand-new perspective, by uncovering group-level antecedents of network formation, by illustrating the impact of concerns in value appropriation, by exploring group dynamics, and by linking network formation behaviors with task performance at the group level.

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FORMATION AND PERFORMANCE IMPLICATION

By

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## **Dissertation Introduction**

Firms often partner to manage environmental uncertainty and to obtain resources. They have used partnerships to share information, reduce risks, cut transaction cost, and foster innovation, etc. Research has shown that both firm attributes and environment influence firm tie formation rate and firms follow mechanisms, such as repeated ties, homophily, reciprocity, and transitivity, in forming dyadic partnerships.

Notwithstanding the important contributions, the current network literature has some limitations. First, the dyad-level research on network formation assumes the independence of focal dyadic tie formation from other participants in a group. However, partnerships in a multi-firm group are a simultaneous commitment made by every firm involved. Firms' decisions to join or not to join a group are based on the identity of all other group members. Sorenson and Stuart (2008) expressively stated that modeling "the choice of a given syndicate partner as being conditionally independent of the other partners that have already joined the syndicate" is a limitation and "In reality, however, the decision to join a syndicate may depend on the identities of other VC firms simultaneously joining in the same financing round or even on the (unobserved) firms who were invited to join the syndicate but declined the invitation".

Second, due to the focus on dyads, the existing literature leaves out an important gap of group dynamics. Nevertheless, one tie formation in a group is related to the other tie formations in the same group. Whether a firm joins a group

interplays with participation of other firms in the same group. Thus, it is important to understand how the formations of ties among potential group members influence each other in the process of group formation.

Third, the focus on dyads also limits our understanding of the performance implication of network formation behaviors. Given that performance implication is at the group level, studying tie formation at the dyad level breaks the linkage between network formation behaviors and group performance. Also, to examine how firms' network formation behaviors may influence their task performance, the performance implication of group network structure should be studied with the considerations of group formation mechanisms.

To fill the gap in the current literature, my dissertation takes a *group* perspective and studies network formation within a group and its performance implication at the *group* level. Similar to the dyad-level research, this dissertation from a group perspective also focuses on partner selection. Different from the dyad literature, this dissertation considers the interplays of tie formations in a group.

In Essay I, I investigate the formation of groups with various network density. Instead of assuming focal ties independent of other group members, as the dyad-level research did, Essay I highlights the path-dependence effect of previous ties among *all* potential group members and simultaneously examines the formation of *all* ties in a group. I argue that both anticipated environmental adaptation and expected internal cooperation processes matter in a group formation. Due to the importance of cooperation, potential group members are concerned about the future coordination cost and possible coalition formation, and take them into consideration when forming

groups. Using Venture Capital (VC) investment data between 1985 and 2008, I develop a novel empirical study design to simultaneously model formation of all ties in a syndicate. I find that syndicates with higher density are more likely to form in more competitive environments, in larger groups, in groups with greater heterogeneity, and in groups with stronger ties. In contrast, syndicates with lower density are more likely to form when environment is less competitive, when group size is smaller, when group member experiences are more homogeneous, and when ties in the group are weaker.

Developed from the group perspective in Essay I, Essay II delves into group structure with a firm focus. It examines how a firm's previous relationships with *all* other potential group members may influence its participation in the group. Particularly, I study when a firm participates in a group with mostly unfamiliar firms. I argue that both value creation and value appropriation are important factors in network tie formation, and that firm experience has opposing effects in these two aspects. I further propose that prior relationships among potential group members may affect formation of potential coalitions, thus influencing the anticipated power distribution in the group. The anticipated power distribution inside a group will exacerbate or alleviate the uncertainty brought by an unfamiliar firm, which in turn influences the likelihood of group formation involving the unfamiliar firm. The combination of a firm focus and a group perspective enables me to explore the dynamics between one firm and other group members. Using the U.S. VC investment data (1985-2008) and a unique matched-sample generation method, I find that a firm's prior strong tie with a group member may prevent it from participating in the

same group with other unfamiliar firms, regardless of the firm's experience. Meanwhile, the likelihood of an experienced firm participating in a group with mostly unfamiliar partners is positively related to the tie strength among other group members.

Essay III examines the performance implication of group network structures. I investigate the impact of VC syndicate network structures on the likelihood of a startup company going public or being acquired. I expect positive impacts of syndicate internal density and external structural holes on startup company performance. Analyses on U.S. VC first round syndicates between 1985 and 2008 reveal significant impacts of both network structure attributes. I also find that the positive effect of syndicate internal density is greater for syndicates with four or more VC firms. Those empirical results are not found to be subject to either endogeneity bias or sample selection bias.

Overall, the three essays in my dissertation study network formation and its performance implication in the context of VC investments. These studies make important contributions in the following aspects:

First, this dissertation contributes to network formation literature. Shifting from the dyad level to the group level, this dissertation provides a new way to capture the simultaneous commitments made in alliance or syndicate formations. It helps to explain the manner in which tie formations in a group influence each other and reach equilibrium in a group formation process. In the group-level network formation, it shows the importance of environmental concerns and cooperative concerns. In the firm-level group participation, it juxtaposes the uncertainty in value creation and the

uncertainty in value appropriation. Built on the apprehension of group-level network formation behaviors, it further fills in the research gap between network formation and task performance. Thus, this dissertation improves our understanding of network formation by bringing in a brand new perspective, by uncovering group-level antecedents of network formation, by illustrating the impact of value appropriation concerns, by exploring group dynamics, and by linking network formation behaviors with task performance at the group level.

Second, this dissertation also casts light on entrepreneurship literature. It not only illustrates the antecedents of the VC syndicate formation and VC firm participation, but also demonstrates how VC syndicate network structures may influence startup company performance. By studying both the internal and external network structures of a VC syndicate and their interaction effects with other syndicates attributes, this dissertation offers a comprehensive view of syndicate density's performance implications.

Last, but not least, the network formation studies in this dissertation bridge the literature on network formation and the research on coalition. By articulating the importance of prior relationships in the coalition formation, this dissertation offers another explanation for forming coalitions. In turn, it accounts for future tie formation inside a group using the connections between coalition formation and power imbalance.

# Essay I: A Group Perspective in Network Formation: How Venture Capital Syndicates Form

## **Introduction**

Firms form many kinds of partnerships to obtain resources and manage uncertainty (Pfeffer & Salancik, 1978). For example, semiconductor firms may form alliances for R&D purposes (e.g., Stuart, 1998), investment banks may form syndicates for underwriting purposes (e.g., Baum, Rowley, Shipilov, & You-Ta, 2005), and Venture Capital (VC) firms may form syndicates to fund start-up companies (e.g., Sorenson & Stuart, 2008). Due to the prevalence and importance of partnerships, large amounts of research have been devoted to study network formation. Researchers have studied network formation at both the actor and dyad levels. Early research focused on the actor level, and found that the firm tie formation rate is influenced by firm size (Burgers, Hill, & Kim, 1993), firm performance (Burgers et al., 1993), firm internal resources and capabilities (Ahuja, 2000b; Gulati, 1999; Park, Chen, & Gallagher, 2002), firm network positions (Gulati, 1999; Powell, Koput, & Smith-Doerr, 1996; Stuart, 1998), and environmental uncertainties (Beckman, Haunschild, & Phillips, 2004; Koka, Madhavan, & Prescott, 2006).

Subsequent research made important progress by moving from the actor level to the dyad level and by focusing on partner attributes and partner selection. It was found that firms are more likely to form ties with partners with whom they have greater interdependence (complementarity), with whom they have worked before (repeated ties), with whom their partners have worked before (transitivity), to whom

they are more similar (homophily), and who have sent them tie invitations before (reciprocity) (e.g., Gulati, 1995a; Gulati & Gargiulo, 1999; Podolny, 1994; Powell, White, Koput, & Owen-Smith, 2005).

However, despite the progress of network formation literature, how groups, such as alliance, syndicates, etc., form is underexplored.<sup>1</sup> As indicated by Sorenson and Stuart (2008), applying the dyad approach to the tie formation in groups involving multiple firms has significant limitations. The dyad approach assumes the independence of focal dyadic tie formation from other participants in a group. However, many groups in the business world involve more than two firms. In the case of venture capital (VC) syndicates, about 45% of the first-round syndicates involve more than two VC firms, not counting the additional firms joining in later rounds. When forming a group, firms make participation decisions based on the identities of all other group members. Tie formation between two firms may be caused by group-level reasons related to other participants. Therefore, studying group formation using the dyad approach, which assumes tie independence, may result in incomplete understanding.

Some examples may illustrate the limitation of using the dyad approach in studying tie formation in a group. For instance, the dyad research found that distant ties were more likely to form in larger groups (Sorenson & Stuart, 2008). The argument behind this finding is that the uncertainty brought by the specific distant tie will be less in a group involving more participants. This may be true if the other ties

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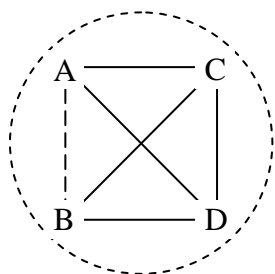
<sup>1</sup> Although Mitsushi and Greve (2009) considered the focal firm tie formation in a group regarding all other group members, theirs is not a group perspective in the sense that they still focused on “one firm versus others” observations. They did not simultaneously examine ties formed among other group members when emphasizing the ties formed between focal firms and other group participants.

in the group are mostly between past partners. However, if the two firms that form a distant tie also face other distant ties in the group, then these distant ties will be less likely to form in a larger group. The difference is exemplified by the two extreme scenarios in Figure 1.1, with two potential groups of different group sizes graphed in each scenario. As shown in Scenario A in Figure 1.1, where Firm A and Firm B are the only partners new to each other in both groups, Group (a) (a group of four) is more likely to form than Group (b) (a group of three) due to greater familiarity and less uncertainty, assuming every other thing being equal. Although group formation in Scenario A is consistent with the argument that partner-specific uncertainty can be reduced in larger groups, Scenario B, where every firm in a group is new to each other, shows the different side of the story that cannot be explained by the argument in the dyad approach. Every other thing being equal, Group (b') (a group of three) is more likely to form when compared to Group (a') (a group of four), as the coordination difficulties will be greater when the group size gets larger in a group involving more new partners. These two extreme scenarios show that tie formations in a group are correlated and all tie formations in a group should be considered simultaneously due to the correlation of ties.

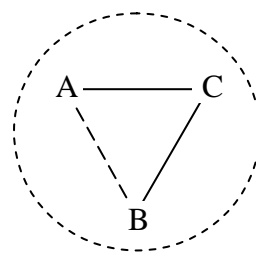


**Figure 1.1: Illustrating Examples about Group Perspective and Dyad Approach**

Scenario A:

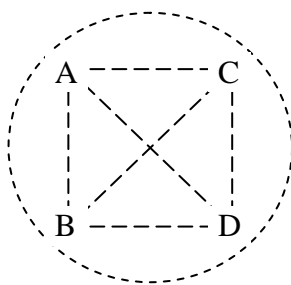


Group (a)

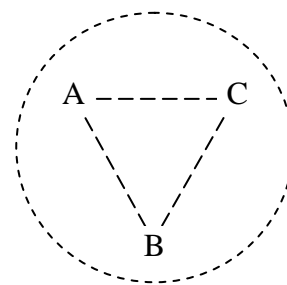


Group (b)

Scenario B:



Group (a')



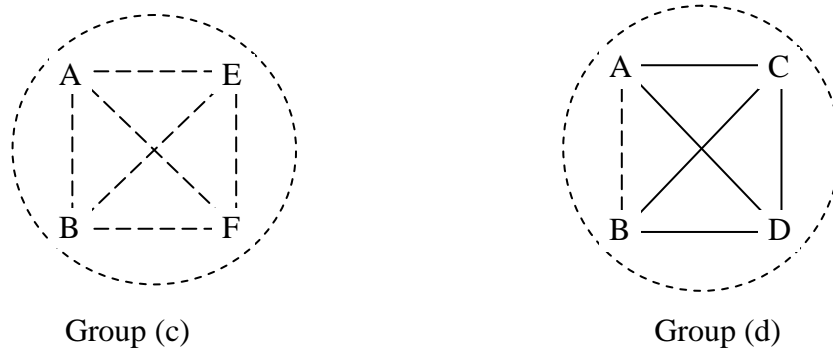
Group (b')

A solid line indicates that there is a preexisting tie between two partners.  
A dashed line indicates that no prior ties exist between two partners.

The importance of tie correlation and the limitation of the dyad approach can also be shown in another example in which the moderating effect of environment on group formation is considered. Prior literature suggested that new ties between new partners are less likely to form in a more competitive environment. However, when taking tie correlation into consideration, not every new tie formation in a group will be negatively affected by environmental competition. The impact of environmental

competition on formation of new ties depends on group context. A group involving some new ties with mostly old ties will not be similarly affected as a group involving only new ties. As shown in the example in Figure 1.2, both Group (c) and Group (d) involve Firm A and Firm B, who are new to each other. But, different from Group (c) in which all four firms are new to each other, Group (d) involves two other firms that had worked with every group member in the group. Although the new tie between Firm A and Firm B is involved in both groups, the new tie in Group (d) may not be negatively affected by environmental competition. This is because the embedded relationships involved in Group (d) may help the group adapt to greater competitive uncertainty, engage in fast decision making, and comply to the legitimacy expectation in a more competitive environment. All of these facilitate the formation of Group (d) in a more competitive environment and discourage the formation of Group (c).

**Figure 1.2: Illustrating examples about group perspective and dyad approach (Cont.)**



A solid line indicates that there is a preexisting tie between two partners.  
 A dashed line indicates that no prior ties exist between two partners.

As illustrated in the above examples, tie formations in a group are correlated and a dyadic tie formation between two firms depends not only on its own tie history,

but also on whether other firms exist in the group and whether other group members are previously connected. To take tie correlation into consideration, I adopt a group perspective to study group formation. This group perspective is different from the dyad approach in two ways. First, rather than focusing on one dyadic tie at a time, this group-level study simultaneously examines the formation of all ties involved in a group, since the formation of one tie may influence the formation of another tie within the same group. Second, from the group perspective, the path-dependence logic in network formation is demonstrated by an in-group network constructed by preexisting ties among all potential group participants. Distinct from the dyad approach, which only considers the effect of past ties related to the focal firm and/or the focal partner, the group perspective integrates the influence of previous ties among all potential group participants on group formation through in-group network structure. This group perspective takes into account that tie formation between two firms may be influenced by preexisting relationships among other firms.

Research has suggested that past interaction intensity among individuals is positively related to group solidarity (Hechter, 1978; Homans, 1950). Similarly, density among group members indicates cohesion (Provan & Milward, 1995). Due to the importance of group density, which is based on past interactions among group members, I study when do groups with various density form. Group density is defined as the proportion of preexisting ties in an in-group network among potential group members relative to their total possible ties. Group density is used to capture firms' preference for past partners due to efficiency in search and effectiveness in evaluation. The potential group members that are likely to become group participants

construct the boundary of group. Based on such group boundary, I examine the effect of group density on formation of groups together with other internal group attributes and external environmental characteristics.

I expect that both adaptation to the environment and expected internal cooperation processes matter in a group formation. Future groups will be formed in a way to better adapt to the competitive environment. The more competitive the environment, the more likely it is that firms will form denser groups to accommodate higher competitive uncertainty, facilitate fast decision making, and comply to the legitimacy expectation. Meanwhile, future groups will also be formed based on anticipated internal cooperation among potential group participants. On the one hand, the concerns of potential group participants regarding future group coordination vary with the group density of the in-group network. Greater coordination concerns due to lower density need to be mitigated by smaller group size and greater homogeneity. But, higher group density will allow group members to benefit from larger group size and heterogeneity. On the other hand, group structure with lower density may cause concerns about coalition/power imbalance in a future group when it is coexisting with some stronger ties. So, a group based on denser previous ties is expected to form to offset the possible power imbalance due to greater tie strength between some potential participants, while a group with lower density is more likely to form when existing ties are weaker. These group formation arguments were tested in this essay with VC investment data between 1985 and 2008.

Overall, this essay makes several important contributions. First, by focusing on group formation, it is able to simultaneously consider the formation of all ties in a

group and provide a brand new perspective on network formation. This is especially meaningful since the group perspective is more consistent with the real world where firms make tie formation decisions based on the identities of all group members. Second, by taking a group perspective, I am able to consider the influences of all related preexisting ties among all potential participants and offer a more complete view about both path dependence and path breaking in network formation. Unlike the dyad literature that links formation of a focal tie only with the tie histories of the focal firm and/or the focal partner, this essay shows that tie formation between two firms may be related to how other firms in a group have been previously connected. Third, the group perspective enables me to uncover group-level mechanisms, such as environmental adaptation management and internal cooperation management, which have been neglected in the dyad-level studies. Group-level logics may invite reconsideration of the findings in dyad-level research, which assumes tie independence. Fourth, this essay illuminates group formation dynamics by introducing a political-process view in tie formation. It not only links coalition arguments with social network theory, but also highlights “power imbalance” as an important contribution of resource dependence theory to the network formation literature. Fifth, I contribute a novel empirical design for quantitatively testing tie formation at a group level. By taking a group perspective, this essay contributes to the current literature both theoretically and methodologically.

### **Theory and Hypotheses**

In this section, I discuss how group density based on previous ties among potential group participants may influence group formation. I begin by connecting

group density with environmental adaptation and emphasize that groups form in a way to best adapt to the external environment. Then, I link group density with the internal cooperation process and introduce the important impact of anticipated internal cooperation processes on group formation. Two main concerns regarding internal cooperation process, coordination and coalition, are discussed in this section.

### **Group Formation and Environmental Adaptation**

Competition occurs when more firms enter into the market and compete for the limited common resources. It is a market property that is out of the control of individual firms. According to the adaptive view (e.g., Lawrence & Lorsch, 1969; Thomson, 1967), interfirm groups need to adapt to external forces to maintain viability. When competition is more intense, groups with higher density are more likely to form as they are considered as more adaptive to the competitive environment for the following reasons.

First, competitive uncertainty is one important dimension of uncertainty (Burgers et al., 1993) and more competition is often accompanied with greater environmental uncertainty. Research has found that firms tend to tie with past partners under high uncertainty (Beckman et al., 2004; Podolny, 1994). Firms faced with higher environmental uncertainty try to use “satisficing” search behaviors (March, 1988) and select partners from those firms they know best. Since firms learn more about other firms through their past relationships, firms will have preferences for the past partners especially in an uncertain environment. Research has found that repeated ties help develop trust (Gulati, 1995b) and trust matters more to alliance performance when environmental uncertainty is higher (Krishnan, Martin, &

Noorderhaven, 2006). Thus, dense groups are more likely to form as a way to respond to higher competitive uncertainty.

Second, Firms adapt to environments through strategic decision making (Swamidass and Newell 1987). In a more competitive environment, more firms compete for the limited resources. Therefore, fast decision making regarding group formation and group function becomes more important when competition is more intense. Higher trust (Coleman, 1988, 1990) and shared behavioral norm (Rowley, 1997) developed in dense networks may promote economies of time (Uzzi, 1996, 1997). The speeded decision making is demonstrated in both group formation and group function processes. That is, a dense in-group network based on preexisting ties not only facilitates the group to form in a faster way, but also helps the formed group adapt to the more competitive environment with a faster and trust-based group decision-making process. The quicker group formation and faster group decision making may enable firms in the group to obtain first-mover advantage in a more competitive environment where more firms compete for limited resources. For example, in the VC context, a syndicate with higher density may form faster to get the deal quicker than a sparse group would. Thus, dense groups are preferred in a more competitive environment due to the fast decision making in both group formation and group function.

Third, groups form in a way to adapt to the environmental expectation. Researchers suggested that firms are “farsighted” and act according to the anticipated reactions of others (e.g., Scherer, 1980). Thus, a group will be less likely to form when the external reaction is expected to be negative and future punishment is

anticipated. One important type of external reaction is related to evaluation of legitimacy and consequential responses (e.g., acceptance or sanctions) regarding the evaluation. Legitimacy, which indicates consonance with social norms or order, has been found to be important to network success (Human & Arizona, 2000). Concerns about other partners' legitimacy influence firms' tie formation behaviors such that firms are less likely to form ties that are hard to justify internally and externally (Hallen, 2008; Marquis, 2003; Meyer & Rowan, 1977). The legitimacy-related external reaction may depend on group density when the environmental competition is higher. Research suggested that legitimacy could be a desirable model of action (Johnson, Dowd, & Ridgeway, 2006; Walker, 2004). When the environment is more competitive, groups based on a dense in-group network may be perceived as the more desirable model because dense networks are able to reduce competitive entries to the focal market (Hochberg, Ljungqvist, & Lu, 2010) and the need to use a dense group network as a barrier to future entry is greater when the competitive pressure is greater. Thus, formation of lower-density groups involving more new ties may not be perceived as desirable and legitimate in a highly competitive environment. Groups with higher density are more acceptable in such an environment.

Collectively, through competitive uncertainty, pressure on decision making and legitimacy expectation, environmental competition will moderate the relationship between group density and group formation Thus,

*Hypothesis 1: The more competitive the environment, the more likely it is that firms will form groups with higher density.*



## **Group Density and Anticipated Internal Cooperation**

Group density may also influence group formation by affecting potential group participants' anticipation about internal cooperative processes. Firms may not cooperate all the time. When their own interests conflict with the common interests of group members (Khanna, Gulati, & Nohria, 1998), some group members may form a coalition to promote their own interests, sacrificing the interests of other group members. Even when firms want to cooperate with each other, they may not be able to coordinate effectively and efficiently. Since firms are often farsighted (e.g., Scherer, 1980), I expect them to take these cooperation issues into consideration during group formation. There are two main categories of concerns regarding internal cooperation: coordination and coalition.

*Coordination concerns.* Previous literature has suggested that to ensure group function properly and perform well, there is always a need for coordination and cooperation in groups (Doz, 1996; Kanter, 1994a). However, coordination difficulties are a major challenge in interfirm relationships (Litwak & Hylton, 1962). The very interdependence among organizations that makes coordination necessary (Pfeffer & Nowak, 1976) often incurs coordination difficulties due to the different goals and commitments of the organizations involved. Therefore, coordination cost and difficulties have been noticed and discussed in various network literature (e.g., Gulati & Singh, 1998; Jones, Hesterly, & Borgatti, 1997). For example, in a paper on governance structure of alliance, Gulati and Singh (1998) found that concerns regarding coordination will influence the governance structure in strategic alliances

and firms are more likely to choose a more hierarchical governance when coordination concerns are greater.

However, concerns regarding coordination may affect not only the governance structure of cooperative groups, but also the formation of such groups. A group will be less likely to form when its anticipated coordination difficulties are higher. The coordination difficulties of groups vary with group density. Since greater group density facilitates trust and exchange (Coleman, 1988) and aids in mutual coordination (McCubbins, Paturi, & Weller, 2003; Reagans & Zuckerman, 2001), fewer coordination difficulties would be expected in a higher density group. However, when group density is lower, coordination concerns among group members will increase due to greater unfamiliarity. A group will only form when other group attributes minimize the coordination concerns arising from lower group density or when coordination concerns due to other group attributes may be eased by higher density.

Multiple group attributes have been identified that correlate with coordination costs and difficulties in a group. Litwak and Hylton (1962) hypothesized that interorganizational coordination is influenced by 1) the level of interdependence between organizations; 2) organizations' awareness about their interdependence; 3) standardization of organizational activities; and 4) the number of organizations involved. Here, I focus on the coordination difficulties arising from group size and interdependence among group members.

If managed appropriately, group size may positively influence task performance of a group. Involvement of more firms may help in financial support,

risk sharing, decision making, etc. For example, Tian (2008) found that greater numbers of VC firms involved in the syndicate may help improve company performance. However, group size is also closely related to coordination needs and difficulties. According to Litwak and Hylton (1962), there is greater coordination required for larger group size. All other things being equal, coordination difficulties will increase, as a group gets larger.

With the benefits and cost of group size, I expect a group to be formed in a way to maximize benefits while reducing cost. Thus, groups formed with lower density will tend to be smaller groups, as smaller group size may help ease the greater coordination difficulties arising from lower density. Meanwhile, since trust can be a means of addressing coordination difficulties (Gulati & Singh, 1998) and trust often develops through prior relationships among organizations, higher group density may ease the coordination issues incurred by larger group size and enable groups to benefit from larger group size. Therefore, I expect,

*Hypothesis 2: The greater the group size, the more likely it is that firms will form groups with higher density.*

Firms form relationships with other firms to obtain complementary resources from their partners. The complementary resources of partners can be different sets of knowledge, skills, and insights. For example, in the VC context, knowledge and insights play an important role in deal selection and value-added processes. Although the complementary resources may bring competitive advantage (Dyer & Singh, 1998), the interdependence among partners with complementary sources may also be an important source of coordination difficulties (Litwak & Hylton, 1962).

Since different experiences of firms often accumulate different knowledge and skills (Haleblian & Finkelstein, 1999) and various knowledge and skills are often complementary, one important manifestation of interdependence is experience heterogeneity. Heterogeneity in experiences may encourage collection of new information so that group members may better support their own opinions. It may also stimulate new and creative thinking while group members are trying to reconcile their conflicting viewpoints. Thus, firms may benefit from partnering with other firms with different experiences; such diversity in experience can enhance decision making (Beckman & Haunschild, 2002). However, firms with different experiences may make different judgments and have different goals. Heterogeneity in experience requires more coordination (Litwak & Hylton, 1962) and may increase coordination difficulties due to conflicts of interest (Ancona & Caldwell, 1992; Reagans & Zuckerman, 2001).

Thus, similar to group size, experience heterogeneity is a double-edged sword. A group is more likely to be formed when the benefit group members obtained from experience heterogeneity will not be offset by the coordination difficulties arising from experience heterogeneity. Since both lower density and higher experience heterogeneity will increase coordination difficulties, the combination of lower group density and greater experience heterogeneity may exacerbate coordination problems. Coordination difficulties arising from lower group density will need to be alleviated by greater experience homogeneity, while higher group density may help with the coordination of a more heterogeneous group. Thus,

*Hypothesis 3: The higher the group experience heterogeneity, the more likely it is that firms will form groups with higher density.*

*Coalition concerns.* When strategic decisions are made in a group, it is often a political process in which conflicting views and interested need to be settled through exercise of power (Eisenhardt & Bourgeois, 1988). However, the political process is neglected in the current network literature. In this essay, I incorporate the political-process view to study group formation. I expect that the anticipated coalition formation, similar to the anticipated coordination difficulties, may also influence the formation of groups.

Coalition formation is an important phenomenon in the political process. When multiple parties are involved and no single alternative can maximize the returns of all group members, a coalition is often formed to promote the interests of its members (Gamson, 1961). Thus, a coalition is defined as “two or more parties who cooperate to obtain a mutually desired outcome that satisfies the interests of the coalition rather than those of the entire group within which it is embedded” (Polzer, Mannix, & Neale, 1998). Unlike the concept of opportunism, a coalition involves more than two parties and is a collective action of coalition members. Moreover, coalition members do not have to pursue their own interests with guile. Since formation of a coalition among a subset of group members may jeopardize the interest of other group members that are excluded from the coalition, the concerns about coalition formation in a group may reduce the likelihood of the group being formed.

Although early research on coalitions regarded them as issue-based, temporary alliances (Gamson, 1961), recent research has suggested that a coalition can be more stable than researchers originally thought and may span multiple issues (Bazerman, Curhan, Moore, & Valley, 2000; Polzer et al., 1998). Specifically, compatible interests and relationships among coalition members may increase the stability of the coalition. According to Polzer et al. (1998), parties with compatible interests are more likely to form a coalition to exclude other parties whose interests are not compatible. And, once a coalition based on compatible interests is formed, the cooperation is likely to increase the stability of the coalition and the identification of the coalition will not recede immediately after the issue is resolved.

Given that a coalition could have certain stability, in this essay I combine network theory with the coalition formation argument based on interest compatibility and previous cooperation. I argue that network ties are a possible basis for coalition formation. Coalition formation is more likely to form between firms that have stronger ties. Research in network theory suggests that trust may emerge from repeated ties (Gulati, 1995b), that trust between partners will facilitate exchange and collective actions (Coleman, 1988), and that stronger ties are often associated with low-level conflict (Krackhardt & Stern, 1988; Nelson, 1989). Thus, I expect that firms with stronger ties are more likely to have compatible interests. Moreover, repeated ties provide an effective means to judge the capability of a potential partner (Li & Rowley, 2002). The more frequently two firms form ties with each other, the more likely they are to have a history of coalition. Therefore, I expect that firms tied

strongly in a group are likely to form a coalition when there is a conflict of interest with other group members.

All other things being equal, a coalition that includes a subset of group members while excluding other group members will lead to a power imbalance in the group. Concerns about power imbalance and formation of such a coalition may prevent the group formation. Since network ties are the basis of coalition formation and a coalition is more likely to form between firms with stronger ties, such a coalition and a power imbalance is likely to occur when lower group density and stronger ties coexist in a group. When stronger ties coincide with lower group density, it is more likely for the strongly connected firms to form a coalition that exclude other group members with whom they do not have connections. On the other hand, although tie strength may facilitate the formation of a coalition, such coalition is less likely to form between firms with stronger ties and exclude other group members in a group with higher density, because network closure can also facilitate trust (Coleman, 1988, 1990) and enable “the joining of individual interests for the pursuit of common initiatives” (Reagans & Zuckerman, 2001). So, groups with higher density are less likely to be affected by the concerns about coalition and power imbalance. Thus,

*Hypothesis 4: The stronger the maximum tie strength among potential group participants, the more likely it is that firms will form groups with higher density.*

## Methodology

### Data

To study the group formation, I used the context of venture capital (VC) syndicates. VC firms often syndicate to fund start-up companies. Research has found that VC syndication can diversify risks involved in deals (Manigart et al., 2006), improve the selection process through information sharing (Lerner, 1994), and help start-up companies succeed through value-added services (Brander, Amit, & Antweiler, 2002; Tian, 2008). Equally, it has been found that syndicates carry coordination difficulties that offset some of the benefits (Wright & Lockett, 2003).

VC syndication offers a fitting context for my study for a number of reasons. First, VC investment deals often involve more than two VC firms in a syndicate, making group perspective necessary and helpful. Second, although the process of decision making regarding a syndicate formation cannot be observed, the final commitment to form a first-round syndicate is always made by the participating firms in the knowledge that every other group members will be on board.<sup>2</sup> Third, syndication is important to VC firms. Success of current investment will improve their chances for future deals. Also, research found that syndicating partners play an important role in each other's investing behaviors (Guler, 2007). Fourth, VC syndication has significant impact on start-up companies. Tian (2008), for example, found that companies backed by VC syndicates performed better than those backed

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<sup>2</sup> As discussed in the VC deal of Vermeer by Ferguson (1999), even though Matrix Partner and Sigma Partners had expressed interest in Vermeer at different point of time, each of the proposals was contingent on finding two other co-investors. It was only in the finalized first-round deal that the three VC investors, including Atlas Venture, made final commitment about the investment with the knowledge that who else will be on board and what will the share distribution look like.



by a single VC. Fifth, although VC syndication is an important phenomenon, it is still not clear how VC syndicate groups get formed. Therefore, it is necessary and interesting to dig into the formation of VC syndicates as groups.

I tested hypotheses in this essay using data on VC investments in start-up companies between 1985 and 2008. The Venture Expert database constitutes my primary data source. To prepare my analysis sample, I constructed a sample of real syndicate groups using the following procedures. First, to ensure that VC firms made participation decisions based on the identities of all of the other VC firms in the syndicate and that all VC firms in a syndicate made their final commitments simultaneously, I only focused on the first-round syndicates. A first-round syndicate is defined as a syndicate formed when a group of VCs first join each other for a specific start-up company. Second, since the main focus of VC syndicates is to back up start-up companies and dynamics of group cooperation may differ based on whether companies formed first syndicates as young or mature companies, I limited the study to U.S.-based companies that were less than ten years old. Third, since first-round syndicates that were at “Startup/Seed” stage, “Early Stage”, or “Expansion” stage accounted for 90 percent in the sample and cooperation within VC syndicates at these stages are more important, I only concentrated on the first-round syndicates at these stages and excluded those first-round syndicates at “Later Stage”, “Buyout/Acquisition” stage, or “Others” stage. Fourth, because the cross board investing behaviors of foreign VC firms are different in many ways from the investing behaviors of U.S. VC firms in the United States, I focused only on the U.S. start-up companies invested by the U.S. venture capitalists. The first round syndicates

for U.S. start-up companies that involved any foreign VC firms only accounted for less than 10 percent, so the whole syndicates that involved any foreign VC firms were excluded. Fifth, due to the difference between angel investors and VC firms, angels were excluded from the analysis. The exclusion of angels did not change the number of start-up companies included in the sample. During the period between 1985 and 2008, there were 6,216 U.S.-based companies having first-round syndicate formed by identifiable VC firms.<sup>3</sup> 4,982 of those were start-up companies less than 10 years old. 4,514 start-up companies were in “Startup/Seed” stage, “Early Stage”, or “Expansion” stage. Of those, 3,830 U.S.-based start-up companies were invested totally by U.S. VC firms.

Consistent with prior research that studies tie formation (Hallen, 2008; Jensen, 2003; Sorenson & Stuart, 2008), I adopted the choice-based sampling approach. Different from prior research on tie formation that used the choice-based sampling approach, I generated and matched hypothetical groups rather than hypothetical dyads for each start-up company. The sample of real syndicate groups is combined with a random sample of hypothetical syndicates that could have but did not form. Although I could have included all the potential hypothetical syndicate groups, including a random sample of hypothetical syndicates has two advantages. First, it is more computationally tractable. Including all hypothetical syndicates may generate computation difficulties. Second, it helps to reduce the autocorrelation among

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<sup>3</sup> Since some VC firms involved in the syndicates were identified as undisclosed firms, I dropped the first-round syndicates with any undisclosed VC firms. While generally only one or two VC firms were not disclosed, it is theoretically important to drop such rounds as the inter-group ties of the undisclosed VC firms are likely to influence the focal constructs.

analyzed groups, since each VC firm would have appeared in the sample for many more times if I had included all the possible syndicate groups.

To construct the random sample of hypothetical syndicates, I first generated a potential VC pool for each start-up company, which included all the potential U.S. VC investors that invested in the same industry, in the same state, in the same year, and the same quarter. Any VC firm in the pool could have invested in the focal start-up company. Although I realized that a hypothetical VC firm could be a VC firm that was interested in the focal start-up company but ultimately invested in another start-up company in a different state, using geographic limitation could effectively control for other possible factors that might have confounded the main focus of the essay.

After establishing the potential VC firm pool for each real investment case, I generated matched samples by randomly selecting VC firms from the potential VC pool to form hypothetical syndicate groups of the same size.<sup>4</sup> Using a random selection in such a choice-based sampling may ensure that when I selected on the dependent variable, I would not select differently on the independent variables for the real and matched samples. Based on the random selection method, a hypothetical syndicate group could be completely different from the real syndicate group, or it

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<sup>4</sup> Since a hypothetical syndicate is generated based on a random combination of potential VCs in the pool, if the size of the hypothetical syndicates for a start-up company is not controlled, hypothetical syndicates with larger size will have a greater number of combinations and account for a higher portion in the hypothetical syndicate distribution for the start-up company. This will make it difficult to select a number of representative hypothetical syndicates for the start-up company, since a random selection will result in an overrepresentation of larger hypothetical syndicates in the matched sample. Moreover, although the group size is the same for the counterfactuals and for the real syndicate of each startup company, I am still able to test the moderating effect of group size using within group variation, because the variation of group formation is due to the interaction between group density and group size. Due to all these considerations, I only generated hypothetical syndicates whose sizes are equal to that of the real syndicate for the start-up company.

could differ by just one VC firm, or two VC firms, etc.<sup>5</sup> Thus, this can be seen as a random draw from a potential syndicate population generated using ANY same-sized combination of VC firms in the pool.<sup>6</sup> For each real case, a maximum of five hypothetical syndicate groups were randomly selected.<sup>7</sup> These hypothetical syndicates were those groups that could have but did not form for the focal start-up company. Since sometimes the VC firms in the potential pool for a specific start-up company were exactly the same VC firms involved in the first-round syndicate and no extra VC firms were available, it was not possible to create any hypothetical groups for these syndicates and they were dropped from the sample. Thus, in my final sample with hypothetical groups, there were 3,349 U.S.-based start-up companies invested by U.S. VCs from 1985 to 2008, in which 42 percent companies have three or more VC firms in the first-round syndicates.<sup>8</sup> Using this sample, I examine how VC syndicates get formed for these start-up companies.

Consistent with previous research based on choice-based samples, I used a conditional logit model grouped on start-up companies to test the hypotheses (e.g., Sorenson & Stuart, 2008). The level of analysis is syndicate groups. Using choice-based sampling and conditional logit allows me to explain the probability of a group

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<sup>5</sup> Since in some cases a lead VC can be identified, I also tested the sensitivity of the matched sample by holding the identified lead VC constant in generating matched hypothetical cases. The results based on the matched sample in this method were similar to the one in which no lead VC is identified and considered.

<sup>6</sup> Since random selection of groups may generate syndicates with VC firms of different sizes, I also used different seeds in computer simulation to generate hypothetical syndicates as a verification of the sample sensitivity.

<sup>7</sup> Less than 5% of start-up companies in the sample do not have five hypothetical syndicates due to the small size of some potential VC pools. However, to verify the results, I also tested the hypotheses using a matched sample with three hypothetical syndicate groups for each real case. The results held constant.

<sup>8</sup> Although half of the sample is syndicates of two firms, it is very important to apply group perspective to such a sample. Since as long as syndicates of two are mixed with multi-firm syndicates in a sample, group perspective will help to distinguish the tie formations involved in different group contexts and take tie correlation into consideration.

of VC firms forming a syndicate for a certain start-up company. The hypothesized relationships are shown as interaction terms between syndicate density and other independent variables. Such an empirical design offers a way to ensure the simultaneous determination of syndicate density and other group attributes. Because some explanatory variables do not vary within a group, these variables will be dropped from the models and their main effects are not estimated. Although Echambadi and Hess (2007) suggested that mean-centering does not reduce multicollinearity caused by interaction terms, I used mean-centered independent variables when putting interaction terms into the regressions for interpretative purpose.

## **Measures**

*Syndicate formation.* Since I estimated the probability that a certain syndicate group will form, the dependent variable in my analysis is the formation of a specific syndicate group, with 1 referring to a syndicate group formed in reality and 0 referring to a hypothetical syndicate group.

*Syndicate density.* This essay examines group formation by focusing on the role of group density. Group density is used to illustrate how prior relationships among potential group members may influence the formation of groups. In the VC syndication context, syndicate density was measured by the proportion of preexisting ties to the possible ties in a syndicate based on tie history from 1962. A tie was established when two VC firms syndicated in the same round for the same company. Syndicate density is a continuous variable between 0 and 1.

*Industry competition.* My first hypothesis argued that the formation of groups with different density levels varies with environmental competition. Previous literature has used the number of competitors to measure the degree of competition (Baker, Faulkner, & Fisher, 1998; Sakakibara, 2002). Since this essay emphasizes the pressure from new entrants in an industry, I used the number of VC firms newly entering into the industry of the focal start-up company in the previous year to measure competition. The more entrants in the previous year coming into the industry, the more competitive the industry is. Due to the skewness of this variable, I used log-transformed industry competition. To verify the results, I also applied a second measure, which counted the total number of VC firms in the start-up company industry, in the analysis and found robust results.

*Syndicate size.* My second hypotheses claimed that groups with different density levels form in a way that coordination concerns will be managed using group size. In the VC context, syndicate size was measured by the total number of VC firms involved. The greater number of VC firms in a syndicate group indicates a larger syndicate size.

*VC experience heterogeneity.* In the third hypotheses, I proposed that groups form in a way that coordination concerns will be managed using both group density and experience heterogeneity. To calculate VC experience heterogeneity, I first calculated the standard deviation of VC firm experience within a syndicate group. However, the standard deviation of VC firm experience might vary depending on those VC firms' average experience. Therefore, following prior literature (e.g., Beckman & Haunschild, 2002), I used the coefficient of variation of VC experiences

as the measure of VC experience heterogeneity and calculated the coefficient of variation by dividing its standard deviation by its average experience. The VC experience used in the heterogeneity calculation was measured as both VC total experience and VC industrial experiences. VC total experience was calculated in three ways: the total number of companies a VC firm has invested until the previous year, the total number of deals invested until the previous year, the total number of years investing as a VC firm. Correspondently, three measures of VC industrial experience were also tested: the number of companies a VC firm invested in the focal industry of a focal company, the number of deals it invested in the focal industry of a focal company, and the number of years investing in the focal industry of a focal company. Due to the limitation of the scope, only results measured by total experience using number of companies will be shown. Results were consistent when other measures of experiences were used.

*Maximum tie strength.* My fourth hypotheses argued that groups with different density will form when coalition concerns that may be caused by strong ties is minimized. Tie strength was measured by the number of co-investments in same syndicates between any two VC firms since 1962. Maximum tie strength was then calculated as the maximum of tie strength of all pairs of VC firms in a syndicate.

*VC type heterogeneity.* In order to have a more complete view of first-round VC syndicates, I included not only independent VC firms, but also other types of VC firms, such as corporate venture capitalist, bank affiliated VCs, etc. Based on rule of homophily, VC firms of similar types are more likely to join each other in a syndicate group. So, I controlled for this effect using VC type heterogeneity. Since categorical

diversity has been measured using the entropy-based measure (Ancona & Caldwell, 1992; Joshi & Roh, 2009; Teachman, 1980), I calculated *VC type heterogeneity* as  $\sum P_i * \ln(1/P_i)$ , where  $P_i$  is the percentage of a specific VC type in a syndicate.

*Average VC geographic distance.* Since VC investments mainly focused on local market, VC firms that were close to each other geographically were more likely to join each other in syndication (Sorenson & Stuart, 2008). Therefore, I calculated average geographic distance among VC firms in a syndicate to control for this effect. Based on zip codes of VC firm offices, I found out corresponding latitudes and longitudes and then calculated the distance between two VC firms using spherical geometry. Because the variable average VC geographic distance was skewed, I used its log transformation to correct the skewness.

*Average company-VC geographic distance.* VC firms' preference on local investments also means that a group of VC firms that are close to the target company are more likely to join in a syndicate. Therefore, I calculated average company-VC geographic distance in a syndicate to control for this effect, using similar method as for average VC geographic distance. Again, I used the log transformation to correct the skewness.

*Inside indirect tie density.* Prior dyad-level research found that two firms were more likely to form a tie when there was an indirect tie between them (Gulati, 1995a; Gulati & Gargiulo, 1999; Hallen, 2008; Sorenson & Stuart, 2001). In this essay, I distinguished whether the indirect tie is through a common third party inside or outside the syndicate. To calculate inside indirect tie density, I first identified whether there is an indirect tie between a pair going through current group members. An



indirect tie exists between two firms with a geodesic distance of two. Thus, if two firms have not co-invested with each other since 1962, but each of them has invested with a common third party, then these two firms have an indirect tie. After I counted the number the indirect ties that go through current syndicate members, I calculated the proportion of such inside indirect ties by dividing it by total possible ties in a syndicate. For a syndicate of two, I assigned inside indirect tie density to be zero. Consistent with prior dyad level literature, I expect a group is more likely to form when inside indirect tie density is higher, since a firm inside the group is more likely to introduce two firms that did not have previous ties into a group.

*Outside indirect tie density.* Similarly, I calculated the proportion of outside indirect ties going through firms outside of the focal syndicate group. Again, I regard a geodesic distance of two as an indirect tie. After identifying the indirect ties through firms outside of the focal syndicate group, I calculated the proportion of outside indirect ties by dividing it by total possible ties in a syndicate. Different from prior dyad research, I expect that the likelihood of group formation will actually decrease when an indirect tie exists through firms outside of the focal syndicate group, since firms will not be willing to lose the bridging role by introducing two unfamiliar firms to tie with each other if the firm itself is not involved in the group.

*VC performance heterogeneity.* Initial Public Offering (IPO) has been the most desirable exit channel for VC firms investing in start-up companies. Therefore, the performance of a VC firm has been traditionally measured by the number of IPOs achieved by the VC firm (e.g. Gompers & Lerner, 1999). Similar to VC experience heterogeneity, I used a coefficient of variation of VC firm IPO numbers to measure

the within-group heterogeneity in performance. As suggested by the homophily argument, I expect that VC firms with similar performances are more likely to tie with each other. Since acquisition is another attractive exit for VC firms, I also calculated a second measure of VC performance using the number of acquisitions achieved by a VC firm in the previous years. The VC performance heterogeneity calculated based on VC firm acquisition performance showed consistent results.

*Company age.* Previous dyadic literature found that firms were more likely to tie with unfamiliar firms when setting uncertainty was low (e.g., Sorenson & Stuart, 2008). Expecting this effect to hold also at group level, I controlled for the effect of setting uncertainty in my estimation of group formation. Since developmental stage of a start-up company influences uncertainty level in a VC syndicate, I used company age as proxy of setting uncertainty (Hallen, 2008). Typically, an older company indicates a more developed stage, while a younger age represents an undeveloped stage.

## **Results**

Tables 1.1 and 1.2, respectively, show the descriptive statistics and the correlation between any two variables in my sample. As shown in Table 1.1, there is about 1% missing values in the variable average company-VC geographic distance and 3.6% missing observations in the variable average VC geographic distance.

Although the proportion of missing value is very low, I still controlled for the possible effect of these missing values by generating dummy variables to identify the missing observations on each variable. This is because deleting the observations with missing values may leave some companies with only real syndicate observations or

with only hypothetical syndicates groups. In that case, in order to use this choice-based sample I would have had to exclude all the companies missing either hypothetical groups or real syndicate groups, which might have incurred a greater amount of data loss.

**Table 1.1: Descriptive Statistics**

	Obs	Mean	Std. Dev.	Min	Max
Syndicate formation	19683	0.170	0.376	0	1
Syndicate density	19683	0.258	0.383	0	1
Industry competition	19683	3.674	1.065	0	5.938
Syndicate size	19683	2.661	1.003	2	11
VC exp heterogeneity	19683	0.953	0.435	0	3
Max tie strength (ln)	8250	1.046	1.146	0	4.804
VC type heterogeneity	19683	0.358	0.376	0	1.792
Avg VC geograhic dist (ln)	18978	5.877	2.250	0	8.511
Avg com-VC geo dist (ln)	19551	5.947	1.711	0	7.905
Inside indirect tie density	19683	0.022	0.078	0	0.600
Outside indirect tie density	19683	0.443	0.429	0	1
VC perf heterogeneity	19683	0.940	0.687	0	3
Company age	19683	1.614	2.015	0	10

**Table 1.2: Correlation Table**

		1	2	3	4	5	6	7	8	9
1	Syndicate formation	1.000								
2	VC type heterogeneity	-0.067	1.000							
3	Avg VC geograhic dist (ln)	-0.123	0.044	1.000						
4	Avg VC geo dist miss dummy	0.002	0.055	-0.411	1.000					
5	Avg com-VC geo dist (ln)	-0.140	0.071	0.705	-0.097	1.000				
6	Avg com-VC geo dist miss dummy	0.002	0.016	-0.029	-0.061	-0.079	1.000			
7	Inside indirect tie density	0.048	-0.039	-0.025	0.000	-0.019	0.001	1.000		
8	Outside indirect tie density	-0.142	0.013	0.054	-0.009	0.047	0.009	-0.063	1.000	
9	VC perf heterogeneity	-0.039	-0.023	0.026	-0.004	0.040	-0.020	-0.013	0.146	1.000
10	VC exp heterogeneity	-0.020	0.063	0.031	0.000	0.027	-0.012	-0.076	-0.065	0.340
11	Syndicate density	0.175	-0.103	-0.102	-0.017	-0.069	-0.016	0.205	-0.560	-0.026
12	Syn density*Company stage	-0.044	0.022	0.011	0.011	0.020	0.009	0.003	0.020	-0.001
13	Syn density*Ind competition	0.015	0.016	0.003	-0.004	-0.003	0.003	-0.010	0.142	0.042
14	Syn density*Syndicate size	-0.040	0.037	0.059	0.016	0.035	0.018	0.212	0.347	-0.033
15	Syn density*Exp heterogeneity	-0.053	0.056	0.031	0.023	0.024	0.008	0.013	0.357	0.035
16	Max tie strength (ln)	0.189	-0.125	-0.088	-0.012	-0.057	-0.013	0.227	-0.394	-0.072
17	Syn density*Max tie strength	0.179	-0.104	-0.078	-0.009	-0.049	-0.008	0.110	-0.308	-0.103

		10	11	12	13	14	15	16	17
10	VC exp heterogeneity	1.000							
11	Syndicate density	-0.254	1.000						
12	Syn density*Company stage	0.015	-0.032	1.000					
13	Syn density*Ind competition	0.041	-0.144	-0.030	1.000				
14	Syn density*Syndicate size	0.097	-0.544	-0.002	0.060	1.000			
15	Syn density*Exp heterogeneity	-0.007	-0.384	0.023	0.115	0.320	1.000		
16	Max tie strength (ln)	-0.250	0.742	-0.045	-0.122	-0.222	-0.305	1.000	
17	Syn density*Max tie strength	-0.224	0.518	-0.058	-0.174	-0.112	-0.358	0.711	1.000

Before testing the hypothesis in the essay, I first show five baseline models using conditional logit regressions in Table 1.3. As expected, VC type heterogeneity, average com-VC geographic distance, and average VC geographic distance all negatively influence syndicate formation. While the non-significance of average com-VC geographic distance missing dummy suggests that missing values in the variable of average com-VC geographic distance will not influence the results, the average VC geographic distance missing dummy is significant and successfully captures the potential effect of missing values in the variable average VC geographic distance. Consistent to my expectation, I find that inside indirect tie density has a positive effect on the formation of syndicates, while outside indirect tie density has a negative impact. These interesting results are another evidence of tie correlation. It shows that a firm joining a group is more likely to introduce two firms that did not have previous ties into the group, while a firm outside of the focal group is less likely to do so. Firms are not willing to forego their 'bridging' role by introducing two unfamiliar firms to form ties with each other if they themselves will not be involved in the group.

**Table 1.3: Baseline Models**

	Model_1	Model_2	Model_3	Model_4	Model_5
	b/se	b/se	b/se	b/se	b/se
DV: Syndicate formation					
VC type heterogeneity	-0.413*** (0.060)	-0.404*** (0.060)	-0.409*** (0.060)	-0.356*** (0.060)	-0.353*** (0.060)
Avg VC geograhic dist	-0.064*** (0.013)	-0.063*** (0.013)	-0.064*** (0.013)	-0.048*** (0.013)	-0.049*** (0.013)
Avg VC geo dist miss dummy	-0.396** (0.125)	-0.393** (0.125)	-0.394** (0.125)	-0.291* (0.126)	-0.286* (0.126)
Avg com-VC geo dist	-0.132*** (0.018)	-0.132*** (0.018)	-0.131*** (0.018)	-0.140*** (0.018)	-0.139*** (0.018)
Avg com-VC geo dist miss dummy	-0.395 (0.475)	-0.410 (0.475)	-0.420 (0.475)	-0.273 (0.486)	-0.239 (0.489)
Inside indirect tie density	1.139*** (0.262)	1.090*** (0.263)	1.101*** (0.263)	0.545* (0.267)	0.554* (0.267)
Outside indirect tie density	-0.845*** (0.051)	-0.850*** (0.051)	-0.838*** (0.051)	-0.384*** (0.066)	-0.383*** (0.066)
VC exp heterogeneity		-0.105* (0.048)	-0.079 (0.051)	0.194*** (0.058)	0.198*** (0.058)
VC perf heterogeneity			-0.051 (0.035)	-0.152*** (0.036)	-0.153*** (0.036)
Syndicate density				0.809*** (0.071)	0.807*** (0.071)
Syn density*Company stage					-0.116*** (0.026)
chi2 df_m	718.086	722.891	725.059	857.455	877.902
N	19683	19683	19683	19683	19683
p	8.70E-151	8.40E-151	2.80E-150	9.10E-178	3.50E-181
ll	-5549.854	-5547.452	-5546.367	-5480.170	-5469.946
r2_p	0.061	0.061	0.061	0.073	0.074

+  $p < .1$ , \* $p < .05$ ; \*\*  $p < .01$ ; \*\*\*  $p < .001$ .

Furthermore, results of both experience heterogeneity and performance heterogeneity agree with my previous discussion. Although VC experience heterogeneity is negatively related to group formation in Model 2, the coefficient turns out to be positive and consistent with my expectation after syndicate density and VC performance heterogeneity are controlled in Model 4. Consistent to the findings in the dyad-level research, I find syndicate density increases the probability of syndicate formation. Based on previous literature, setting uncertainty as measured by company age is also controlled in Model 5. Syndicates with lower density are more likely to form in older start-up companies where setting uncertainty is lower, while higher density syndicates are likely to be formed when startup companies are younger.

Based on baseline models, I tested the hypotheses using conditional logit regressions and show the results in Table 1.4. From Model 6 to Model 9, I added independent variables and their related interaction terms one at a time. The main effects of independent variables are not shown in the models, since they were dropped out of the regressions due to lack of variation within groups. In Model 10, variables related to the first three hypotheses were inputted, while variables regarding hypothesis 1-4 were all included in Model 11. Since hypothesis 4 only applies for groups with three or more firms, Model 11 only included syndicates with three or more VC firms.

**Table 1.4: Hypothesis Testing**

	Model_6	Model_7	Model_8	Model_9	Model_10	Model_11
	b/se	b/se	b/se	b/se	b/se	b/se
DV: Syndicate formation						
VC type heterogeneity	-0.356*** (0.060)	-0.346*** (0.061)	-0.358*** (0.060)	-0.206* (0.090)	-0.353*** (0.061)	-0.216* (0.090)
Avg VC geograhic dist	-0.049*** (0.013)	-0.050*** (0.0132)	-0.049*** (0.013)	-0.052+ (0.031)	-0.050*** (0.013)	-0.053+ (0.031)
Avg VC geo dist miss dummy	-0.281* (0.126)	-0.302* (0.126)	-0.293* (0.126)		-0.302* (0.126)	
Avg com-VC geo dist	-0.139*** (0.018)	-0.138*** (0.018)	-0.139*** (0.018)	-0.171*** (0.042)	-0.138*** (0.018)	-0.171*** (0.042)
Avg com-VC geo dist miss dummy	-0.234 (0.491)	-0.300 (0.490)	-0.241 (0.489)	-1.382 (0.913)	-0.298 (0.492)	-1.395 (0.921)
Inside indirect tie density	0.534* (0.267)	-0.267 (0.288)	0.486+ (0.268)	0.061 (0.299)	-0.343 (0.289)	-0.105 (0.303)
Outside indirect tie density	-0.408*** (0.066)	-0.395*** (0.065)	-0.416*** (0.067)	-0.889*** (0.139)	-0.444*** (0.066)	-0.969*** (0.140)
VC perf heterogeneity	-0.158*** (0.036)	-0.135*** (0.037)	-0.157*** (0.036)	-0.132* (0.058)	-0.143*** (0.037)	-0.125* (0.058)
VC exp heterogeneity	0.194*** (0.058)	0.205*** (0.058)	0.179** (0.058)	0.312** (0.106)	0.188** (0.058)	0.317** (0.106)
Syndicate density	0.808*** (0.071)	1.132*** (0.082)	0.843*** (0.072)	0.771*** (0.217)	1.161*** (0.082)	0.452+ (0.235)
Syn density*Company stage	-0.111*** (0.026)	-0.110*** (0.026)	-0.117*** (0.026)	-0.119* (0.059)	-0.105*** (0.026)	-0.101+ (0.059)
Syn density*Ind competition (H1)	0.266*** (0.060)				0.281*** (0.060)	0.451*** (0.134)
Syn density*Syndicate size (H2)		0.752*** (0.094)			0.751*** (0.094)	0.606*** (0.182)
Syn density*Exp heterogeneity (H3)			0.359** (0.120)		0.250* (0.122)	0.614* (0.302)



**Table 1.4: Hypothesis Testing (Cont.)**

Max tie strength				0.171*** (0.045)		0.137** (0.046)
Syn density*Max tie strength (H4)				0.152 (0.097)		0.244* (0.106)
chi2 df_m	897.609	944.656	886.825	474.608	971.538	504.099
N	19683	19683	19683	8250	19683	8250
p	1.90E-184	1.50E-194	3.90E-182	5.58E-94	2.00E-198	7.68E-98
ll	-5460.092	-5436.569	-5465.485	-2236.514	-5423.128	-2221.769
r2_p	0.076	0.080	0.075	0.096	0.082	0.102

+  $p < .1$ , \* $p < .05$ ; \*\*  $p < .01$ ; \*\*\*  $p < .001$ .

Industry competition was introduced in Model 6. In Hypothesis 1, I argued that a densely connected group is more likely to form when environment is more competitive. As indicated in Model 6, Model 10 & 11, Hypothesis 1 is supported. The interaction term between syndicate density and industry competition is positive and significant in all three models. Based on Model 6, increasing group density from 0.4 to 0.6 when industry competition is one standard deviation above the mean will increase the likelihood of group formation by one third compared to when industry competition is at the mean.

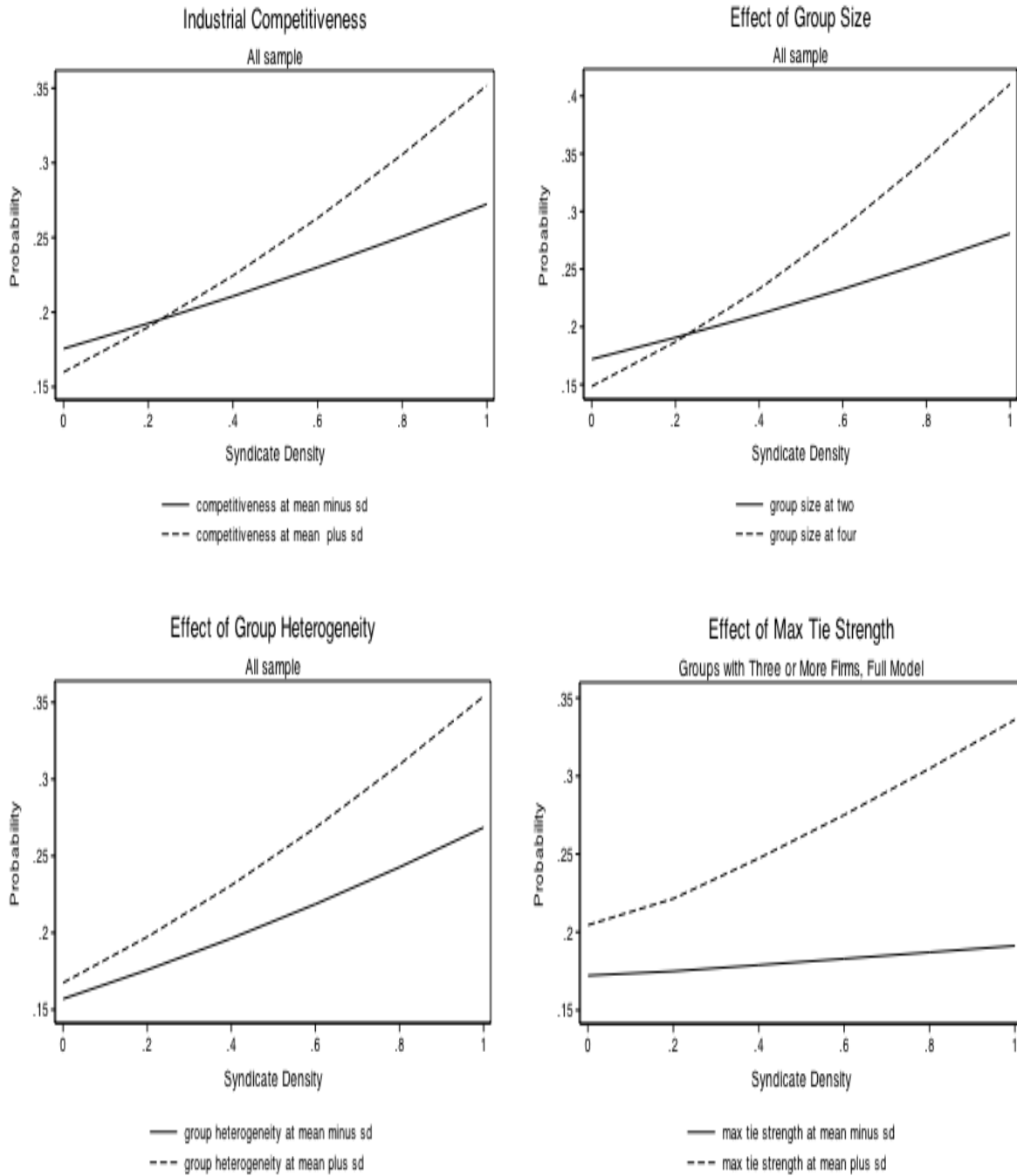
Model 7 added the interaction between syndicate density and syndicate size. According to Hypothesis 2, firms need to balance increasing coordination difficulties arising from larger group size and caused by lower group density in a group formation. Thus, syndicates with higher density are more likely to be in larger groups, while syndicates with lower density are more likely form with a smaller number of participants. Consistent with my expectation, I find support for Hypothesis 2 in Models 7, 10 and 11. With a one-unit increase of group size, the formation likelihood of a group with a density of 0.6 would increase more than two times as much as a group with a density of 0.4.

In Model 8, I introduced the interacting effects of syndicate density with VC experience heterogeneity. As expected in hypothesis 3, I find that the greater the VC experience heterogeneity, the higher the formation likelihood of denser groups. Although only results based on experience measured by total number of companies a VC firm has invested before is shown in Models 8, 10 and 11, all other experience measures yielded the same results. Based on Model 8, when the syndicate density

increases from 0.4 to 0.6, the increase in group-formation probability when VC experience heterogeneity is one standard deviation above the mean is 30 percent more than when it is at the mean.

In Model 9 the interacting term between maximum tie strength and syndicate density was included. In Hypothesis 4, I argued that the greater the maximum tie strength among potential group participants, the more likely to form a group with higher density. Although this effect was not significant in Model 9, I found support for this hypothesis in Model 11. If maximum tie strength among potential group participants increases by one standard deviation, then the increase in probability of formation of a group with a density of 0.6 is one and a half times that of a group with a density equal to 0.4. Following the suggestions of Hoetker (2007), I graphed the interaction effects in the four hypotheses in Figure 1.3. As expected, the graphs show support for my hypothesis.

**Figure 1.3: Interaction Effect in Hypothesis Tests**



To verify the effect of industry competition, I conducted some additional analyses. First, industry heat is positively correlated with industry competition. It could be that industry heat, rather than industry competition, is influential. To ensure the effect of industry competition and distinguish it from industry heat effect, I included industry heat in my analysis. Industry heat was measured in two ways: 1) the total number of companies receiving VC funding in the start-up company industry in the previous year (i.e., industry heat - company); 2) the total number of IPOs in the start-up company industry in the previous year (i.e., industry heat - IPO). I tested the effect of industry competition and industry heat based on Model 6, Model 10, and Model 11. Using both measures, I found that the moderating effect of industry heat was significant when put in the regression without the interaction term between industry competition and syndicate density, but lost significance when the latter is added. This provides some support to my industry competition argument.

Second, another alternative explanation could be that the greater the competitive entries in the previous year, the greater the availability of past partners. In order to rule out this alternative explanation, I also measured industry competition using the number of entries in the focal year. Again, the hypothesized relationship held constant.

A third analysis regarding industry competition effect tested the composition of syndicates in a more competitive environment. I used entrant percentage, i.e., the percentage of new VC entrants to the start-up company industry in the focal syndicate, as the measure of syndicate composition. I tested not only the effect of the interaction term between entrant percentage and industry competition, but also the

effect of the interaction of their square terms. I found that the new entrant percentage in a syndicate in high competitive environment was either lower or higher. This is consistent with my argument about environmental competition and legitimacy expectation, since a higher percentage of entrants also suggested that incumbents use denser groups to reduce competitive entries so that new entrants have to syndicate among themselves to enter the industry of the start-up company. This effect held even after I added the interaction term between industry competition and syndicate density. When similar analysis was conducted based on Model 11 or groups with more than two VC firms, the inverted U effect disappeared. Thus, only in syndicates of two will new entrants with previous connections form a dense syndicate in a new industry when environment is more competitive.

To test how the hypothetical relationships may vary with group size, I conducted separate analyses on subsamples with syndicate sizes equal to two, three, or four and greater than four. As shown in Table 1.5, the two dummy variables that are responsible for controlling for the effect of missing values on geographic distance variables were dropped in some models due to high collinearity. Interestingly, industry competition is only associated with the new syndicate relationship formation in smaller syndicate groups with two or three VC firms, but not in larger syndicate groups. A possible explanation could be that it is easier for firms to quickly form and operate a smaller dense group with past partners in a more competitive environment. Larger groups with higher density will take longer to form and make strategic decisions, which may to some extent offset the benefits of higher density in a competitive environment. Also, in a smaller group in which only two or three VC

firms participate, forming new ties is even more provocative in a highly competitive environment. Therefore, it is not too surprising to find that industry competition only has a moderating effect in a smaller group. Another interesting result is about the interaction effect between VC experience heterogeneity and syndicate density. This relationship is only significant in larger groups with four or more VC firms, which indicates that interdependence may only increase coordination difficulties when the group size is larger. Coordination difficulties due to interdependence among group members are easier to manage in smaller groups, even when the group density is lower.

**Table 1.5: Separate Analysis Based on Subsamples**

	Model_12 Group of Two b/se	Model_13 Group of Three b/se	Model_14 Group of Four or more b/se
DV: Syndicate formation			
VC type heterogeneity	-0.466*** (0.083)	-0.275* (0.112)	-0.071 (0.156)
Avg VC geograhic dist	-0.044** (0.015)	-0.051 (0.033)	-0.071 (0.093)
Avg VC geograhic dist miss dummy	-0.242+ (0.129)		
Avg com-VC geo dist	-0.130*** (0.020)	-0.179*** (0.046)	-0.122 (0.111)
Avg com-VC geo dist miss dummy	0.110 (0.531)	-1.662 (1.021)	10.117 (595.893)
Outside indirect tie density	-0.293*** (0.076)	-0.707*** (0.162)	-1.882*** (0.293)
VC exp heterogeneity	0.133+ (0.069)	0.216+ (0.128)	0.545** (0.194)
VC perf heterogeneity	-0.152** (0.047)	-0.174* (0.072)	-0.064 (0.100)
Syndicate density	0.721*** (0.082)	0.736** (0.246)	0.230 (0.756)
Syn density*Company stage	-0.104*** (0.029)	-0.048 (0.066)	-0.325* (0.131)
Syn density*Ind competition	0.243*** (0.068)	0.455** (0.151)	0.395 (0.299)
Syn density*Exp heterogeneity	0.214 (0.135)	0.559 (0.344)	1.221+ (0.653)
Inside indirect tie density		-0.159 (0.370)	0.177 (0.541)
Max tie strength		0.181** (0.059)	0.088 (0.077)
Syn density*Max tie strength		0.140 (0.123)	0.459* (0.215)
Syn density*Syndicate size			0.504 (0.348)
chi2 df_m	522.867	322.684	213.131
N	11433	5286	2964
p	3.00E-104	2.17E-60	4.51E-37
ll	-3173.646	-1425.253	-780.657
r2_p	0.076	0.102	0.120

+  $p < .1$ , \* $p < .05$ ; \*\*  $p < .01$ ; \*\*\*  $p < .001$ .



## **Discussion and Conclusion**

In this essay, I examine how inter-firm groups get formed. Unlike the prior literature that focused on dyad level, I study group formation from a group perspective. The dyad-level research has assumed focal ties independent of other group participants. In this essay, I take into consideration the fact that one tie formation may influence the formation of another tie in the same group and simultaneously examine all tie formation involved in a group. Further, different from the dyad-level research that only focused on tie histories of the focal firm and/or the focal partner, this essay emphasizes that one tie formation might be related to the tie histories among other partners in the group. So, it examines the impact of prior relationships among all potential group members. Specifically, It explains how potential group members may get together either through path dependence or path breaking and how group density based on the prior ties among potential group members may influence group formation together with external or internal situations. Using venture capital investment data from 1985 to 2008, I find that syndication groups are formed in a way that better adapts to the environment and better manages the internal cooperation.

Connecting group density with environmental adaptation, I argue that the more competitive the environment, the more likely it is that firm will form a group with higher density, since higher density helps the group adapt to greater competitive uncertainty, engage in fast decision making, and comply to the legitimacy expectation in a more competitive environment. Although the prior research at the dyad level has suggested that firms are less likely to form a new tie with new partners when

environment is more competitive, no empirical evidence is provided. More important, dyadic research neglected one important issue—not all new ties between new partners will be influenced by environmental competition. The negative influence of environment on new tie formation depends on the group situation, i.e., whether there are other firms involved in the group and how other group participants are previously connected. I argue that firms' greater preference for past partners in a more competitive environment comes from higher group density. It is high-density groups that may reduce partner-specific uncertainty and facilitate fast decision making; past ties in a low-density group will not be very helpful in uncertainty reduction and speeded-up decision making. Furthermore, it is the new tie formation involved in a lower-density group that may be negatively influenced by legitimacy judgment when competition is greater. Groups with higher density are perceived to be more legitimate when dense networks are expected as entry barriers.

Besides the linkage with environmental adaptation, I also link group density with internal cooperation process. I argue that group density may influence both cooperation difficulties and cooperation willingness. First, group density may demonstrate different levels of coordination difficulties such that important group attributes, e.g., group size and group heterogeneity, will have to be simultaneously adjusted in a group formation to minimize coordination difficulties. Thus, groups with lower density will form in smaller groups or groups with less heterogeneity, since coordination difficulties arising from lower density can be eased by smaller group size or group homogeneity. Groups with higher density will form in larger

groups or more heterogeneous groups, as higher density can improve the coordination issues caused by larger group size or greater heterogeneity.

Although the impact of group size on tie formation has been studied on a dyadic level, group level analysis in this essay has shown a completely different prediction. Also using VC investment data, Sorenson and Stuart (2008) found that distant ties between two VC firms were more likely to form in larger syndicates, since the uncertainty brought by the distant focal partner would be smaller when group size was larger. However, when shifting the analysis from a dyadic level to a group level, I found that the smaller the group size, the more likely it is for firms to form groups with lower density. The reason behind the different predictions was the coordination issue arising from tie correlation. Since all tie formations in a group are correlated and the group is the unit to pursue certain tasks, coordination is an important issue at the group level. Coordination between two partners is less meaningful when there are other firms involved in the same group. When coordination at group level and tie correlation in a group are taken into consideration, groups with lower density will be more likely to form in smaller groups, not in larger groups.

Different from the finding regarding group size, the finding about group heterogeneity is consistent with the homophily hypothesis prevailed in dyadic level studies. However, despite the seemingly similar predictions, I believe that the driver under the relationship is coordination concerns, rather than simply homophily. If homophily is the underlying reason, then I should not have found the positive main effect of experience heterogeneity. This argument is also supported by the separated analysis based on subsamples of different group sizes. If homophily is the reason

behind the relationship between group heterogeneity, group density, and group formation, the results should hold in all regressions with different group size. The fact that group heterogeneity only matters in larger groups implies that coordination difficulties are the source of this effect, since coordination difficulties arising from group heterogeneity and interdependence increase with group size.

Second, group density may also incur concerns regarding coalition formation and power imbalance. Since network ties are a basis of coalition formation and strong ties may foster the formation of coalition, the coexistence of lower density and stronger ties may cause power imbalance. Thus, groups with higher density are more likely to form when stronger ties exist, while groups with lower density may form as weak ties coincide. Such network dynamics cannot be studied using the dyad approach. By including multiple relationships and multiple parties in the study, this essay displays dynamics in network formation by focusing on the coalition formation within groups. The coalition argument in this essay suggests that competition and cooperation can coexist simultaneously and interplay with each other. Often when firms cooperate to benefit from resource interdependence, they still keep competition and power relationships in mind.

In sum, this essay enhances our understanding of network formation. Taking a group perspective, this essay provides a way to capture the simultaneous commitments made in alliance or syndication formation and to examine how previous relationships among all group members may influence group formation. The group perspective enables me to reveal the group level logics that have been neglected in previous dyad research. Equally, it offers an effective way to dig into the formation of

certain group attributes, such as group density, which are important to group outcomes.

While contributing to the understanding of tie formation from a group perspective, this essay also highlights some important aspects of resource dependence theory that has been neglected in network formation literature. According to Casciaro and Piskorski (2005), the resource dependence theory has two aspects, mutual dependence and power imbalance. However, current dyadic literature in social network formation only emphasizes the mutual dependence side and argues that firms are more likely to tie with partners that have complimentary resources. Although the mutual dependence argument of resource dependence theory has helped our understanding of tie formation, it undermines the contribution of resource dependence theory to network formation literature. Taking a group perspective, this essay is able to demonstrate the impact of power imbalance on network formation with the illustration of coalition formation argument.

Moreover, this essay also makes theoretical contribution by linking two important theoretical perspectives in network formation literature, resource dependence theory and social network theory. In the dyadic literature, while resource dependence theory has been adopted to explain the needs of tie formation, social network theory has been used to address the concerns in tie formation. However, the coalition argument in this essay bridges the two theoretical perspectives by suggesting the role of the social network in coalition formation and by linking coalition with power imbalance in a group.

Besides its contribution to network formation theory, this essay also contributes to the entrepreneurship literature by examining the formation of first-round syndicates. VC syndicates have been an important phenomenon in the VC industry, but little is known in terms of how VC firms get together in the first place to back up a specific company. This essay focuses on an important group attribute, syndicate density, and explains how VC firms form syndicates. A clear and more complete understanding of how syndicate groups form will help VC firms become more conscious about how different factors may combine to influence the formation of network relationships. This essay suggests that VC firms exploring network relationships need to pay attention to environmental adaptation, coordination difficulties, and potential coalition issues.

This essay has some limitations. First, the theoretical argument made in this essay has some boundary conditions. It only applies to the groups that are formed for certain business tasks and for a long-term purpose by several cooperating firms. It may not apply to the groups formed purely for learning purpose and superficial alliances, such as a research and development consortium. Second, the start-up company sample used in the essay may have limitations. To ensure firms make simultaneous final commitment regarding syndicate participation, I only focused on the companies having VC syndicates in their first rounds. Since it is possible that companies of higher qualities will be able to get more VC firms involved and companies backed up by a single VC in the first round may be relatively lower in quality, the companies included in the sample may be of higher quality on average. Third, by taking a group perspective, I focused only on the overall group density, but

could not identify how the group density was distributed within the group and how a firm's connections interplayed with its characteristics as well as other group members' attributes. In the future, it is also interesting to take a closer look of inside the group to understand how the within-group distribution of prior ties may influence network formation.

This essay also creates interesting opportunities for future research. First, future research may add context-rich qualitative evidences to the study of group formation. For example, anecdotal comments or stories in the VC industry may help our understanding of the process of syndicate formation. Second, based on the arguments about competition and group density, I may further explore how participating in groups of lower density may influence firms' future tie formation. For example, it is interesting to examine whether simultaneously tying with too many new partners will lead to cut off of past ties as well as less invitations from past partners, and whether such associations will be moderated by competition pressure. Or, future study may test whether the intensive competition among VC firms in a state or industry area may increase the average density of VC syndicates in the following year. Third, the hypothetical groups generated in this essay have the same group size as the real case syndicate. Although the combination of various group density levels and certain group size enables the test of their interaction effect, we may generate hypothetical groups varying in group size for a certain real syndicate group. This adaptation has meanings in two folds. On the one hand, it may validate the results I obtained in this essay. On the other hand, it will enable the test of main effect of group size on group formation. Fourth, future research may further verify the

positive interaction effect between group density and group size on group formation using a different design. This essay suggests that the formation of one new tie is related not only to the group size, but also to the other tie formations simultaneously involved in the same group setting. When the other ties in the group are mostly between past partners, a new tie is more likely to form in a larger group. However, while the other ties in the group are also between new partners, a new tie is more likely in a smaller group. Thus, future research may test the moderating effect of group size and group setting on the formation of a dyadic new tie. Fifth, in this essay, I controlled for the different effects of indirect ties depending on whether the third party is a potential group member. Subsequent research may empirically compare and contrast these effects with those found in earlier dyadic studies and nail down the specifics that cause such difference. Last, but not the least, VC syndicates are formed for specific startup companies. Founders of startup companies often play an important role in the syndicate formation. Therefore, it is interesting to examine how founders' backgrounds may influence the formation of VC syndicates.

Overall, this essay contributes to both the network formation literature and the research in entrepreneurship. With the novel empirical design, the new group perspective enables me to take tie correlation into consideration, uncover group-level formation mechanisms, and dig into group dynamics. Guided by the group perspective, the findings in this essay greatly enhance our understanding of syndicate formation of VC firms.



## Essay II: Uncertainty in Value Creation and Value

### Appropriation: Group Participation of an Unfamiliar Firm

#### **Introduction**

Essay I has examined when firms form cooperating groups with various group density. Although the group perspective enables me to take tie correlation into consideration and study multiple tie formations simultaneously, using a group perspective alone may overlook some interesting specifics inside a group. Thus, in this second essay, I study group formation by combining a firm focus and a group perspective.

Previous studies have found that firms prefer to form alliance or syndicates with the partners they worked with before (e.g., Gulati, 1995a; Gulati & Gargiulo, 1999; Li & Rowley, 2002). Despite this preference for past partners and repeated ties, research suggested that there are also benefits from partnering with new partners and, thus, firms are sometimes motivated to explore new ties (Baum et al., 2005; Lavie & Rosenkopf, 2006). Some of the factors that have been found to drive the formation of inter-firm ties with new partners are: firm-specific uncertainty, firm-specific absorptive capacity, and firm performance. Firms facing high firm-specific uncertainty are more likely to form new ties (Beckman et al., 2004). Firms that accumulate absorptive capacity through working with old partners are likely to leverage this experience through tie formation with new partners (Lavie & Rosenkopf, 2006). Further, firms become more open to new partners when their performance is below historical or social expectations (Baum et al., 2005).

However, because firms cannot use their prior experience to evaluate the capability and reliability of new partners, they face higher uncertainty when tying with new partners. To reduce the uncertainty involved in tie formation with new partners, firms often use network background of a potential partner and their similarity (homophily) with potential partners as criteria to choose new partners with less uncertainty. For example, Powell, White, Koput, and Owen-Smith (2005) studied the network expansion of dedicated biotech firms and found that when starting new tie attachment with unfamiliar firms of the same type, dedicated biotech firms were more likely to choose those most-connected firms. Using various homophily measures such as co-location, size-difference, etc., they also found that homophily usually held strongly in tie formation with new partners. Likewise, Shipilov, Rowley and Aharonson (2007) studied how investment banks initiate and terminate ties and found that it was more likely for investment banks to tie with new partners that they were indirectly connected through third-party ties or from same network cliques. In addition, they discovered that unfamiliar investment banks similar in both status and level of specification were more likely to form new ties with each other.

Besides selecting new partners with less uncertainty, firms also tend to tie with new partners in less uncertain settings. Sorenson and Stuart (2008) argued that different settings influence the perceived need for familiarity and trust, thus impacting the characteristics of the ties. Using VC syndicates as their settings, they found that socially or industrially distant ties are more likely to form in less uncertain settings, such as syndicates for more mature companies, syndicates with smaller size, or syndicates involving a greater number of past partners.

Despite the important contributions of these studies, there are still some limitations in the existing research. First, the current literature on new tie formation only focuses on the dyad formation involving partners new to each other. However, in a multi-firm group, a partner may be new to more than one firm. Then, the uncertainty brought by the partner is not determined by the partner's relationship with one firm alone. Instead, the uncertainty and unfamiliarity brought by a partner may vary with the partner's relationships with all other firms. Only when we consider all ties together can we better understand the impact of partner uncertainty on tie formation.

A second limitation in the current literature is related to setting attributes. In the prior research (Sorenson & Stuart, 2008), setting uncertainty has largely been regarded as predetermined before tie formation. However, in a setting involving multiple firms, setting uncertainty could co-evolve with the tie formation in the setting. Once group members are assumed, the uncertainty in the setting will be determined. Meanwhile, the group will be finalized if setting uncertainty is considered under control. Therefore, the uncertainty brought by a new partner interacts with the setting uncertainty to influence group formation. The tie formations in a group co-evolve with the setting uncertainty. Such co-evolution and in-group dynamic have been overlooked in the prior literature, but the impact of uncertainty brought by a new partner should not be examined assuming it is isolated from the ties among other partners.

Third, partner uncertainty is not only related to value creation, but also related to value appropriation. There are costs associated with partnering and partner value

appropriation may undermine a firm's performance despite the initial purpose of partnership (Bae & Gargiulo, 2004; Lavie, 2007). Thus, it has been found that ties are more likely to form when there are appropriate defense mechanisms to avoid misappropriation (e.g., Gulati & Singh, 1998; Katila, Rosenberger, & Eisenhardt, 2008), and firm network background has been used as an implicit way to address possible misappropriation from new partners (Chung, Harbir, & Lee, 2000; Gulati, 1995a). However, these studies, due to the focus on dyads, have overlooked group network structure as an important defense mechanism. Group network structure, as the immediate setting, may influence partner value appropriation through its influence on power distribution/power asymmetry in a group. Perceived uncertainty about an unfamiliar partner may be different depending on the power distribution in the setting. Power asymmetry in a group may exacerbate or attenuate the uncertainty brought by a new and unfamiliar partner, depending on whether the power advantage is on the side of focal unfamiliar partner or on the side of other group members. An unfamiliar partner that is in an advantaged power position will be far more threatening than the one that has less power over other group members. However, despite that a network has been viewed as a political economy (Benson, 1975), the political nature of networks is underexplored in the network formation literature. Even though my first essay has found that power asymmetry in a group will reduce group formation, how such power asymmetry influences the participation and inclusion of a particular firm remains unknown.

To further our understanding of partner unfamiliarity/uncertainty and tie formation, I study tie formation involved in a group by combining a firm focus and a

group perspective. The combination of a firm focus and a group perspective enables me to study ties in a group by separating two parts: one is the relationships a firm has with other (potential) group members; the other is the relationships among other (potential) group members. By separating the two parts, I am able to study how unfamiliarity and uncertainty may influence a firm's participation in a group.

The dyad-level research has found that a firm is less likely to tie with an unfamiliar partner. Similarly, I expect that a firm is less likely to join the group if it is unfamiliar with other (potential) group member. However, such a firm still participates in groups involving multiple new partnerships. In this essay, my research examines under what situation a firm will participate in a group with mostly unfamiliar partners. Different from prior research, which has focused on the uncertainty brought by one unfamiliar partner to a certain focal firm, this study analyzes the uncertainty brought by an unfamiliar firm to all other group members. This is because the likelihood of a new partner participating in a group is not only related to its relationship with one of the other group members (even with the one that is most important), but also associated to its relationships with all other group members.

By focusing on a firm's prior relationships with all other (potential) group members, I am able to study the dynamics between one firm and all other (potential) group members, which has been neglected in the prior network formation literature. I argue that value creation has to be examined together with value appropriation. The same firm attribute that may reduce the uncertainty in value creation may actually increase the uncertainty in value appropriation in certain group setting. We know that

power is closely related to value appropriation as well as interest distribution, and the conflicting views and interests in the strategic decisions process often need to be settled through the exercise of power. Thus, I emphasize the power aspects of group dynamics in network formation inside a group. I argue that power distribution inside a group will exacerbate or alleviate the uncertainty brought by an unfamiliar firm, thus influencing the likelihood of group formation involving the unfamiliar firm. Only the power asymmetry that reduces uncertainty about an unfamiliar firm will help its group participation. When the uncertainty brought by an unfamiliar partner may be increased by power asymmetry, groups involving this unfamiliar firm will not be formed.

In particular, I propose that the value appropriation uncertainty in a group brought by an unfamiliar partner depends on: 1) the unfamiliar partner's prior tie strength with the other (potential) group members, and 2) the prior relationships among other (potential) group members. Moreover, I explore the role of firm experiences as a signal of capability in value creation as well as its role as a signal of power extension in value appropriation. I argue that the effects of the two network variables will be even stronger for more experienced firms. My arguments are tested using U.S. VC investment data between 1985 and 2008.

This essay contributes to both the network formation literature and the research on coalition and power. First, this essay examines when a firm is more likely to form ties with multiple new partners simultaneously. Studying a firm's tie formation with other group members enables me to explore the dynamics between one firm and other group members. Second, current literature suggests that an unfamiliar firm's

uncertainty can be signaled by the firm's network background. In contrast, I argue that the perceived partner uncertainty brought by an unfamiliar firm is directly related to the internal network of the setting. Third, this study combines the coalition argument and the network theory. It provides another explanation of coalition formation in addition to resource distribution and suggests that prior ties between firms offers an important base for coalition formation.

### **Theory and Hypotheses**

A new partner often brings two types of uncertainty: one is related to the partner's capability in value creation; the other is related to its reliability and ability in value appropriation. In this section, I first show that participating in a group is less likely when a firm is new to most of other (potential) group members. Next, I explain how firm experience and prior relationships among potential group members may influence the uncertainty brought by an unfamiliar firm in value creation and value appropriation, thus impacting its group participation. Last, I contrast value creation and value appropriation by discussing the dual effects of firm experience in both aspects.

#### **Uncertainty and Group Participation**

Since prior relational experiences often provide information about partners' capability and reliability, research found that past partners are often preferred due to the reduced uncertainty (e.g., Gulati, 1995a; Gulati & Gargiulo, 1999; Li & Rowley, 2002). Consistent with the dyad literature, Essay I shows that groups with lower density are less likely to form. Similarly, a firm's specific tie density, which is based

on the prior tie history a firm has with other (potential) group members, may also play an important role in the firm's group participation. All things being equal, the greater number of (potential) group members a firm is new to, the greater amount of uncertainty the firm will bring to the group to be formed. When a firm is new to all other (potential) group members, other (potential) group members are less likely to learn about the unfamiliar firm from each other. This will incur a greater amount of uncertainty about the new partner. Thus,

*H1: A firm is less likely to become a member of a group when it has lower tie density with other group members.*

### **Value Creation: Experience as a Signal of Capability**

Besides previous partnerships, a firm's attractiveness as a partner also depends on its attributes. Generally, a firm with more capability and resources will be more attractive in partnership formation because the ultimate goal of cooperation is to obtain resources that cannot be obtained otherwise (e.g., Baum, Calabrese, & Silverman, 2000). For example, Li and Rowley (2002) found that a firm tended to work with past partners that were more experienced. When a partner's value appropriation is controlled, a firm will benefit more from partners with more resources (Lavie, 2007).

When there are no previous partnerships, obtaining information from relational experiences is not an option and thus there is higher uncertainty regarding a new partner's capability in value creation. In an uncertain situation like this, firms often search for signals for quality (Spence, 1973). For a firm unfamiliar to other group members, its experience is often used as a signal for the assessment of its



capability and its controllable resources. An experienced firm is often considered as more capable and richer in resource. The signaling effect of experience has been well documented. Research suggested that firms signaling strong capability in uncertain situations are more likely to be accepted. For example, Higgins and Gulati (2006) found that the legitimizing signal sent out by the experiences of a firm's top management team attracted more and high-quality investors in undertaking an IPO. Thus, signals, such as experience, may reduce uncertainty brought by an unfamiliar firm in value creation, which in turn increases the attractiveness of the unfamiliar firm to other (potential) group members. Therefore,

*H2: The likelihood that a firm joins a group with firms with whom it has lower tie density will be higher if the firm is more experienced.*

### **Value Appropriation: Power and Network Formation**

However, a new partner not only adds uncertainty in value creation, but may also bring uncertainty in value appropriation. The amount of the uncertainty brought by a new partner in value appropriation depends on its power position inside a group. A partner's uncertainty in value appropriation may be either exacerbated or alleviated by its power position relative to other group members.

Power is defined as the potential or capacity to influence other firm's behaviors (Tushman, 1977). A firm's power position corresponds to its capacity of value appropriation. Since power per se is relational (Chassagnon, 2009), prior research has established close links between power and networks. On the one hand, powerful parties may benefit more from exchange or cooperation networks. In exchange networks, more powerful firms tend to use their bargaining power to obtain

more favorable exchange conditions (Casciaro & Piskorski, 2005). Even in horizontal cooperation networks, firms often have conflicting interests along with the cooperation. Power, as the key factor in the strategic decision-making (Eisenhardt & Bourgeois, 1988; Pfeffer & Salancik, 1974), is often the way to solve such conflicting views. Thus, more powerful firms are able to appropriate more value from the partnerships and alliances (Bae & Gargiulo, 2004; Khanna et al., 1998; Lavie, 2007; Levy, 2008).

On the other hand, firm power can be derived from network connections. A firm's power is directly related to its dependency on the environment or other firms (Emerson, 1962). Although the power and dependency in a dyad relationship are often determined by their resources, a firm can gain leverage by forming ties with a third party that may have certain control over the other party (Gargiulo, 1993). Thus, firm power can be derived from "network structures or patterns of direct linkage between agencies in a specific network" (Benson, 1975).

Because power enables firms to appropriate more values from cooperation and can be derived from network structures, I argue that firms are concerned about the future power distribution at the stage of group network formation. Based on Essay I, which shows that coalition concerns and power imbalance may reduce the likelihood of group formation, I further argue that the likelihood that a firm may participate in a group with unfamiliar partners depends on its expected power position in the group to be formed.

In a group involving more than two actors, coalition is an important way to change an actor's power position over other actors (Caplow, 1956; Emerson, 1962).

Coalition members cooperate to promote their own interest even though that may sacrifice the interest of other group members (Polzer et al., 1998). Hence, a firm in a weak position is likely to gain a powerful position by forming a coalition with other firms (Emerson, 1962).

While game theorists focus on coalition payoff, sociologists and psychologists have considered resource distribution as the main driver for coalition membership (Caplow, 1956; Cook & Gilmore, 1984; Gamson, 1961; Komorita & Chertkoff, 1973). However, because actors only have bounded rationality (Simon, 1955) and may not be a “utility maximizer” with full information (Cook & Gilmore, 1984), coalition in reality may not form purely based on resources and calculated payoff. Interactive histories among actors as well their future interactions (Cook & Gilmore, 1984) may play an important role in coalition formation. Furthermore, compatible interests as well as trust are found to be necessary in forming a coalition and coalitions are stable to some extent (Bazerman et al., 2000; Polzer et al., 1998). Thus, I argue that whether a firm is part of a coalitional subset of a group depends on its prior ties with other group members as well as the prior ties among other group members.

It has been suggested that trust often emerges from repeated ties (Gulati, 1995b), that stronger ties are often associated with low-level conflicts (Krackhardt & Stern, 1988; Nelson, 1989), and that frequent interactions may increase the formation likelihood of a coalition (Stevenson, Pearce, & Porter, 1985). Therefore, stronger ties between subgroup members are often likely to foster formation of coalitions. Since actors tend to rely on those they trust when facing uncertainty (Mizruchi & Stearns,

2001), a group member new to most of the other group members is even more likely to form a coalition with the group member it was strongly tied to.

Without many prior interactions to prove its reliability, a firm new to most of other (potential) group members may bring a higher level of uncertainty into the group. In such a situation, a coalition involving the unfamiliar firm may dramatically increase the power of the unfamiliar firm in the group, adding a greater amount of uncertainty in value appropriation. Once a group is formed, an unfamiliar group member in a possible coalition will be more threatening to other group members it is unfamiliar to. Therefore, I argue that a firm's group participation with mostly unfamiliar (potential) group members will be influenced by the anticipated power distribution in the coming group. A firm strongly tied with one (potential) group member but unfamiliar to most of other (potential) group members will not be favored due to the higher uncertainty it brings in value appropriation. Thus, I expect

*H3a: The likelihood that a firm joins a group with firms with whom it has lower tie density will be even lower when its maximum tie strength with other potential group members is greater.*

On the other hand, an unfamiliar group member's relative power in a group also depends on the prior ties among other group members. The same logic between strong ties and coalition formation will also work on the side of other group members. The greater tie strength among other group members, the more likely that they have compatible interests and trust among each other. In a situation where there are conflicting interests from an unfamiliar group member, other group members may form a coalition among themselves and exclude the unfamiliar firm from the

coalitional subgroup. The coalition can be used to protect the interests of other group members from being appropriated and alleviate the value-appropriation uncertainty from the unfamiliar firm. Hence, I expect that other (potential) group members take the expected power distribution into consideration in the group participation process of an unfamiliar firm. The reduced uncertainty from an unfamiliar firm due to its disadvantaged power position in the coming group will increase the likelihood that the unfamiliar firm is included in the same group. Thus,

*H3b: The likelihood that a firm joins a group with firms with whom it has lower tie density will be higher when the other potential group members have stronger ties among themselves.*

### **Value Creation versus Value Appropriation: Experience as a Signal of Power**

As argued above, unfamiliarity not only brings uncertainty regarding a new partner's capability, but also adds uncertainty regarding its reliability. While capability refers to a firm's ability in value creation, reliability is related to its ability in value appropriation. However, a firm attribute that enables a firm to contribute more to a group may also facilitate the firm to appropriate greater value. Firm experience is such an attribute. Although experience may signal a firm's capability and thus reduce the uncertainty in value creation, it may also pose greater partner uncertainty in value appropriation, in some cases. Experienced firms may be able to appropriate higher value with the price of other firms' interests. Thus, for a firm to be participating in a group with other potential group members with whom it has lower tie density, experience may deliver different information. The conflicting information from experience may create a tension between value creation and value appropriation.

One occasion that may exacerbate the likelihood of value appropriation by an unfamiliar but more experienced firm is when the firm has a strong tie with another group member. Unfamiliar with most of other group members, a firm is more likely to form a subgroup coalition with its past partner based on the strong tie. Such a coalition will increase the power of the unfamiliar firm and help it promote its own interest. When an experienced firm has a strong tie with one (potential) group member but is unfamiliar to most of other (potential) group members, its experience sends out a stronger signal of power in value appropriation compared to the signal of capability in value creation. Thus,

*H4a: Firm experience will strengthen the positive interaction effect of firm-specific tie density and maximum tie strength on firm participation in H3a i.e., the likelihood that a firm joins a group with firms with whom it has lower tie density will be even lower if the firm has greater experience as well as stronger ties with other potential group members.*

However, the negative effect of experiences as a signal of power may be alleviated if other (potential) group members are tightly connected with strong ties. Even when the unfamiliar firm is the most powerful actor in the group, the “all weak again strong” coalition among other group members may also be able to achieve a power balance (Cook & Gilmore, 1984). Therefore,

*H4b: Firm experience will strengthen the negative interaction effect of firm-specific tie density and alter tie strength on firm participation in H4a i.e., the likelihood that a firm joins a group with firms with whom it has lower tie density will*

*be higher if the firm has greater experience and other potential group members are strongly tied to each other.*

## **Methodology**

### **Data**

I study the likelihood that a firm participates in a group using venture capital investment data between 1985 and 2008. As in Essay I, VC syndication is the application of group formation in the VC context. VC syndication formation is an appropriate setting to test my hypotheses in this essay because: 1) VC investment involves high uncertainty and one important purpose of syndication is to reduce risks involved in deals (Manigart et al., 2006). Given that, syndicate members are especially concerned about the uncertainty brought by unfamiliar syndicate members; 2) VC firms make final commitment simultaneously with the knowledge of who else is on board, despite that they may show their interests in investment at different points of time. Thus, for any firm to be involved in a deal, each potential group member needs to agree. This will enable me to study how the prior relationships of a firm with all other potential group members will influence its chance of getting involved.

The primary data source I used is the Venture Expert database. As in Essay I, I included first-round syndicates by U.S. VC firms (excluding angels) for U.S.-based startup companies that are in “Seed Stage”, “Early Stage”, or “Expansion Stage” and that are less than ten years old. However, since I focus on in-group networks to refer to the power distribution in a syndicate, only syndicates with three or more VC firms

were included in this study. There are totally 1397 first-round syndicates included in the sample.

As in Essay I, I prepared a VC pool for each startup company by including all U.S. VC firms that invested in the same industry, same state, same year, and the same quarter of the focal startup company. Nevertheless, the focus of this essay, a firm's group participation, makes it different from Essay I in generating hypothetical samples. In this essay, to generate the matched hypothetical groups, I replaced one VC firm in a real syndicate case (except for the lead VC) at a time. For example, if the real syndicate includes firms A, B, C, and D and firm A is the lead VC, I first hold firms A, C, and D constant and replace firm B by randomly selecting one potential VC investor from the VC pool for the startup company to generate a hypothetical case. Firm C is then replaced using a similar approach and then firm D is the next. Since I am interested in when a firm may participate in a group with partners with whom it has a lower density, I group on the startup company and the other potential group members in my analysis to control for the effect caused by the other group members for this specific startup company.

Although I study group participation of a firm in this essay and generated hypothetical groups by replacing one firm at a time, the empirical design in this study is consistent with the group perspective I proposed in Essay I. To examine when firm D participates in a group consisting of firms A, B, and C, with whom firm D has lower tie density, I assume that 1) firms A, B, and C are willing to work with each other, and 2) firms A, B, and C will make a commitment of group participation as long as firm D is acceptable to them as the other group member. However, both



assumptions are consistent with the main essence of the group perspective, which emphasizes that any group member unacceptable to others may make the formation of a group involving all of them fall apart. Keeping other group members constant and only concentrating on one group member at a time will help avoid the possible confounding effects from the other group members. If the other group members were also replaced in hypothetical cases, it would have been difficult to distinguish whether the group fails to form because of the focal firm or because of the other firms that have been replaced simultaneously. Meanwhile, this study and empirical design are different from dyadic level studies in that the likelihood of a firm participating in a group depends on all other potential group members, rather than just one of them. Therefore, this firm-focused group perspective is appropriate to study the research question in this essay.

Based on the methods I discussed above, I generated one hypothetical case for each VC firm involved in a real syndicate. Thus, each VC firm in the real syndicate (except for the lead VC) could be the focal VC that may be replaced in hypothetical cases, and the total number of hypothetical cases for a startup company is determined by the syndicate size (excluding the lead VC if there is one). By keeping other firms constant and replacing one firm at a time, the choice-based sampling approach used in this essay enables me to study when a particular firm may participate in a group together with other group members with whom it has lower tie density. I tested my hypotheses using the conditional logit model. As argued in Essay I, the conditional logit model is suitable for matched samples in this essay. The main effects of the

independent variables lacking within-case variation will not be estimated in the conditional logit model.

## **Measures**

### *Dependent variable:*

*Firm participation* is a dummy variable, indicating whether a focal VC firm participates in the syndicate. A focal VC firm refers to the real VC syndicate member to be replaced in the real case or the hypothetical VC firm that replaced a real VC syndicate member. Firm participation is equal to one if the focal VC firm was a real syndicate member for the specific deal and equal to zero when the focal VC firm did not participate in the deal but could have joined.

### *Independent variables:*

*Firm-specific tie density* measures the ratio of existing ties between a focal VC and other VCs in a syndicate divided by total possible ties between the focal VC and the other VCs. It is a continuous variable between 0 and 1. When the focal VC firm has worked with all other syndicate members prior to the current deal, this variable equals to 1. On the other extreme, it is equal to 0 if the focal VC firm has no prior ties with any of the other syndicate members.

*Experience of focal VC* was calculated by counting the total number of startup companies a focal VC firm has invested in prior years before the current deal. To correct for the skewness of this variable, I did a log transformation.

*Focal firm maximum tie strength.* I first measured the tie strength between a focal VC firm and each of the other syndicate members. Then, I calculated the maximum strength of these ties. This variable is used as a proxy to indicate whether

the focal VC is likely to form a coalition with the other syndicate members it partnered with before. A stronger tie indicates a higher possibility of coalition formation involving the focal VC. A potential coalition may increase the power of the focal VC firm, thus increasing the uncertainty in value appropriation brought by the focal VC firm. Since this variable is skewed, a log transformation was used.

*Average tie strength among other members.* It is measured as the average of tie strength among all the other syndicate members excluding the focal VC firm. I calculated this variable as the proxy for coalition formation among the other group members except for the focal VC firm. Again, higher average tie strength represents a higher chance of a coalition formation among the other group members. A coalition formation among other group members will reduce the power of the focal VC firm, thus decreasing the uncertainty in value appropriation brought by the focal VC firm.

*Control variables:*

*VC type heterogeneity.* Since the sample includes not only independent VC firms, but also other types of VC firms, such as corporate VC, investment banks, etc., I used the VC type heterogeneity to control for the tendency that VC firms in similar type are more likely to join together. It is an entropy measure calculated as  $\sum p_i * \ln(1/p_i)$ , where  $p_i$  is the percentage of a specific VC type in the syndicate group.

*Focal VC distance to other members:* VC firms tend to work with other VC firms that are geographically closer (Sorenson & Stuart, 2001). Therefore, I calculated the average geographic distance between a focal VC firm and other syndicate members in a syndicate to control for this effect. From the zip codes of VC firm offices, I found out the corresponding latitudes and longitudes. Then, I

calculated the distance between the focal VC firm and every other syndicate member using spherical geometry and took an average of them. A log transformation is used to correct for the skewness.

*Focal VC distance to the company.* Since VC firms tend to invest in local start-up companies, I also calculated the geographic distance between the focal VC firm and the startup company using spherical geometry. Then, a log transformation was used to correct for the skewness.

*Average experience of other members.* To test the effect of focal firm experience, I controlled for the experience level of the other group members. It was calculated as the average of the experiences of the other group members except for the focal VC firm. The experience was measured as the total number of startup companies a VC firm has invested until the prior year.

*Focal firm inside indirect tie density.* I first calculated the number of indirect ties between the focal VC firm and the other syndicate members through VC firms inside of the focal syndicate. Then, I divided this number by the total possible indirect ties between the focal VC firm and the other syndicate members to measure focal firm inside indirect tie density.

*Focal firm outside indirect tie density.* Similarly, I first calculated the number of indirect ties between a focal VC firm and other syndicate members through VC firms outside of the focal syndicate, and then divided it by the total possible indirect ties between the focal VC firm and the other syndicate members.

## Results

The descriptive statistics shown in Table 2.1 indicates that 3%-4% of the observations have missing values on the two distance variables. When using conditional logit models, simply dropping the missing observations in analysis may lose within-case variation on some variables and thus lead to a greater loss of usable observations. To control for the effect of missing values, I generated dummy variables to indicate the missing observations.

**Table 2.1: Descriptive Statistics**

Variable	Obs	Mean	Std. Dev.	Min	Max
Firm participation	9202	0.5000	0.5000	0	1.0000
Firm-specific tie density	9202	0.2821	0.3465	0	1.0000
Focal firm experience (ln)	9202	3.0485	1.6375	0	6.7081
Focal firm maximum tie strength (ln)	9202	0.8277	1.0879	0	4.6913
Avg tie strength among other members	9202	2.8076	7.0987	0	86.0000
VC type heterogeneity	9202	0.4555	0.4007	0	1.6094
Focal firm distance to other members (ln)	8947	6.1861	1.8641	0	7.9015
Focal firm distance to company (ln)	8870	5.1240	2.3306	0	7.9091
Avg exp among other members	9202	63.4076	63.8434	0	533.0000
Focal firm inside indirect tie density	9202	0.0765	0.1720	0	0.8571
Focal firm outside indirect tie density	9202	0.4084	0.3600	0	1.0000

The within-group correlation matrix is given in Table 2.2. It shows that both focal-specific tie density and focal firm maximum tie strength are positively correlated with the dependent variables, firm participation, while focal firm outside indirect tie density is negatively correlated with firm participation. Also, not surprisingly, focal-specific tie density, focal firm experience, and focal firm maximum tie strength all positively associate with each other.

In this essay, I study how firm-specific tie density may influence its likelihood of participating in a group and when a firm may still join in a group mostly consisting of firms with whom it is not familiar. To examine my hypotheses, I used conditional

logit models and the results are shown in Table 2.3. Model 1 includes all control variables. As expected, VC type heterogeneity, focal VC firm distance from other group members or the startup company, and focal VC outside indirect tie density all significantly reduce the likelihood of a focal firm participating in the group. Meanwhile, inside indirect tie increase the chance that a focal firm joins in the group. Even though this essay emphasizes a firm focus together with a group perspective, all these results show a strong consistency with those in Essay 1

**Table 2.2: Correlation Table**

		1	2	3	4	5	6	7	8	9
1	Firm participation	1								
2	Firm-specific tie density	0.3176	1							
3	Focal firm experience (ln)	-0.026	0.513	1						
4	Focal firm maximum tie strength (ln)	0.3061	0.7918	0.584	1					
5	VC type heterogeneity	-0.0719	-0.0928	-0.1003	-0.1267	1				
6	Focal firm distance to other members (ln)	-0.1746	-0.133	0.0207	-0.1223	0.076	1			
7	Focal firm distance to company (ln)	-0.1296	-0.0675	0.0546	-0.0688	0.095	0.4887	1		
8	Firm-spec tie density*avg exp of other members	0.0237	0.2297	0.1572	0.2402	-0.0322	-0.0217	0.0248	1	
9	Focal firm inside indirect tie density	-0.0041	0.0409	0.1363	0.1503	-0.0189	-0.0118	0.0151	-0.0359	1
10	Focal firm outside indirect tie density	-0.2862	-0.5737	0.1392	-0.4031	0.0235	0.1065	0.0762	-0.1451	0.1307
11	Focal firm exp*firm-spec tie density	0.1713	0.3007	-0.1418	0.298	0.0115	-0.0497	-0.0451	0.1128	-0.2724
12	Firm-spec tie density*firm maxi tie strength	0.221	0.5259	0.3198	0.6299	-0.099	-0.0989	-0.0531	0.3486	-0.373
13	Firm-spec tie density*avg tie strength of others	0.0295	0.1955	0.0872	0.1705	-0.0512	-0.0637	-0.0245	0.5098	-0.0626
14	Focal firm exp*firm max tie strength	0.2013	0.3349	0.114	0.6084	-0.0356	-0.0704	-0.0503	0.1769	-0.1455
15	Focal firm exp*firm-spec tie density*firm max tie strength	0.1534	0.5776	0.6141	0.6997	-0.0883	-0.0535	-0.0073	0.3131	-0.1381
16	Focal firm exp*avg tie strength of others	0.0472	0.1177	-0.0337	0.1389	-0.0273	-0.0786	-0.0295	0.3384	0.0198
17	Focal firm exp*firm-spec tie density*avg tie strength of others	-0.0303	0.0659	0.1722	0.1311	-0.0112	-0.0285	-0.0091	0.109	-0.1388

		10	11	12	13	14	15	16	17
10	Focal firm outside indirect tie density	1							
11	Focal firm exp*firm-spec tie density	-0.5916	1						
12	Firm-spec tie density*firm maxi tie strength	-0.3919	0.5503	1					
13	Firm-spec tie density*avg tie strength of others	-0.1275	0.0558	0.2712	1				
14	Focal firm exp*firm max tie strength	-0.4526	0.7719	0.6583	0.0824	1			
15	Focal firm exp*firm-spec tie density*firm max tie strength	-0.2348	0.4293	0.8472	0.186	0.6368	1		
16	Focal firm exp*avg tie strength of others	-0.1204	0.1966	0.2206	0.6853	0.1761	0.1717	1	
17	Focal firm exp*firm-spec tie density*avg tie strength of others	-0.0112	0.1134	0.257	0.2844	0.1461	0.3016	0.3218	1

**Table 2.3: Conditional Logit Regressions on Matched Sample**

	model_1	model_2	model_3	model_4
	b/se	b/se	b/se	b/se
VC type heterogeneity	-0.3800 0.1021***	-0.2743 0.1043**	-0.3547 0.1066***	-0.2118 0.1049*
Focal firm distance to other members (ln)	-0.1249 0.0177***	-0.1154 0.0180***	-0.1049 0.0183***	-0.1147 0.0181***
Focal firm distance to other members missing	0.3213 0.4142	0.4113 0.4230	0.3165 0.4347	0.4408 0.4274
Focal firm distance to company (ln)	-0.0332 0.0113**	-0.0353 0.0115**	-0.0286 0.0117*	-0.0340 0.0116**
Focal firm distance to company missing	-1.2835 0.4061**	-1.2769 0.4151**	-1.1795 0.4267**	-1.2733 0.4196**
Firm-spec tie density*avg exp of other members	-0.0012 0.0010	-0.0043 0.0011***	-0.0039 0.0011***	-0.0056 0.0012***
Focal firm inside indirect tie density	0.3203 0.1485*	0.0040 0.1560	0.0569 0.1646	0.0244 0.1999
Focal firm outside indirect tie density	-1.3068 0.0732***	-0.7460 0.0843***	0.0616 0.1169	-0.7731 0.0852***
Firm-specific tie density		1.2691 0.0988***	2.5475 0.1502***	0.5532 0.1427***
Focal firm experience (ln)			-0.2699 0.0227***	
Firm-specific tie density*Focal firm experience			0.0142 0.0640	
Focal firm maximum tie strength (ln)				0.2422 0.0504***
Firm-specific tie density*Firm max tie strength				0.2324 0.1112*
chi2 df_m	525.2259	701.5290	852.9653	759.0452
N	9202	9202	9202	9202
p	2.70E-108	3.20E-145	8.00E-176	1.20E-155
ll	-2926.5570	-2838.4060	-2762.6880	-2809.6480
r2_p	0.0823	0.1100	0.1337	0.1190

Hypothesis 1 proposes that a firm is less likely to join a group with firms with whom it has lower tie density. Consistent with Hypothesis 1, Model 2 shows the positive effects of focal firm-specific tie density on the focal VC's likelihood to join the syndicate. Based on the finding in Model 2, I further explore how the likelihood of a firm participating in a group with unfamiliar partners may depend on the uncertainty it brings in value creation and value appropriation.



From the perspective of value creation, I examine the role of experience as a signal of capability and expect that firm experience will increase the chance that a firm joins a group with unfamiliar partners (Hypothesis 2). However, although Model 3 shows a positive interaction between focal firm experience and firm-specific tie density, the effect is not significant. In contrast, this interaction term becomes significant in Models 6 and 8 in Table 2.4, when the three-way interaction of focal firm experience, firm-specific tie density, and focal firm maximum tie strength is included. The three-way interaction is used to capture the role of experience as a signal of power. It suggests that firm experience may reduce a firm's chance of participating in the group if the firm is perceived as having more power due to the greater experience. The contrasting results in Models 3, 6, and 8 confirm that experience has dual roles in an uncertainty situation. A firm's experience is not only a signal of capability, but may also become a signal of power in value appropriation. The conflicting information coming from experience may create a tension between value creation and value appropriation. As suggested by Models 3, 6, and 8, only when experience's negative effect in value appropriation is controlled can its positive effect in value creation be demonstrated.

**Table 2.4: Conditional Logit Regressions on Matched Sample (Cont.)**

	model_5 b/se	model_6 b/se	model_7 b/se	model_8 b/se
VC type heterogeneity	-0.2762 0.1043**	-0.2500 0.1089*	-0.3561 0.1066***	-0.2481 0.1090*
Focal firm distance to other members (ln)	-0.1158 0.0180***	-0.0980 0.0188***	-0.1053 0.0183***	-0.0989 0.0188***
Focal firm distance to other members missing	0.4091 0.4229	0.3679 0.4482	0.3146 0.4347	0.3703 0.4501
Focal firm distance to company (ln)	-0.0354 0.0115**	-0.0229 0.0119+	-0.0290 0.0117*	-0.0235 0.0120*
Focal firm distance to company missing	-1.2752 0.4150**	-1.1686 0.4401**	-1.1803 0.4267**	-1.1794 0.4420**
Firm-spec tie density*avg exp of other members	-0.0036 0.0843***	-0.0066 0.1205	-0.0030 0.1177	-0.0058 0.1214
Focal firm inside indirect tie density	-0.0044 0.0013**	-0.1920 0.0012***	0.0046 0.0013*	-0.2433 0.0014***
Focal firm outside indirect tie density	-0.7458 0.1561	0.0639 0.2181	0.0531 0.1692	0.0503 0.2217
Firm-specific tie density	1.2749 0.0990***	1.5241 0.2129***	2.5495 0.1518***	1.4565 0.2168***
Focal firm experience (ln)		-0.4248 0.0322***	-0.2661 0.0235***	-0.4237 0.0326***
Focal firm exp*firm-spec tie density		-0.2905 0.1137*	0.0047 0.0672	-0.2733 0.1162*
Focal firm maximum tie strength (ln)		0.5869 0.0827***		0.6026 0.0836***
Firm-spec tie density*firm maxi tie strength		0.4231 0.2005*		0.4362 0.2040*
Firm-spec tie density*avg tie strength of others	-0.0100 0.0095		-0.0188 0.0129	-0.0116 0.0144
Focal firm exp*firm max tie strength		-0.0503 0.0417		-0.0630 0.0423
Focal firm exp*firm-spec tie density *firm max tie strenght		0.0623 0.0843		0.0891 0.0876
Focal firm exp*avg tie strength of others			0.0021 0.0030	-0.0004 0.0032
Focal firm exp*firm-spec tie density *avg tie strength of others			-0.0050 0.0063	-0.0152 0.0070*
chi2 df_m	702.6199	1040.0590	856.3146	1048.6560
N	9202.0000	9202.0000	9202.0000	9202.0000
p	1.70E-144	3.50E-212	9.80E-174	2.80E-211
ll	-2837.8600	-2669.1410	-2761.0130	-2664.8420
r2_p	0.1102	0.1631	0.1343	0.1644

From the perspective of value appropriation, Hypotheses 3a and 3b address how group settings influence a firm's likelihood to participate. Hypothesis 3a proposes that a firm is even less likely to participate in a group where it has a strong tie with one group member but is new to most of other group members. Results in Model 4 show that on average, a stronger tie with one group member will increase a firm's likelihood to join the group. This finding confirms the strong tie argument in network theory. However, Model 4 also suggests that a strong tie may become an obstacle in group participation. If a firm has a previous strong tie with one group member but is new to most of others in the same group, the perceived uncertainty brought by the firm to the other new partners in the group will be increased. This perception happens because the firm's power may increase when it forms a coalition with its trustful past partner. As expected, the interaction between focal firm-specific tie density and focal firm maximum tie strength shows support to Hypothesis 3a.

On the other hand, Hypothesis 3b presents that a firm is more likely to participate in a group with firms with whom it has lower tie density, if other firms were strongly connected to each other in prior years. Model 5 in Table 2.4 shows a negative interaction between focal firm-specific tie density and average tie strength among other group members. This negative sign suggests that when focal firm-specific tie density is lower, greater average tie strength among other group members may increase a firm's group participation. However, the effect is not significant. This may be because the uncertainty brought by the focal VC not only depends on the prior ties among group members, but also depends on its own attributes at the same time. A focal VC without much resource or experience is less likely to pose a big

threat or add greater uncertainty to the other group members despite its lack of relational experiences with other group members. In such a case, it is not necessary that other members are tightly tied based on prior ties.

Hypotheses 4a and 4b discuss how experience plays a role as a signal of power in value appropriation. Model 6 includes the variables testing hypothesis 4a, which displays a stronger interaction effect between focal firm-specific tie density and focal firm maximum tie strength for more experienced focal firms. Although the positive three-way interaction is consistent with my expectation, the effect is not significant. This suggests that as long as a firm has strong ties with one group member, it may bring more uncertainty to other group members with whom it is unfamiliar, regardless of the firm's prior experience, and such uncertainty will reduce the firm's likelihood to join the group, no matter whether the firm is experienced or not.

Hypothesis 4b suggests that an experienced (less experienced) firm is more likely to join a group with unfamiliar firms who are (are not) tightly tied among themselves. This hypothesis was examined using a three-way interaction between focal firm-specific tie density, firm experience, and average tie strength among other group members. Although the effect is not significant in Model 7, it is significant in the full model, showing support for Hypothesis 4b. This result helps explain why Hypothesis 3b is not supported. It suggests that due to the value appropriation concerns, tie strength among the other group members is positively related to a firm's participation in a group with more new partners if it is more experienced. Nevertheless, strong ties among the other group member will reduce a less

experienced firm's likelihood to participate in the group with more new partners, because strong ties among other group members makes value appropriation of a new partner a less concern but value creation a bigger problem.

### **Discussion and Conclusion**

This essay examines the factors that influence the likelihood of a firm participating in a group with partners with whom it has lower tie density. It discusses and juxtaposes the two important aspects in partnership network: value creation and value appropriation. From the perspective of value creation, I show that experience as a signal of capability can help reduce the uncertainty about a new partner in value creation. From the perspective of value appropriation, I find that a firm's prior strong tie with one group member may prevent it from participating in the same group with other unfamiliar firms, regardless of the firm's experience. I also find that the likelihood of an experienced firm participating in a group with unfamiliar partners is positively related to the tie strength among other group members. In the process of a firm forming a group with mostly new partners, a firm's experience may both decrease the uncertainty in value creation and increase the uncertainty in value appropriation.

This essay has several important contributions to the network literature. First, it extends the research on new tie formation from a dyadic level to a firm-focused group level. While the prior research focuses on when a focal firm forms ties with one new partner, this essay studies tie formations of a firm with all other potential group members and investigates when a firm participates in a group together with partners with whom it has lower tie density. The combination of a firm focus and a group

perspective enables me to explore the impact of in-group network relationships on power distribution and then on value appropriation. By focusing on one firm at a time, I am able to dig into the dynamics between one firm and other potential group members. Also, studying multiple ties simultaneously enables me to discover how potential members in a group setting may constrain each other in a group formation. Extending on Sorenson and Stuart (2008)'s research about setting impact on tie formation, this essay shows the dynamics between setting attributes and tie formation. Rather than viewing group setting as a preset before group formation, I emphasize that potential group members may take active roles in determining the setting attribute and controlling for uncertainty.

Second, this essay unveils some interesting aspects of tie strength and firm experience in new tie formation. The analysis shows that while strong prior ties may provide endorsement to promote tie formation between partners, the likelihood of group participation is lower when the preexisting tie between a focal firm and another potential group member is stronger, given that the focal firm is new to most of other potential group members. This suggests that a firm's previous strong ties are not always helpful in future tie formation. Meanwhile, although experience may reduce the uncertainty about a new partner in value creation by signaling the partner's capability, it may also generate concerns about power distribution and power dominance in value appropriation. Through studying the prior relationships among potential group members, this essay is able to disentangle the two different effects of firm experience.

Third, this essay links the network formation literature with the research on coalition, power, and value appropriation. By studying a firm's group participation involving multiple parties, I argue that: 1) prior network relationships among the other potential group members may influence an unfamiliar partner's power through possible coalition formation involving or excluding the unfamiliar partner, thus impacting its perceived uncertainty in value appropriation; and 2) the perceived uncertainty in value appropriation may influence the participation likelihood of the unfamiliar partner. That is, potential coalition may either facilitate or hinder firm participation depending on whether coalition formation is expected to reduce or increase uncertainty in value appropriation. Since concerns about a firm's uncertainty in value appropriation may prevent the firm from participating in the group, both value creation and value appropriation are important factors in affecting partnership formation. This essay echoes the prior studies in that partners with most resources may not be best choice for partnerships, since the powerful partner with the most resources may appropriate more value from alliances (Bae & Gargiulo, 2004; Lavie, 2007).

This essay also casts light to the research on exploration and exploitation. Prior literature has treated a firm's tie formation with past partners as exploitation and tie formation with new partners as exploration (e.g., Beckman et al., 2004; Lavie & Rosenkopf, 2006). However, the way to achieve exploration has not been well understood in current literature. Firms may explore multiple new relationships at one time or gradually develop new relationships. Prior literature on new tie exploration focuses on the accumulation of new partnerships during a certain period, thus

overlooking the process of exploration in different contexts. This essay fills in the gap and uncovers the conditions under which a firm is tied to multiple new partners simultaneously.

The essay has practical implications to practitioners. By distinguishing the uncertainty in value creation and the uncertainty in value appropriation, it shows the situations in which the uncertainty in value appropriation may overshadow the uncertainty in value creation when there is a tension between the two. When forming multi-firm alliances or syndicates, potential participants may judge the potential uncertainty from unfamiliar partners using internal network structures in the setting. In group participation with many new partners, a preexisting strong tie with a potential group member may not be as helpful as expected.

This essay also has some limitations deserving future efforts. Since I study in-group networks and focus only on groups with three or more firms, I take the perspective of majority group members and study when a firm may participate together. By taking the perspective of majority group members, I emphasize the constraints that may be posed by other group members. I assumed that in most cases, despite the unfamiliarity, a firm is motivated to participate in a syndicate because of the opportunity to invest in a startup company. Although I agree that firm motivation is also important in group participation, a firm's group participation is still up to the approval of every other group member. If other group members have concerns about a particular firm, the firm will not be able to participate in the same group regardless of its motivation. Indeed, if the motivational side were a factor of greater importance, we should have seen that a firm's likelihood to participate in a group with other new



partners is higher when its preexisting tie is stronger. But the empirical results suggest the opposite.

Research in the future may add inputs of richer contextual evidences.

Qualitative examples or stories will better illustrate value appropriation in a specific context. Moreover, future research may use the methodology developed in this essay to study the evolution of groups. For example, future research may examine whether the internal network of a first round VC syndicate influences the change of group size or group composition. It may further examine what kinds of VC firms are more likely to be added in a subsequent round. The study of syndicate evolution involves greater complexity though. For example, it is likely that more than one additional firm join in the subsequent round. For subsequent syndicates with multiple newly added VC firms, researchers may also take into consideration the prior relationships among the incoming firms.

# Essay III: Impact of Syndicate Network Structures on Startup Company Performance

## Introduction

In the first two essays, I have found that Venture Capital (VC) firms tend to form syndicates with familiar partners. However, whether such syndicate behaviors actually influence syndicate performance remains unknown. Thus, in the third essay, I examine the potential impacts of syndicate network attributes on startup company performance.

Due to the high uncertainty in VC investment, VC firms often syndicate to back up start-up companies. VC syndication can help select startup companies with better quality (selection hypothesis); offer financial and nonfinancial resources and add value to startup companies through monitoring and nurturing (value addition hypothesis); help share risks in VC investment (risk sharing hypothesis); and also boost VC reputation by investing in successful startup companies (window-dressing hypothesis) (Brander et al., 2002). While risk sharing and window-dressing are important to the performance of VC firms, selection hypothesis and value addition hypothesis suggest a positive relationship between VC syndication and the startup company performance.

Empirical studies have already confirmed the positive impact of the use of syndication. For example, Baker (2000) found that syndication at the second round was positively related to its chance of going public, although the impact of

syndication declined as the VC firm ages. Brander, Amit, and Antweiler (2002) indicated that rate of return to VC syndication was higher than that of single VC investment. Even controlling for the endogeneity issue of VC syndication, Tian (2008) discovered that companies backed by VC syndicates performed better than those backed by single VC firms.

Although these studies have pointed out the importance of VC syndication, how attributes of VC syndicates may influence startup company performance is still underexplored. Some studies have shown that syndicate size (Brander et al., 2002; De Clercq & Dimov, 2008; Tian, 2008) and syndicate homogeneity in performance (Du, 2009) are positively related to a startup company's performance. But, many other important attributes of VC syndicates are left unexamined. One of these important attributes is syndicates' network structure. When VC firms form a syndicate, their prior relationships among each other constitute an internal local network structure at the group level and the syndicate itself locates in an overall VC network based on its members' connections with other VC firms outside of the focal syndicate. Since prior research has shown that firm network structure is critical to firm performance, it is important to study how the network structures of VC syndicates may influence the performance of startup companies.

In this essay, I investigate the impact of both internal network density within a syndicate and external structural holes of a syndicate in the overall VC network. Based on the traditional social capital theory of network closure, I argue that syndicate internal density will have a positive impact on a startup company's performance. Drawing from the network structural hole theory, I expect a positive

influence from a VC syndicate's network structural hole position. Moreover, I propose that the effects of syndicate internal density and external structural hole will vary depending on the company's age and other syndicate attributes, such as syndicate size and heterogeneity. To test these hypotheses, I used the data of U.S. VC investments from 1998 to 2003. The empirical results suggest that there are significant impacts of both syndicate internal density and external structural holes, even when endogeneity and selection bias are taken into consideration.

This study has important contributions to entrepreneurship literature. It extends the literature on VC syndication and startup companies by combining the network structure theory with the VC syndication phenomena.<sup>9</sup> Although some prior research has found that a lead VC firm's network position has an positive contribution to a startup company's performance (Hochberg, Ljungqvist, & Lu, 2007), current research has shown that other non-lead VC firms in a syndicate also play an important role in the startup company's performance (e.g., Brander et al., 2002; Tian, 2008). As such, it is interesting and necessary to examine the impact of the syndicate network structure both inside a syndicate and outside a syndicate (rather than outside a particular VC firm).

Second, prior literature (at the dyad level) and my first two essays (at the group level) have suggested that firms prefer to form ties with their prior partners. However, whether such network tie formation behaviors have positive economic

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<sup>9</sup> Although De Clercq and Dimov (De Clercq & Dimov, 2008) studied the impact of internal relationships in a syndicate on startup company performance, there are two major issues in their study. First, there is a mixing level of studies. Their study focuses on individual VC level and examines how a focal VC's (not necessarily lead VC) total number of prior interactions with other VC syndicate members influence the startup company performance. Second, their study did not control for endogeneity; the positive relationships between internal network and startup company performance may be due to sorting, rather than influence.

implication is still unknown. The prior research on group density is at the team level, where team members are mostly assigned instead of self-selected (Reagans, Zuckerman, & Mcevily, 2004; Reagans & Zuckerman, 2001). To my knowledge, there is no study distinguishing network self-selecting behaviors and network influences at the inter-firm group level. However, such distinction is quite important, since it enables us to study the direct impact of such network formation behaviors. So, one interesting research question to ask is: Will the tendency to form dense groups actually help group performance?

### **Theory and Hypotheses**

From the structural perspective, I study the role of network configuration in this essay. The two important aspects in network structures are closure and structural hole. In this study, I investigate both the internal network closure and the external structural hole of a VC syndicate and examine how such network structures influence the syndicate performance.

Closure is defined as the extent to which an ego's partners are tied to each other. A network with higher closure indicates greater network cohesiveness. The traditional social network theory has emphasized the positive influence of network closure and proposes that actors in a network benefit from network embeddedness. According to the traditional social network theory, network relations carry information and the connectivity among actors in a network facilitates information flow. The existence of common third parties and indirect ties not only makes it easier to access information, but also helps validate the accuracy of the information (Gargiulo & Benassi, 2000; Walker, Kogut, & Shan, 1997). The rapid information

flow in a dense network will help establish norms of behaviors that enforce actors to cooperate (Gargiulo & Benassi, 2000; Walker et al., 1997). Because reputation arising from the network embeddedness may increase cost of defection (Gargiulo, Ertug, & Galunic, 2009) and prevent actors from engaging in malfeasance (Granovetter, 1985; Raub & Weesie, 1990), firms in a dense network are less likely to engage in opportunistic behaviors that could jeopardize cooperation. Therefore, the social norms and sanction mechanisms produced by network closure often facilitate development of trust (Coleman, 1988, 1990) and, thus, reduce the need and cost for monitoring and coordination (Gulati & Singh, 1998).

All these aspects of network closure promote cooperation among partners. Since group performance depends on successful involvement of collaboration (Kanter, 1994b), network closure has been expected to influence group performance positively. Empirical studies have shown the proof of such positive impact of network closure. For example, at the team level, research found that team internal network density helps establish cooperation norms (Lazega, 2001), significantly increase team productivity (Reagans & Zuckerman, 2001) and reduce the duration needed to complete a project (Reagans et al., 2004). Even though these studies have greatly improved our understanding of the impact of network density, network density effects in these studies have always been detached from network formation behaviors because individuals in a team are often assigned by supervisors. Studying network density of groups formed by firm self-selection can shed light to the consequences of network formation behaviors.

In the context of VC investment, VC firms put more than money into the startup company they are investing in: They add values in three aspects: management assistance, intensive monitoring, and reputational capital (Black & Gilson, 1998). Thus, cooperation among VC syndicate members is important. Moreover, since investment in startup companies involves a tremendous amount of uncertainty, trust among VC syndicate members becomes especially important. The repeated interaction among syndicate members enables expectations of their partners' behaviors. In addition, trust among syndicate members may also improve the chance of securing following-on investment. All these informal mechanisms will complement the formal cooperation mechanisms to facilitate cooperation and ensure the success of the investment deal (Wright & Lockett, 2003). Therefore, I expect

*H1: Syndicate internal density will positively influence the performance of the startup company.*

The central argument behind the positive impact of network closure on team performance is its role in reducing coordination cost through the improvement of trust. However, coordination required in the syndicate may vary with the group context, depending on who are involved in the syndicate. As argued in Essay I, coordination difficulties increase with both group size and group heterogeneity (Litwak & Hylton, 1962; Litwak & Rothman, 1970). Hence, the need to facilitate coordination will be greater in larger or heterogeneous groups. Greater density will improve coordination more in larger or heterogeneous groups than in smaller or homogenous groups. Therefore, a bigger positive impact of network closure on group performance will be expected in larger or heterogeneous syndicates.

*H2: The positive impact of syndicate density on startup company performance will be greater in larger syndicate groups.*

*H3: The positive impact of syndicate density on startup company performance will be greater in more heterogeneous syndicate groups.*

As opposed to the need for network density caused by difficulties in coordination, some group tasks may increase the necessity for coordination and cooperation. Younger companies are short of structure, routines, operation mechanisms, as well as client and customer resources (Bruderl & Schussler, 1990; Stinchcombe, 1965). The VC investors often become their first organizational partners (Hallen, 2008) and offer help in both management and monitoring (Black & Gilson, 1998). Thus, the necessity for nonfinancial inputs from VC investors will depend on the developmental stage of the startup company. Younger companies tend to need greater nonfinancial support from VC syndicate members than mature companies. Therefore,

*H4: The positive impact of syndicate density on startup company performance will be greater for younger startup companies.*

Besides the local internal network constructed by the ties among syndicate members, a syndicate itself is also located in a VC syndication network resulted from the prior ties of its syndicate members with other VCs who are not participating in the focal syndicate. A firm's network position has been found to be influential by both the network closure perspective (Coleman, 1988) and the structural hole theory (Burt, 1992, 1997).



Developing from the pioneering work of “strength of weak ties” by Granovetter (1973), Burt (Burt, 1992, 1997) proposed that network benefits actually come from sparse networks, rather than from cohesive relations. He used the structural hole to refer to “the separation between nonredundant contacts” (Burt, 1992). According to the structural hole theory, although network embeddedness increases the amount and speed of information flow within the network, the information that an actor gets from a dense ego network is often redundant. On the other hand, actors in a network rich of structural holes will get information from disconnected clusters. The adding of new information from disconnected partners increases both efficiency and effectiveness of the information flow. Besides the benefits arising from information diversity, actors in a bridging position also have the advantage in negotiating relationships. Actors with more structural holes enjoy the control benefits by taking the role of *tertius gaudens* — Simmel (1955)’s conception for “the third party who benefits” (Burt, 1992) — and playing other partners against each other. Thus, the structural hole theory suggests that to maximize the benefits from the network, an actor should increase size and nonredundancy as much as possible (Podolny & Baron, 1997).

Both the network closure perspective and the structural hole theory argue the positive influence of network structure in the economic field by emphasizing its role in information access and control. However, the two theories depart in how network structure influences actors’ economic performances. Since increase in network closure means decrease in the structural hole, the two theories seem to give contradictory predictions in terms of which type of network structure is more

beneficial. While the network closure perspective emphasizes the importance of establishing norms and trust in economic action (Coleman, 1990), the structural hole theory argues that network benefits mainly come from nonredundant information and control (Burt, 1992, 1997). The network closure perspective argues that cohesive relationships benefit information flow and provide concerted control through a sanction mechanism, but the structural hole theory proposes that cohesive relationships negatively influence information flow and kill the bridging opportunities.

Despite the seeming contradiction of the traditional social network theory and the structural hole theory, researchers have reconciled these two perspectives by distinguishing local and global structural holes (Burt, 2000; Reagans et al., 2004). These studies concluded that while network closure within a team fosters team performance through facilitating coordination and cooperation, external structural holes beyond the team will help improve the team's performance by providing nonredundant information and brokerage opportunities. Thus, while network closure within a group has positive impact on group performance, structural holes outside of the ego group may help the group perform better. Empirical research has shown support for the positive impact of structural holes at the team-level ego network. For instance, Reagans, Zuckerman and Mcevily (2004) found that the external range measured by the average structural hole of team members helped reduce the project duration of the team. Zaheer & Soda (2009) discovered that structural holes in a TV production team's ego network improved the audience share of the TV production. Vissa and Chacar (2009) found that Indian software ventures whose management

teams had more structural holes in the their external advisory networks were more likely to achieve greater improvement in their sales revenue.

Using VC investment context, Podolny (2001) suggested that structural holes may bring firms various opportunities as well as information about how to fill those opportunities. The information diversity due to greater amount of structural holes not only will reduce egocentric uncertainty as found by Podolny (2001), but also may boost performance of the VC syndicates. Thus, based on the previous literature, I expect a positive impact of external structural holes of VC syndicates.

*H5: A syndicate's external structural holes will positively influence the performance of the startup company.*

In the VC syndication network, information and knowledge sharing is very critical to the performance of both portfolio companies and VC firms. A focal syndicate with more structural holes in its ego network is more likely to add value to the portfolio company due to its access to diverse information. However, since different tasks may require different types of knowledge and information, an ego's ability to benefit from network structure may differ depending on the type of the task. Research has found that structural holes are more important to exploratory task than to exploitative task. For example, Hansen, Podolny, and Pfeffer (2001) found that teams having a network rich in structural holes required a longer time to complete an exploitative project but completed exploratory projects more quickly. Similarly, Lechner, Frankenberger, and Floyd (2010) found that structural holes had greater positive effect on the performance of organizational units responsible for exploratory initiatives.

In VC investment context, VC syndicates provides monitoring and management assistance besides financial support (Black & Gilson, 1998). Due to the lack of structure and organizational routines in younger companies (Bruderl & Schussler, 1990; Stinchcombe, 1965), the knowledge needed for monitoring and nurturing an early stage company is more tacit and intensive than that needed for a company in a later stage. Thus, depending on the stage of startup companies, the nature of VC syndicates' tasks varies. Information with greater diversity will be more helpful in decision making for earlier-stage companies than for later-stage companies. Therefore, I expect that the external structural holes have a greater positive influence on performance of younger companies.

*H6: The positive impact of syndicate structural holes on startup company performance will be greater for a younger company.*

## **Methodology**

### **Data**

As shown in the first essay, VC firms self-select into deals when forming syndicates for startup companies. Following the first two essays that study VC syndicate formation, in this essay I study the performance implication of syndicate behaviors and examine how VC syndicate attributes may influence the performance of startup companies. Consistent with prior essays, I used first round syndicate data from the VentureXpert database. Different from the prior two essays that used matched samples to study syndicate formation behaviors, this essay used first round syndicates formed in real cases to study the performance implication of syndication behaviors. Based on the VC syndication network formed by VC co-investments in the

same round, I studied how the internal network relationships and the external network position of a first round syndicate influence the likelihood of the startup company going public or being acquired by larger firms.

Given the fact that the average duration for an IPO is usually less than 5 years (about 4.7 years) (Cumming & Macintosh, 2001), I focused on startup companies that received their first syndicate investment between 1985 and 2003 to ensure that the companies whose first round syndicates formed in 2003 still have 5 years to achieve IPO or acquisition<sup>10</sup>. To check the existence of selection bias and connect syndicate formation behaviors and performance implication, this study only includes the startup companies studied in Essay 1 and funded from 1985 to 2003. The sample contains 2,447 startup companies with first round syndicates formed by U.S. VCs.

## **Measures**

### *Dependent variable:*

*Startup company performance.* Since VC firms form syndicates to facilitate the success of startup companies, startup company performance is a critical indicator measuring the performance of VC syndicates. Research suggested that VC firms provide both financial and nonfinancial inputs to startup companies and the nonfinancial inputs are closely related to the success of a startup company (Black & Gilson, 1998). Since financial inputs and nonfinancial support are linked to each other, in order to recycle the nonfinancial inputs for a new deal, VC firms need to exit from their current investments. Therefore, exit from an invested startup company is an important indicator of success for the VC investors. The dependent variable in this

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<sup>10</sup> To make sure that firms funded in later 1990s or early 2000s will have enough time to exit, I verify the results using the time frame between 1985 and 2000. The results held robust.

essay is a dummy variable that indicates whether a startup company went public or was acquired by the end of 2008.

*Independent variables:*

*Syndicate internal density:* Syndicate internal density is used to measure the cohesion and closure of VC syndicates. It is calculated as the proportion of preexisting ties to the possible ties in a syndicate based on tie history of syndicate members in the prior five years. It is a continuous variable with the range between 0 and 1.

*External structural holes:* To measure the external network position of a focal VC syndicate, I accumulate the ties between its members and other VC firms outside of the focal syndicate in the current year. Thus, a focal syndicate is treated as the ego in the VC syndication network when its external network structure is measured. A VC partner who did not invest in the focal syndicate but had ties with *any* members in the focal syndicate becomes an alter in the ego network of the focal syndicate. The tie strength between a focal syndicate and its alter VC will be calculated by the total tie strength its syndicate members have with this particular alter. Based on the ego network of a focal syndicate, I measured its external structural holes using Burt's efficiency measure (Zaheer & Soda, 2009). Even though Burt has proposed different measures of structural holes, I adopted his efficiency measure in this essay because 1) the argument in this paper about syndicate-level ego networks focuses on information and knowledge sharing; 2) the constraint measure of structural holes focuses more on dependency; 3) unlike effective size of an ego network, ego network efficiency takes

account of the size of the ego network and measures the number of structural hole per contact.

To measure efficiency, I first calculated the effective size of the ego network, which measures the extent to which information access, timing, and referrals from ego's contacts are nonredundant. Then, I divided the effective size of the ego network by ego network size to calculate the efficiency of an ego network. Thus, the efficiency of an ego network of syndicate  $i$  is calculated as

$$\sum_j [1 - \sum_q p_{iq} m_{jq}] / N$$

where,

$p_{iq}$  is the proportion of the ego  $i$ 's ties with alter  $q$

$m_{jq}$  is the tie strength between alter  $j$  and  $q$  divided by the maximum tie strength alter  $j$  has with anyone in the network.

$N$  is the total number of contacts  $i$  has in its ego network.

*Syndicate size* is measured by counting the number of VC firms involved in a first round syndicate.

*Syndicate experience heterogeneity* is calculated using coefficient of variation, which is the standard deviation of syndicate member experience divided by the average of syndicate member experience. VC experience used in this measure was calculated as the total number of companies a VC firm has invested in until the prior year of the syndicate was formed.

*Company age*: Company age is measured as the age of the company when the first round syndicate was formed.

### *Control variables*

I included three categories of control variables. The first category of control variables refers to the quality and characteristics of the startup company. The quality of a startup company is highly related to its likelihood of going to IPO or being acquired by a larger firm. Due to the data limitation, it is impossible to directly observe the quality of startup companies. However, prior research has suggested that quality can be represented using appropriate proxies (e.g., Kirsch, Goldfarb, & Gera, 2009). In this essay, I used the total amount of money invested in the first round syndicate as a proxy to control for the quality of the startup company. The underlying assumption is that VC firms collect information to judge the quality of the company and then approximately arrange their financing based on their judgment. Startup companies with more promising future are likely to get more money in the first round, which, according to the resource-based view (Barney, 1991), will in turn help them to succeed. Thus, I controlled for the investment amount in the first round of syndication when studying the impacts of syndicate network structures on startup company performance. To remove effect of inflation, I converted all investment amounts to 1985 dollars. Since this variable is skewed, I took the log transformation to correct for the skewness.

Liability of newness (Stinchcombe, 1965) and liability of adolescence (Bruderl & Schussler, 1990) perspectives agreed that companies are going to be more promising and less likely to fail when they mature. Moreover, startup companies at different investment stages may require different amounts of nurturing and monitoring. Thus, besides including company age of the startup company, I took into



consideration the startup company stage at the first round syndicate. I created dummy variables to indicate whether the first round syndicate happens in the seed or the early stage as opposed to the expansion stage. The company stage is correlated to the company age, but these two variables still vary with each other. So, following prior research (e.g., Chemmanur & Tian, 2010), I included both in the performance functions.

The second category of control variables includes the attributes of the first round syndicates. The first is the average geographical distance between VC syndicate members and the startup company they invested in. As shown in Essay 1, this distance variable was calculated using the spherical geometry based on corresponding latitudes and longitudes of locations of VC firms and startup companies. Second, since research found that group diversity influences both internal and external network structures of the group (Reagans et al., 2004), I also included various measures of syndicate heterogeneity. Besides the VC experience heterogeneity, I controlled for two other heterogeneity variables of VC syndicates. VC type heterogeneity was calculated based on the entropy-based measure  $\sum p_i * \ln(1/p_i)$ , where  $p_i$  is the percentage of a specific VC type in the syndicate group. VC performance heterogeneity was measured by the coefficient of variation of VC performance in the syndicate, which equals to the standard deviation of syndicate member performance divided by the average of syndicate member performance. VC performance was represented by the number of IPOs a VC has until the year before the focal syndicate was formed.

I also controlled for variables that reflect environmental influences. One of these variables is the industry heat measured by total number of IPOs in the industry of the startup company in the year prior to the focal syndicate. Other environmental variables include industry dummies and year dummies. I also controlled for the location of a startup company using dummy variables indicating whether the company is in Massachusetts or in California.

In accordance with the dependent variable, which is a dummy, I first used a probit model to test the hypotheses. Then, I also employed a probit model with continuous endogeneous variables to control for the endogeneity and adopted heckman selection model to control for potential sample selection bias.

## **Results**

The descriptive statistics are given in Table 3.1. From this table, we can see that the syndicates I included in the sample vary in size, from involving only 2 to 11 VC firms. Although average VC distance and first round investment amounts only have less than 1% missing values, I generated dummy variables to control for the missing values for these two variables. This is because both the regular probit model and the probit model with endogeneous variables (ivprobit in Stata) drop observations that perfectly predict the outcome variable. Thus, simply dropping missing observations may aggravate the loss of sample size. Meanwhile, I dropped the observations with missing values in current structural holes. The reason is that a firm's structural hole position is suspected to be endogeneous and it is not appropriate to put the dummy variable controlling for the missing observations as the endogeneous variable in the ivprobit model. To keep the regular probit model and the

ivprobit model comparable, I dropped all the observations with missing values on structural hole in the analysis.

**Table 3.1: Descriptive Statistics**

	Obs	Mean	Std. Dev.	Min	Max
Successful exit	2447	0.489	0.500	0.000	1.000
Syndicate density	2447	0.377	0.427	0.000	1.000
External structural hole	2398	0.880	0.086	0.250	1.000
Syndicate size	2447	2.723	1.056	2.000	11.000
VC perf hetero	2447	0.928	0.678	0.000	3.000
Company age	2447	1.595	2.093	0.000	10.000
First round amount	2419	7.919	1.099	-0.403	11.769
Seed stage	2447	0.294	0.456	0.000	1.000
Early stage	2447	0.501	0.500	0.000	1.000
Avg geo dist b/w com & VC	2438	5.657	1.900	0.000	7.901
VC type hetero	2447	0.343	0.377	0.000	1.609
VC exp hetero	2447	0.959	0.455	0.000	3.000
Industry heat	2447	32.168	36.144	0.000	131.000
CA dummy	2447	0.463	0.499	0.000	1.000
MA dummy	2447	0.141	0.348	0.000	1.000
Area density	2447	0.103	0.145	0.000	1.000
Avg geo dist among VCs	2370	5.410	2.540	0.000	7.908
Past structural hole	2383	0.886	0.075	0.143	1.000

The correlation matrix is shown in Table 3.2. One interesting finding from this table is that syndicate internal density is positively correlated with the syndicate's external structural holes ( $r=0.19$ , with  $p$  value less than 0.0001). That is, the more densely connected syndicate members accumulate greater number of structural holes. One interpretation is that VC firm syndication network is really based on reciprocity. When they keep reproducing prior ties, they leave large structural holes in-between. Also, it shows that syndicates with greater heterogeneity in performance have more structural holes, larger syndicate size, and also more heterogeneity in experience. Not surprisingly, companies in seed stages tend to receive less amounts of investment than those in expansion stages.

I have argued that the internal density and external structural holes of a syndicate will positively influence startup company performance (Hypothesis 1 and 5). To test these effects, a probit model with Heteroskedasticity-robust standard errors was used and the results are shown in Table 3.3. In model 1, I include all control variables. As expected, companies that received greater amounts of money in the first syndicate round had better chance to exit. Companies that received their first syndicate round in the seed stage were less likely to go public or be acquired. Since the geographic distance may increase the difficulty of VC monitoring and nurturing, average geographic distance between VC syndicate members and startup companies negatively influenced the possibility of a successful exit.

**Table 3.2: Correlation Table**

		1	2	3	4	5	6	7	8	9
1	Successful exit	1.000								
2	Syndicate density	0.074	1.000							
3	External structural hole	-0.060	0.192	1.000						
4	Syndicate size	0.058	-0.053	0.236	1.000					
5	VC exp hetero	-0.022	-0.322	0.029	0.209	1.000				
6	Company age	0.052	-0.080	-0.118	-0.034	0.014	1.000			
7	First round amount	0.036	-0.028	0.228	0.251	0.065	0.083	1.000		
8	Seed stage	0.018	0.106	0.015	-0.001	-0.055	-0.234	-0.330	1.000	
9	Early stage	-0.054	-0.016	0.103	0.006	0.009	-0.022	0.179	-0.656	1.000
10	Avg distance b/w com & VC	0.002	-0.059	0.083	0.175	0.039	0.008	0.120	-0.009	-0.029
11	VC type hetero	-0.009	-0.175	-0.017	0.279	0.187	0.081	0.087	-0.061	-0.025
12	VC ipo hetero	0.014	-0.019	0.272	0.316	0.423	-0.018	0.137	0.000	0.037
13	Industry heat	-0.060	-0.094	0.067	0.012	0.054	-0.003	0.179	-0.142	0.091
14	CA dummy	0.009	0.033	0.067	0.011	-0.008	-0.112	-0.045	0.075	-0.023
15	MA dummy	0.035	0.082	-0.003	-0.005	-0.055	0.010	-0.028	0.038	-0.004

		10	11	12	13	14	15
10	Avg distance b/w com & VC	1.000					
11	VC type hetero	0.126	1.000				
12	VC ipo hetero	0.093	0.064	1.000			
13	Industry heat	0.004	0.039	0.021	1.000		
14	CA dummy	0.017	-0.072	0.038	-0.101	1.000	
15	MA dummy	-0.127	0.002	-0.019	-0.031	-0.384	1.000

**Table 3.3: Probit Models of Syndicate Density and Structural Hole**

	Model_1 b/se	Model_2 b/se	Model_3 b/se	Model_4 b/se
DV: successful exit				
First round amount	0.134 0.029***	0.129 0.029***	0.143 0.030***	0.139 0.030***
First round amount missing	0.570 0.337+	0.556 0.338+	0.453 0.370	0.441 0.371
Seed stage	-0.151 0.086+	-0.160 0.086+	-0.139 0.088	-0.142 0.088
Early stage	-0.062 0.072	-0.069 0.072	-0.055 0.074	-0.059 0.074
Avg dist b/w com and VC	-0.025 0.014+	-0.024 0.014+	-0.020 0.015	-0.018 0.015
Avg dist b/w com and VC missing	-1.185 0.561*	-1.171 0.560*	-1.078 0.616+	-1.090 0.618+
VC type hetero	-0.095 0.075	-0.080 0.075	-0.103 0.076	-0.088 0.076
VC perf hetero	0.019 0.045	0.008 0.046	0.036 0.047	0.028 0.048
Industry heat	-0.002 0.001	-0.002 0.001	-0.002 0.001	-0.002 0.001
CA dummy	0.029 0.059	0.026 0.059	0.038 0.060	0.038 0.060
MA dummy	0.065 0.084	0.054 0.084	0.073 0.084	0.062 0.084
Syndicate size	0.047 0.029	0.049 0.029+	0.055 0.030+	0.060 0.030*
VC exp hetero	-0.086 0.066	-0.051 0.069	-0.092 0.069	-0.047 0.072
Company age	0.018 0.014	0.019 0.014	0.019 0.014	0.020 0.014
Syndicate density		0.131 0.068+		0.167 0.071*
External structural hole			-0.757 0.348*	-0.941 0.357**
Industry dummies	Yes	Yes	Yes	Yes
Year dummies	Yes	Yes	Yes	Yes
_cons	-0.324 0.312	-0.381 0.313	0.204 0.397	0.248 0.398
chi2 df_m	255.308	258.979	259.977	265.589
N	2447	2447	2398	2398
P	9.26E-33	4.95E-33	3.24E-33	7.60E-34
L1	-1567.903	-1566.068	-1531.811	-1529.004
r2_p	0.075	0.076	0.078	0.080

In Model 2, 3, and 4, I added my main independent variables, syndicate density and structural holes. As expected, the results in Table 3.3 show that syndicate density has significant and positive relationships with companies' chances of exit. But surprisingly, structural holes have a negative impact on the startup company's likelihood of going public or being acquired. The underlying reason may be that the advantages from structural holes become questionable when cohesive ties are needed as a precondition to ensure actors' willingness to share certain critical information and resources (Gargiulo et al., 2009; Podolny & Baron, 1997). The expected benefits of structural holes in VC syndicate external networks are mostly from information diversity, but lack of trust or the competition among VC firms may prevent critical information from transferring through bridging ties.

However, the results about network structure variables in Table 3.3 may be biased due to endogeneity issues and sample selection bias. Endogeneity bias happens when internal network density and external structural holes are correlated with the unobservables in the error term that affect startup company performance. Typically, syndicate density or structural hole may be choice variables that are related to the startup company quality. Here, I used instrumental variable models to examine the existence of endogeneity and correct for the bias caused by the potential endogeneity issue. The instruments need to be correlated with the endogenous variable, uncorrelated with the error term in the structural model, and do not affect the dependent variable.

For internal network density, I used two instrumental variables. One instrumental variable is the network density among all VC firms invested in the focal

startup company's industry and geographic state in the prior five years. This area network density is expected to have negative correlation with focal syndicate network density. Higher network density in the area may help the flow of tacit knowledge among VCs regarding to the startup company. So, the uncertainty about the startup company may be reduced due to the information flow in the area. Research has suggested that actors turned to those they trust in a situation with high uncertainty (Mizruchi & Stearns, 2001). Thus, the decreased uncertainty about a particular deal may reduce the need for high syndicate density. Meanwhile, there is no theory suggesting that the area network density is either correlated with the quality of the focal company (thus with the error term) or affect the performance of the focal company (i.e., chance of going public or being acquired).

In order to avoid the weak instrument issue, I included another instrumental variable for internal syndicate density, which is the average geographic distance among VC syndicate members. Usually, VC syndicate members that are far from each other are less likely to work with each other (Sorenson & Stuart, 2001). Hence, I expect that greater average geographic distance should be negatively correlated with the syndicate density. Although geographic distance between VC firms and startup companies may be related to the startup company performance, it is unlikely that distance among VC syndicate members will systematically influence startup company performance, especially after controlling for the distance between VC firms and startup company<sup>11</sup>. To remedy the effect of the missing observations on this instrumental variable, I also included a dummy variable indicating missing

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<sup>11</sup> The result of the probit model that regresses startup company performance on average distance among syndicate members supports it



observations to control for the possible impact of missing values. The F test suggests that both instrumental variables significantly improve the model fit.

For external structural holes of a focal syndicate, I used the past structural holes as the instrumental variable. Past structural holes are calculated based on the ego network ties of the current VC syndicate members in the prior 5-year moving window. That is, for a focal syndicate formed in 1999, I instrumented the current structural holes on the past structural holes of the syndicate in the period between 1994 and 1998. Since network structure evolves depending on prior network ties, I expect that the network structural hole in the prior five years will be positively correlated with the current structural hole of the focal syndicate. Because the structural hole is sensitive to time and past structural holes may disappear due to the formation of new ties, structural holes existing in prior years should not influence performance of the current syndicate. Again, the F test shows that this instrumental variable significantly improves the model that explains current structural holes.

To control for the endogeneity, I used the ivprobit model in Stata to examine the impact of internal density and external (current) structural holes of VC syndicates. As shown in Table 3.4, I included internal syndicate density and external structural holes in Model 5 and Model 6 respectively, and add both of them together in Model 7. The Wald tests of exogeneity in all three models are not significant. The insignificant Wald tests suggest that I cannot reject the null hypothesis that error term in the structural model and error term in the reduced-form model are not correlated, which means that there is no endogeneity issue. In fact, the *rho* in both Model 4 and 5 shows that the error term correlation is almost 0.

**Table 3.4: Probit Models Endogeneous Variables**

	model_5		model_6		model_7		
	b/se		b/se		b/se		
	IV probit MLE		IV probit MLE		IV probit Twostage		
	DV: density	DV: exit	DV: efficiency	DV: exit	DV: density	DV: efficiency	DV: exit
first round amount	0.037	0.131	0.007	0.134	0.025	0.008	0.135
	0.009***	0.038***	0.002***	0.031***	0.009**	0.002***	0.031***
first round amount missing	0.106	0.562	0.076	0.242	0.105	0.079	0.276
	0.098	0.347	0.019***	0.391	0.104	0.019***	0.395
seed stage	0.073	-0.156	0.029	-0.195	0.035	0.028	-0.176
	0.025**	0.097	0.005***	0.095*	0.025	0.005***	0.010+
early stage	0.060	-0.066	0.015	-0.101	0.025	0.015	-0.093
	0.021**	0.082	0.004***	0.077	0.022	0.004***	0.078
avg dist b/w com and VC	0.014	-0.024	0.001	-0.024	0.009	-0.002	-0.019
	0.006*	0.016	0.001	0.015	0.006	0.001	0.017
avg dist b/w com and VC missing	-0.028	-1.175	-0.036	-1.060	0.081	-0.046	-1.098
	0.131	0.563*	0.026	0.622+	0.146	0.027+	0.627+
VC type hetero	-0.109	-0.086	-0.009	-0.091	-0.092	-0.009	-0.074
	0.022***	0.105	0.004*	0.077	0.022***	0.004*	0.084
VC perf hetero	0.078	0.012	0.013	-0.004	0.012	0.013	0.006
	0.013***	0.069	0.003***	0.056	0.014	0.003***	0.057
Industry heat	0.000	-0.002	0.000	-0.002	0.000	0.000	-0.002
	0.000	0.001	0.000	0.001	0.000	0.000	0.001
CA dummy	0.010	0.027	0.007	0.021	-0.004	0.008	0.026
	0.020	0.062	0.003*	0.061	0.020	0.004*	0.061
MA dummy	0.080	0.058	0.003	0.062	0.061	0.004	0.047
	0.026**	0.103	0.004	0.085	0.026*	0.005	0.090
Syndicate size	-0.008	0.048	0.011	0.037	-0.018	0.010	0.055
	0.009	0.031	0.002***	0.033	0.009*	0.002***	0.043
VC exp hetero	-0.272	-0.065	-0.014	-0.041	-0.265	-0.014	0.017
	0.020***	0.190	0.004***	0.076	0.021***	0.004***	0.135

**Table 3.4: Probit Models Endogeneous Variables (Cont.)**

	model_5		model_6		model_7		
	b/se		b/se		b/se		
	IV probit MLE		IV probit MLE		IV probit Twostage		
	DV: density	DV: exit	DV: efficiency	DV: exit	DV: density	DV: efficiency	DV: exit
Company age	-0.012	0.019	-0.001	0.017	-0.011	-0.001	0.019
	0.004**	0.016	0.001+	0.014	0.004**	0.001+	0.015
Syndicate density		0.079					0.269
		0.651					0.485
External structural hole				0.416			-0.548
				1.070			1.838
Area density	-0.134				-0.094	0.010	
	0.065*				0.066	0.012	
avg geo dist among VC	-0.024				-0.023	0.003	
	0.005***				0.005***	0.001**	
avg geo dist among VC missing	-0.074				-0.049	0.002	
	0.050				0.050	0.009	
past structural hole			0.393		1.379	0.392	
			0.022***		0.123***	0.023***	
Industry dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes
_cons	0.447	-0.359	0.404	-0.600	-0.542	0.404	-0.058
	0.093***	0.418	0.024***	0.826	0.135***	0.025***	1.156
athrho							
_cons	0.020		-0.091				
	0.250		0.077				
Insigma							
_cons	-0.965		-2.695				
	0.014***		0.015***				
Wald test of exogeneity		0.010		1.400			0.580
chi2 df_m		235.748		234.411			234.382
N		2447		2362	2362	2362	2362
p		8.51E-29		1.48E-28	3.10E-114	2.00E-169	3.59E-28
ll		-2677.661		1508.174	-1003.427	3020.173	

In order to verify the validity of my instrumental variables, I tried to use only one of the instrumental variables for syndicate density in both Model 5 and Model 7, and obtained similar results. I also calculated another alternative instrumental variables, which are 77 area dummies indicating the industry and state of each focal startup company. Again, the results hold robust when I put the alternative instrumental variable alone or together with the other two instrumental variables used in Models 5 through Model 7. The reason that I did not find significant endogeneity issue in the sample may be because there are two opposing explanations in terms of how syndicate density is correlated with the quality of a startup company. One is the reciprocity argument. VC firms may choose to form syndicates with familiar partners when a startup company is more promising and regard this as a gesture of reciprocity. The other is the uncertainty argument, which suggests that VC firms tend to form syndicates with familiar partners when they are more uncertain about the quality of the startup company. Since promising startup companies tend to demonstrate less uncertainty, the two effects may randomly cancel each other so that endogeneity does not show up in the sample. According to Wooldridge (2002), the regular probit model is more preferable when there is no endogeneity. Thus, based on the results from the probit model in Table 3.3, I find support for hypothesis 1 and opposite effect for hypothesis 5.

In addition to the endogeneity issue caused by reversed causality, there may be sample selection bias, because only the performance of the syndicates formed in reality can be observed. In order to examine this possibility and control for the potential selection bias, I chose the Heckman selection model based on the formation

regression in Essay I. As shown in Table 3.5, the Wald test in Model 8 suggests that the error term in the selection equation is uncorrelated with the error term in the interest equation (again, the correlation value  $\rho$  is close to 0). The results from the Heckman selection model further confirm the appropriateness of using a regular probit model.

**Table 3.5: Heckman Selection Model**

	Model_8 b/se	
	DV: successful exit	DV: syndicate formation
First round amount	0.052 0.011***	0.009 0.005+
First round amount missing	0.185 0.127	0.010 0.077
Seed stage	-0.052 0.032	0.002 0.015
Early stage	-0.024 0.028	-0.001 0.012
Avg dist b/w com & VC	-0.011 0.011	-0.055 0.011***
Avg dist b/w com & VC missing	-0.368 0.136**	-0.370 0.178*
VC type hetero	-0.040 0.035	-0.167 0.034***
VC perf hetero	0.006 0.020	-0.058 0.023*
Industry heat	-0.001 0.001	0.000 0.000
CA dummy	0.014 0.022	-0.029 0.010**
MA dummy	0.018 0.033	-0.074 0.014***
Syndicate density	0.099 0.094	0.634 0.042***
External structural hole	-0.439 0.249+	-1.639 0.212***
Syndicate size	0.026 0.014+	0.064 0.009***
VC exp hetero	-0.006 0.036	0.160 0.036***
Company age	0.008 0.005	0.002 0.002
Avg geo dist among VC		-0.029 0.009***

**Table 3.5: Heckman Selection Model (Cont.)**

	Model_8	
	b/se	
	DV:successful exit	DV:syndicate formation
Avg geo dist among VC missing		-0.171 0.083*
Inside indirect tie density		0.317 0.164+
Outside indirect tie density		-0.160 0.037***
Industry competition		-0.004 0.019
Industry dummies	Yes	Yes
Year dummies	Yes	Yes
_cons	0.567 0.160***	0.628 0.195**
Athrho		
_cons		0.142 0.333
Lnsigma		
_cons		-0.741 0.037***
Wald test of indp		0.180
chi2 df_m		346.880
N		14291
P		3.87E-49
L1		-7724.302

To test whether internal density and external structural holes of the focal syndicate will have different influences depending on group context and syndicate attributes (hypotheses 2,3,4, and 6), I put interaction terms of the network structure variables with other independent variables in the models 9 through 13 and the results are given in Table 3.6. None of the interaction terms is significant. This may be because the interaction terms used in the models assumed linear function, but the moderation effect of group context may not be linear. To explore this possibility, I did further analysis in split samples and coded syndicate size, syndicate heterogeneity, and company age into categorical variables accordingly.

**Table 3.6: Probit Models of Interaction Terms (Based on Linear Measures)**

	model_9	model_10	model_11	model_12	model_13
	b/se	b/se	b/se	b/se	b/se
DV: successful exit					
first round amount	0.139 0.030***	0.139 0.030***	0.141 0.030***	0.139 0.030***	0.139 0.030***
first round amount missing	0.443 0.371	0.431 0.371	0.452 0.371	0.443 0.371	0.443 0.371
seed stage	-0.146 0.088+	-0.140 0.088	-0.132 0.088	-0.142 0.088	-0.134 0.088
early stage	-0.061 0.074	-0.058 0.074	-0.050 0.074	-0.059 0.074	-0.052 0.075
avg dist b/w com and VC	-0.018 0.015	-0.017 0.015	-0.017 0.015	-0.018 0.015	-0.017 0.015
avg dist b/w com and VC missing	-1.095 0.619+	-1.087 0.618+	-1.104 0.618+	-1.099 0.620+	-1.107 0.620+
VC type hetero	-0.083 0.076	-0.087 0.076	-0.082 0.076	-0.087 0.076	-0.076 0.077
VC perf hetero	0.033 0.048	0.032 0.048	0.029 0.048	0.029 0.048	0.038 0.048
Industry heat	-0.002 0.001	-0.002 0.001	-0.002 0.001	-0.002 0.001	-0.002 0.001
CA dummy	0.035 0.060	0.035 0.060	0.036 0.060	0.037 0.060	0.030 0.060
MA dummy	0.060 0.084	0.058 0.084	0.058 0.084	0.061 0.084	0.051 0.085
Syndicate density	0.198 0.076**	0.154 0.072*	0.163 0.071*	0.166 0.071*	0.181 0.077*
Structural hole	-0.945 0.357**	-0.937 0.357**	-0.939 0.357**	-0.909 0.363*	-0.932 0.363*
Syndicate size	0.051 0.031	0.060 0.030*	0.059 0.030*	0.060 0.030*	0.048 0.031
VC exp hetero	-0.041 0.072	-0.039 0.072	-0.044 0.072	-0.048 0.072	-0.028 0.073
Company age	0.021 0.014	0.021 0.014	0.024 0.014+	0.019 0.014	0.025 0.015+
Syndicate density*Syndicate size	0.088 0.083				0.098 0.085
Syndicate density*VC exp hetero		-0.135 0.150			-0.158 0.152
Syndicate density*Company age			-0.045 0.031		-0.042 0.032
Structural hole*Company age				-0.074 0.140	-0.018 0.145

**Table 3.6: Probit Models of Interaction Terms (Based on Linear Measures)  
(Cont.)**

	model_9 b/se	model_10 b/se	model_11 b/se	model_12 b/se	model_13 b/se
Industry dummies	Yes	Yes	Yes	Yes	Yes
Year dummies	Yes	Yes	Yes	Yes	Yes
_cons	0.440 0.414	0.240 0.392	0.291 0.399	-0.551 0.327+	-0.434 0.324
chi2 df_m	266.702	266.400	267.716	265.871	269.847
N	2398	2398	2398	2398	2398
p	1.19E-33	1.36E-33	7.78E-34	1.69E-33	4.78E-33
ll	-1528.448	-1528.599	-1527.941	-1528.863	-1526.876
r2_p	0.080	0.080	0.081	0.080	0.081

Syndicate size was coded into a dummy variable, with 1 indicating four or more VC firms involved in the syndicate, and 0 indicating two or three VC firms in the syndicate. The results of model 14 in Table 3.7 show that the interaction term between internal syndicate density and syndicate size dummy is positive and significant, which tells that syndicate density has greater impact on startup company performance if syndicates have four or more members. In fact, for syndicates with four or more VC firms, the impact of syndicate density jumps up by almost three times. To make sure that the results in Model 14 are not biased by endogeneity, I ran a probit model with endogeneous variables (based on both Model 5 and Model 7) in split samples of syndicates with two or three VCs and syndicates with four or more VCs separately.<sup>12</sup> Again, the Wald test shows that there is no endogeneity in both subsamples. Thus, the results in Model 14 provide evidence to support Hypothesis 2.

<sup>12</sup> This is because having interaction terms of an endogeneous variable and controlling for endogeneity simultaneously are empirically difficult.



**Table 3.7: Probit Models of Interaction Terms (Based on Categorical Measures)**

	model_14	model_15	model_16	model_17	model_18
	b/se	b/se	b/se	b/se	b/se
DV: successful exit					
First round amount	0.144 0.032***	0.145 0.032***	0.148 0.032***	0.145 0.032***	0.144 0.032***
First round amount missing	0.473 0.390	0.452 0.393	0.492 0.390	0.461 0.394	0.467 0.389
Seed stage	-0.154 0.088+	-0.145 0.088	-0.140 0.088	-0.147 0.088+	-0.148 0.088+
Early stage	-0.069 0.075	-0.065 0.075	-0.055 0.075	-0.063 0.075	-0.063 0.075
Avg dist b/w com and VC	-0.018 0.015	-0.017 0.015	-0.017 0.015	-0.017 0.015	-0.017 0.015
Avg dist b/w com and VC missing	-1.070 0.568+	-1.077 0.568+	-1.077 0.572+	-1.072 0.566+	-1.061 0.562+
VC type hetero	-0.071 0.076	-0.076 0.076	-0.074 0.076	-0.076 0.076	-0.066 0.076
VC perf hetero	0.039 0.046	0.033 0.045	0.031 0.045	0.028 0.045	0.045 0.046
Industry heat	-0.002 0.001	-0.002 0.001	-0.002 0.001	-0.002 0.001	-0.002 0.001
CA dummy	0.037 0.060	0.037 0.060	0.040 0.060	0.039 0.060	0.031 0.060
MA dummy	0.057 0.085	0.054 0.085	0.056 0.085	0.060 0.084	0.045 0.085
Syndicate density	0.143 0.072*	0.261 0.093**	0.213 0.082**	0.170 0.070*	0.265 0.103*
External structural hole	-0.892 0.376*	-0.869 0.377*	-0.911 0.379*	-0.776 0.466+	-0.863 0.467+
Syndicate size dummy (four or more VCs)	0.082 0.081	0.119 0.078	0.120 0.078	0.122 0.078	0.078 0.081
Syn density*syndicate size dummy	0.542 0.243*				0.548 0.245*
VC exp hetero dummy (greater than mean)	-0.011 0.061	0.008 0.063	-0.011 0.061	-0.015 0.061	0.015 0.063
Syn density*VC exp hetero dummy		-0.192 0.133			-0.191 0.134
Company age dummy (<=1)	-0.161 0.115	-0.159 0.115	-0.169 0.119	-0.151 0.118	-0.176 0.123
Company age dummy (<=3 & >=2)	-0.185 0.124	-0.186 0.124	-0.192 0.127	-0.177 0.127	-0.196 0.132
Company age dummy (<=5 & >=4)	-0.012 0.147	-0.009 0.147	-0.009 0.149	-0.023 0.152	-0.020 0.155
Syn density*com age dummy (<=1)			-0.017 0.166		-0.016 0.170

**Table 3.7: Probit Models of Interaction Terms (Based on Categorical Measures)**

	model_14	model_15	model_16	model_17	model_18
	b/se	b/se	b/se	b/se	b/se
Syn density*com age dummy (<=3 & >=2 )			-0.425		-0.385
			0.260		0.260
Syn density*com age dummy (<=5 & >=4 )			-0.139		-0.115
			0.254		0.263
Structural hole*com age dummy (<=1)				-0.045	0.034
				0.816	0.832
Structural hole*com age dummy (<=3 & >=2 )				-0.649	-0.468
				1.131	1.141
Structural hole*com age dummy (<=5 & >=4 )				-0.208	-0.027
				1.143	1.171
Industry dummies	Yes	Yes	Yes	Yes	Yes
Year dummies	Yes	Yes	Yes	Yes	Yes
_cons	0.488	0.455	0.480	-0.308	-0.310
	0.423	0.424	0.424	0.347	0.349
chi2 df_m	248.513	242.036	242.632	240.772	251.341
N	2398	2398	2398	2398	2398
p	1.39E-29	2.00E-28	8.34E-28	1.77E-27	1.43E-27
ll	-1526.783	-1528.008	-1527.691	-1528.85	-1524.374
r2_p	0.081	0.081	0.081	0.080	0.083

Hypothesis 3 argues that there are moderating effects of group heterogeneity such that the impact of syndicate density is greater for more heterogeneous groups. I generated a group heterogeneity dummy using its mean<sup>13</sup>. It was coded as 1 for syndicate groups with heterogeneity greater than the sample mean and 0 for the remaining syndicate groups. I added the group heterogeneity dummy and its interactions with syndicate density into Model 15. As shown in Table 3.7, the interaction term is not significant. Again, to verify the results, I split the sample based on the group heterogeneity dummy and checked endogeneity on both subsamples (syndicates with heterogeneity below mean and syndicates with heterogeneity above mean). The results show that internal density and external structural holes are

<sup>13</sup> To verify the results, I also coded a group heterogeneity dummy using its median and obtained similar results.

significant and consistent with prior findings in the subsample including more heterogeneous syndicates, but not in the subsamples of less heterogeneity syndicates. However, the Wald tests on both subsamples are insignificant, suggesting that there are no endogeneity issues in both subsamples and results in the regular probit models are correct. Thus, hypothesis 3 is not supported.

Hypothesis 4 and 6 propose that syndicates' internal density and external structural holes have greater impact when the startup company is younger. Model 16 and 17 in Table 3.7 included company age as a categorical variable and its interactions with syndicate density and external structural holes. The insignificance of interaction terms indicates that the effects of syndicate density and external structural holes do not vary with company age. To validate there is no endogeneity bias in the results, I tested Model 7 on subsamples split by the categorical values of company age. Surprisingly, the Wald test indicates existence of endogeneity in the subsample for companies two or three years old. Further, syndicate density only has a positive and significant impact on the performance of startup companies that were two or three years old when they received their first round syndicate funding. The results may suggest that the companies at this stage just passed their "honeymoon" and are more likely to fail (Bruderl & Schussler, 1990). And there is greater uncertainty involved in these companies. Thus, the uncertainty argument may overshadow the reciprocity argument for companies at two or three years old so that syndicate density does not have significant influence in the regular probit model for this subsample, but shows significant impact once the endogeneity is controlled. However, there is no

evidence that syndicate density and structural holes have greater impacts for younger companies. Thus, hypotheses 4 and 6 are not supported.

### **Discussion and Conclusion**

Following the first two essays that study group network formation, this third essay studies the performance implication of such group formation behaviors. It examines how the internal and external network structure attributes of a VC syndicate may influence the startup company performance. Specifically, I explore the impacts of a syndicate's internal density and external structural holes on the startup company's chance of going public and being acquired.

In this essay, I argue that syndicate density may positively influence the startup company performance because network closure contributes to the development of trust and improve the coordination/cooperation inside a syndicate. Because the need for coordination is greater in VC syndicates that are larger in size, that have greater heterogeneity, or that are formed for younger startup companies, I further argue that the positive impact of syndicate density will be greater in those syndicates. In addition to the network structure within a syndicate, I also study the role of a syndicate's external network structure. Based on the structural hole theory, I argue that a syndicate's external structural holes have positive impact on startup company performance, mostly due to the greater access to diverse information.

Syndicates network attributes are the result of syndicate formation behaviors. When studying the impact of syndicate network structure attributes, it is important to take into consideration the sorting and self-selecting behaviors in syndication

formation. The empirical results suggest that formation of dense syndicates or syndicates with more structural holes does not vary systematically with unobserved variables, such as startup company quality. In addition, there is no significant sample selection bias either. Given the nonexistence of such potential biases, the empirical analysis find significant impacts of syndicate density as well as the syndicate external structural holes, although the impact of external structural holes is opposite to my initial expectation. Also, greater impact of syndicate density is observed in larger syndicates with four or more VC firms.

Prior studies on teams have found a positive impact of global or external structural holes on team performance (Reagans et al., 2004; Reagans & Zuckerman, 2001). However, sharing knowledge and information generates a cost for the information provider (Reagans & Mcevily, 2003). Networks with cohesive ties and high closure may facilitate such exchange due to the established trust and normative order (Coleman, 1990). Besides, there may be a cost associated with non-sharing in dense networks due to the reputation distribution and the sanction mechanisms. Because of the safe environment of knowledge sharing created by dense ties among alters, Ahuja (2000a) found that greater amount of structural holes decreased a firm's innovation and Gargiulo, Ertug, and Galunic (2009) found that information acquirers benefited more from network closure. Thus, the negative impact of structural holes found in this essay suggests that information sharing in the VC syndication network may depend on the partners' willingness to share. It also indicates that the effect of network structures not only depends on the location of the network structural hole (i.e., local or global structural hole), but also simultaneously depends on the types of

network ties (i.e., the purpose of network ties). Even global structural holes may have a negative impact on ego performance. Only when the type of network ties is taken into consideration can influences of network structures be explained.

Although we find a positive impact of syndicate density on startup company performance, there was also a positive correlation between syndicate density and external structural holes. That is, when VC firms keep forming repeated ties, it may leave structural holes in the ego network of a syndicate. It is likely that the positive impact of syndicate density may be offset by the negative impact of external structural holes. Repeated ties may actually be a double-edged sword depending on the type or the purpose of the network ties.

This research casts light on how network formation behaviors may influence the group performance. Although it has been found that firms tend to form ties with familiar partners, it is not clear whether such network formation behavior may actually have positive influence on task performance. Due to the important influence of prior ties in network tie formation, the study of syndicate network structure based on prior ties has important meaning to the network formation literature. The performance consequence of such formation behaviors may be used to explain future network tie formation. Also, the opposite influences of internal density and external structural holes suggest that in firm cooperation networks, firms need to simultaneously consider two different network structures (both internal and external) as well as the type of network ties.

This essay also makes contributions to the entrepreneurship literature. Research has established that VC syndicates add more value to startup companies

than single VC investment (Brander et al., 2002; Tian, 2008). However, when VC syndication gets more popular, it is necessary to explain what kinds of syndicates are more helpful. Taking a structural perspective, this essay links the network theory with the entrepreneurship literature and explores the type of network structures of VC syndicates that are more beneficial for startup companies.

There are also some limitations in this study. First, this current study only focuses on a startup company's likelihood of going public or being acquired. It is interesting to examine how the internal and external network structures of syndicates may influence other aspects of startup company performance, such as the duration of exit. Second, future research may also study the process that first round VC syndicates influence startup company performance. For example, greater closure of the first round VC syndicate may increase the likelihood of subsequent VC investment and bring greater amount of fund in subsequent round, both of which will in turn increase the chance of successful exit. Third, there are still many questions left unanswered regarding what kind of syndicates are more helpful to the success of startup companies. Future research may study the impacts of the shared experiences of the first round VC syndicate members as well as the variation of their tie strengths. Furthermore, future studies should extend beyond first round syndicates and take a dynamic point of view to consider how the evolution of syndicates in subsequent rounds may influence the success rate of startup companies. Fourth, research has suggested that many group attributes may have opposing effects. For example, syndicate size may enable startup companies to receive more support, but may also generate difficulties in coordination. Syndicate density may facilitate cooperation

within the group, but may sacrifice support from outside of the group. How firms could take advantage of the positive side while minimizing the negative side is another interesting question for future research.



## Summary and Conclusion

Networking and partnership are important phenomena in the business world. Since inter-firm groups, alliances, or syndicates often involve more than two firms, it is important to understand the interplay of tie formations among all potential group members and its impact on task performance.

Using VC syndicates as my research context, I examine three research questions in this dissertation: 1) How do groups with different levels of density form? 2) When is it more likely for a firm to participate in a group with mostly unfamiliar firms? and 3) How do group internal and external network structures influence task performance, and how may group attributes moderate these relationships?

Taking a group perspective, I simultaneously examine the formation of *all* ties in a group by focusing on the path-dependence effect of previous ties among *all* potential group members. Then, to get into the group structure while still capturing all tie formations involved in a group at the same time, I combine a firm focus with the group perspective. Although a pure group perspective enables me to discover group-level mechanisms, the firm-focused group perspective aids to uncover the group formation dynamics between one firm and other group members and explains how group formation may fail because of one particular firm. These group-level network formation studies help me link network formation behaviors with task performance through group network attributes. All together, the three essays enrich our understanding in both network formation and the entrepreneurship field.

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