The Causes and Consequences of the Initial Network Positions of New Organizations: From Whom Do Entrepreneurs Receive Investments?

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This paper examines the mechanisms by which new organizations establish their initial network positions, or sets of network ties from which their future tie networks evolve. I develop hypotheses from two competing logics, one based on the effects of previously developed network ties and the human capital of a new organization's founders and the other based on the effects of a new organization's early accomplishments. I test these logics in a study of 92 Internet security ventures forming ties by receiving investments from venture capitalists and other investment organizations between 2000 and 2005. In contrast to how the network positions of established organizations evolve, I find that new organizations forming their first ties early obtain their initial network positions through their founders' ties and human capital, while new organizations forming their first ties later achieve their initial network positions through their organizational accomplishments. ●

Network ties between organizations are both widespread and important, as they allow organizations to gain access to resources that may be difficult to develop or acquire otherwise (Pfeffer and Salancik, 1978; Granovetter, 1985; Burt, 1992; Uzzi, 1996; Ahuja, 2000a). These network ties come in many forms, including alliances, board interlocks, and equity investments between organizations (Mizruchi, 1996; Brass et al., 2004; Santos and Eisenhardt, 2009). Through these various types of network ties, organizations exchange industry information (Burt, 1992), acquire financial capital (Sorenson and Stuart, 2001; Katila, Rosenberger, and Eisenhardt, 2008), benefit from trust and reciprocity in supplier-buyer ties (Uzzi, 1996), share resources and capabilities (Gulati, 1995; Ahuja, 2000a), collaborate to foster innovation (Powell, Koput, and Smith-Doerr, 1996; Baum, Calabrese, and Silverman, 2000; Katila and Mang, 2003), and gain and lose status (Podolny, 1994). Certain network ties are more valuable than others, however, as some partners can provide better resources to and confer greater status on the organizations with whom they are connected (Stuart, Hoang, and Hybels, 1999; Hochberg, Ljungqvist, and Lu, 2007).

Recognizing the importance of network ties in determining the behavior and performance of organizations, a number of organizational theorists have explored the dynamics by which an established organization's ties and related network position, defined as the exact set of other organizations with whom an organization has direct network ties, evolve over time (Podolny, 1994; Stuart, 1998; Gulati and Gargiulo, 1999; Ozcan and Eisenhardt, 2009). Many of these studies have found that which network ties an organization will form in the future is largely determined by the organization's existing network position and organizational status (Walker, Kogut, and Shan, 1997; Cox, 2006). Specifically, because organizations show a strong tendency toward forming ties with the same organizations repeatedly (tie repetition) and with their partner's partners (tie transitivity), new tie formation is heavily influenced by an organization's network of past ties (Podolny, 1994; Gulati, 1995; Baum et al., 2005; Hallen and Eisenhardt, 2009). Additionally, because partners often have roughly equal status (high status similarity), which new ties an organi-

zation forms is also strongly influenced by its present status (Podolny, 1994; Gulati and Gargiulo, 1999; Chung, Singh, and Lee, 2000). Collectively, because of the social mechanisms of tie repetition, tie transitivity, and status similarity, organizations are most likely to form new ties with organizations with which they have either previously worked, or that have worked with their prior partners, or who are of a similar status (Podolny, 1994; Gulati, 1995). For example, in Baum et al.'s (2005) study of syndication among Canadian investment banks, 91 percent of all ties that were formed exhibited either tie repetition or tie transitivity. Thus organizational network positions remain relatively stable over time, with new ties typically being formed with organizations that are similar in terms of their network ties and status (Podolny and Phillips, 1996; Baum, Shipilov, and Rowley, 2003; Powell et al., 2005).

Yet despite a growing body of literature on how network positions evolve, prior research has not explained how an organization is able to establish its initial network position, the one from which future ties and benefits grow. There are several possibilities. Logically, and in a dynamic paralleling the formation of new ties by established organizations (Podolny, 1994; Gulati and Gargiulo, 1999), the previously developed network ties and human capital of a new organization's founders might be the primary determinants of an organization's initial network ties. Under this founder-history logic, new organizations would be more likely to form ties with organizations to which their founders either directly or indirectly have ties. Similarly, new organizations with more skilled and knowledgeable founders (i.e., those with high human capital) would be more likely to form ties initially with higher-status organizations. In contrast and given that a new organization is a new social entity, its initial ties may instead depend primarily on the new organization's early accomplishments, and new organizations with more accomplishments relative to their peers may be more likely to form ties initially with higher-status organizations. Under this organizational-accomplishments logic, with whom a new organization forms its initial ties would depend on what the new organization's founders achieve after the new organization's founding, not what the founders did or whom they knew previously. Yet because achieving meaningful accomplishments often takes time, the relative influence of these logics may shift as a new organization ages. I examine these competing logics for the causes of initial network positions by analyzing the initial investment ties between new Internet security ventures and professional investors (e.g., venture capitalists and private equity firms) that occur when professional investors make equity investments in new organizations. I focus on these ties because they are typically the first ties formed by high-potential, new organizations (Katila, Rosenberger, and Eisenhardt, 2008). They are also among the most important of a new organization's early ties, having a long-lasting impact on a new organization's future investments (Sorenson and Stuart, 2001) and likelihood of having a successful liquidation event (Hochberg, Ljungqvist, and Lu, 2007). I complement the primary analysis with a secondary analysis exploring the

consequences of initial network positions on the formation of subsequent ties.

INITIAL NETWORK POSITIONS

Founders' Ties and Human Capital as Determinants

An organization's ability to form network ties, and thus alter its network position, is restricted by its attractiveness to potential partners (Eisenhardt and Schoonhoven, 1996). Thus organizations lacking desirable resources will often be more limited in their ability to form ties than organizations with unique and valuable resources (Ahuja, 2000b). But even for an organization with desirable resources, uncertainty about exactly what the organization will contribute to a tie will also reduce its attractiveness to potential partners (Podolny, 1994; Gulati, 1995). Resources such as technical innovations, product development capabilities, and access to customers are difficult to evaluate quickly and accurately without actually forming a tie. Overall, when selecting among many potential partners who may provide similar resources, organizations are more likely to select the potential partner for whom there is less uncertainty about whether the network tie will produce the desired benefits (Podolny, 1994; Gulati, 1995; Eisenhardt and Schoonhoven, 1996).

Prior literature has found that existing direct ties are one powerful mechanism by which organizations may reduce their uncertainty about potential partners (Podolny, 1994; Gulati, 1995; Sorenson and Stuart, 2001; Baum et al., 2005), highlighting how direct ties facilitate the flow of accurate information between each of the participating organizations. In turn, this firsthand knowledge is likely to lead to a new tie, with each organization being more certain about what the other may contribute to such a tie (Podolny, 1994; Gulati, 1995). In support of this argument, Gulati (1995) found that publicly traded firms are more likely to form strategic alliance ties with the firms with whom they have previously formed alliances. Similarly, Podolny (1994) found that investment banks have a strong tendency toward co-managing debt offerings with the banks with whom they have previously worked. Overall, these and other researchers have found that organizations exhibit a strong tendency for tie repetition, working repeatedly with partners with whom they have worked in the past (Sorenson and Stuart, 2001; Baum et al., 2005).

Although new organizations without prior network ties will lack the past organization-level ties through which they may acquire accurate information about potential partners, their founders are likely to have relevant personal ties gained through a lifetime of education, employment, and previous entrepreneurial endeavors (Granovetter, 1973; Feld, 1981; Saxenian, 1994; Hsu, 2007). Prior research indicates that such individual-level ties may also lead to interorganizational ties. For example, corporations located in metropolitan areas with elite social clubs, which foster ties among local managers, have been found to form board interlock ties more frequently with other local corporations (Kono et al., 1998; Marquis, 2003). Similarly, corporations whose technical managers sit on the same industry technical committees have been

found to be more likely to form alliance ties later (Rosenkopf, Metiu, and George, 2001). Thus these findings suggest that, like organization-level ties between organizations, personal ties between employees at different organizations also reduce uncertainty by facilitating the flow of accurate information about each organization.

For new organizations, even though the personal ties of their founders are likely to have been developed when the founders were at a different organization, these ties may nonetheless reduce the uncertainty that a new organization and a potential partner may have about each other, for several reasons. First, potential partners with ties to a founder are likely to benefit from any information they may previously have acquired about the founder's abilities and the relevance of those abilities to the new organization (Rosenkopf, Metiu, and George, 2001; Broschak, 2004). Second, out of a desire to preserve their ties to potential partners, founders have a strong incentive to be honest, allowing potential partners to be more confident in any disclosed information (Powell, 1990; Gulati, 1995). Third, new organizations whose founders have ties to a potential partner are also likely, because of information gained from their founders' prior interactions with the potential partner, to be less uncertain about the potential partner's ability to contribute to a new tie. Therefore, just as established organizations are likely to form new ties with the organizations with whom they have previously formed ties, and personal ties between employees of established organizations may lead to organization-level ties, so too are new organizations likely to form new ties with the organizations with whom their founders have prior ties.

Hypothesis 1: A new organization and a potential partnering organization are more likely to form a new tie if they are already connected through a direct tie with the founder(s).

Prior literature has also found that established organizations exhibit a strong tendency to form ties with other organizations with whom their prior partners have ties and so about whom they can indirectly acquire information (Gulati, 1995; Sorenson and Stuart, 2001). Although new organizations will not have such indirect ties of their own prior to forming their first tie, a new organization and a potential partner may still acquire accurate information about each other if a founder of the new organization has a tie with one of the potential partner's partners (i.e., the potential partner and the founder both have previously worked with a common partner). Furthermore, in situations involving such founders' indirect ties, new organizations and potential partners are more likely to trust information they receive, as the connecting organization is jeopardizing its own ties with both the founder and the potential partner if it provides unreliable information (Powell, 1990). Thus new organizations and potential partners are likely to be less uncertain about what to expect in a new tie if they are already connected through a founder's indirect tie.

Additionally, founders' indirect ties are also likely to lead to the formation of new ties, as each organization is more likely to view the other as legitimate. As with uncertainty, concerns about partners' legitimacy have also been found to have a

strong influence on the formation of network ties, because organizations may be hesitant to form ties with less legitimate organizations out of concern about justifying the tie internally and externally (Meyer and Rowan, 1977; Marquis, 2003).[1] Indirect ties, however, may improve the legitimacy of an organization in the eyes of a potential partner because of the example set by the common partner (Galaskiewicz and Wasserman, 1989; Mizruchi, 1993; Davis and Greve, 1997).

Furthermore, founders' indirect ties are also likely to foster discipline on the part of the connected organizations. In forming a new tie, an indirectly connected new organization and a potential partner not only jeopardize possible future ties with each other in the event of duplicitous or untoward behavior, but each also jeopardizes its existing tie with the common partner. Therefore, when connected through a founder's indirect tie, a new organization and a potential partner will each have strong incentives both to represent themselves accurately and to contribute their full resources and energy toward any tie that they might form, making ties formed on the basis of founders' indirect ties especially attractive (Powell, 1990; Ahuja, 2000a). Overall, due to the benefits of reduced uncertainty, increased legitimacy, and greater discipline, new organizations are likely to form ties with organizations with which their founders have indirect ties.

Hypothesis 2: A new organization and a potential partnering organization are more likely to form a new tie if they are already connected through a founder's indirect tie.

As an alternative to network ties, signals of quality are another powerful mechanism by which organizations may reduce the uncertainty that potential partners might have about them. Signals such as an organization's status (Podolny, 1994; Chung, Singh, and Lee, 2000), the connections of an organization's top management team and board members (Higgins and Gulati, 2003, 2006), and an organization's winning of awards (Rao, 1994) all allow potential partners to infer the quality of an organization and its resources. Furthermore, many of these signals are positional attributes, allowing an organization to be ranked easily relative to other organizations in the same population (Shipilov, 2005). Accordingly, such signals play an important role in the formation of many interorganizational network ties, as they allow potential partners outside of an organization's local clique of direct and indirect network ties to evaluate the organization quickly (Podolny, 1994; Stuart, 1998; Gulati and Gargiulo, 1999). Therefore, organizations may seek to form ties with high-ranking potential partners, interpreting high rank as indicative of high quality. Additionally, ties with high-ranking potential partners may be more legitimate, being easier to justify because they involve the "obvious" choice among possible partners (Galaskiewicz and Wasserman, 1989).

One signal that is especially influential in the formation of interorganizational ties is an organization's status as determined by its prior network partners (Podolny, 1994; Chung, Singh, and Lee, 2000). Status based on such prior affiliations differs from other signals of quality in that it is derived and triangulated from multiple other observables (Podolny, 1993;

Podolny and Phillips, 1996). For example, each tie that an organization has previously formed represents an endorsement from a different organization. Thus affiliation-based status is a "multifaceted and encompassing" signal (Podolny, 1993: 834), reflecting and summarizing the detailed and varied information available to an organization's network partners (Podolny, 1993). Furthermore, not only does status indicate the quality and legitimacy of an organization, it also indicates the social benefits that a partner may expect with regard to improving (or lowering) its own status (Podolny, 1994).

For these reasons, organizations exhibit a strong preference for forming network ties with high-status partners (Podolny, 1994; Hsu, 2004). High-status partners are likely to be unwilling to form ties except with organizations of equally high status, however, thus essentially forcing lower-status organizations to form ties with other lower-status organizations. Consequently, ties typically exhibit status similarity, with both partners having near equal status (Podolny, 1994; Gulati and Gargiulo, 1999). Such status similarity has been found to be a primary driver of tie formation in settings such as investment banks forming alliance ties for the purpose of debt-offering syndicates (Podolny, 1994; Chung, Singh, and Lee, 2000) and automotive, industrial automation, and materials firms forming strategic alliance ties (Gulati and Gargiulo, 1999). Furthermore, studies have also found that status generally overwhelms other signals of quality, such as recent performance, in influencing which ties an organization is likely to form (Stuart, 1998; Gulati and Gargiulo, 1999).

Initially, though, new organizations will lack the network ties that confer such status. Instead, potential partners may look to the signal provided by a founding team's human capital, its possession of productivity-enhancing skills and knowledge (Becker, 1964; Eisenhardt and Schoonhoven, 1996; Shane and Stuart, 2002; Hsu, 2007). Like status, founders' human capital is inferred from other observables, including both experiences that have allowed the founders to learn various skills and knowledge and successes demonstrating such skills and knowledge. Thus, as with status, human capital is also a multifaceted and encompassing signal, as multiple observables allow for the underlying human capital to be inferred. Because a new organization's permanence is likely to be a major source of uncertainty for potential partners and the founders' human capital is a signal of the founding team's ability to help their organization succeed, potential partners are likely to seek ties with new organizations whose founders have higher human capital (Eisenhardt and Schoonhoven, 1990; Higgins and Gulati, 2003). Moreover, potential partners are also likely to prefer ties with new organizations whose founders have higher human capital because such ties will be more legitimate, being easier to justify both internally and externally (Galaskiewicz and Wasserman, 1989). In a process similar to that by which status similarity emerges, new organizations whose founders have higher human capital will form ties primarily with high-status partners, leaving new organizations whose founders have less human capital to form ties primarily with low-status partners.

Hypothesis 3: A new organization and a potential partnering organization are more likely to form a new tie if the new organization's founders' human capital is more similar to the status of the partnering organization.

Organizational Accomplishments as a Determinant

While the ties and human capital of a new organization's founders reflect their personal history, an organization's accomplishments reflect how the organization itself has behaved and performed recently (Podolny, 1993; Rao, 1994). Although a few studies have shown that the accomplishments of established organizations influence the number of ties that organizations form (Ahuja, 2000b) and the speed with which they are formed (Shane and Stuart, 2002; Katila and Mang, 2003), studies of network evolution have generally found that an established organization's existing social ties and status are more important than its accomplishments in determining which ties are formed (Gulati, 1995; Stuart, 1998; Sorenson and Stuart, 2001). For a new organization, though, the founders' ties and human capital may provide less accurate and relevant information to potential partners. Ties with a new organization's founders may reveal how they personally performed in a prior context, but that context is likely to involve somewhat different market, technical, and organizational challenges (Stinchcombe, 1965; Romanelli, 1989). Similarly, the educational experiences and prior personal successes used to infer a founding team's human capital are also likely to predict only partially how well the team will address the new organization's unique challenges (Eisenhardt and Schoonhoven, 1990; Baum and Silverman, 2004). Likewise, founders' ties and human capital may provide less legitimacy than developed ties and status, as such legitimacy originates at the individual and not the organizational level. Overall, even when founders' have prior ties or high human capital, potential partners may still be concerned about the quality and legitimacy of the founded organization.

Given the limitations of founders' ties and human capital to reduce uncertainty and provide legitimacy, potential partners may instead base their decisions about ties on a new organization's accomplishments since its founding. Like both organizational status and founders' human capital, an organization's accomplishments is a positional attribute that can be used to rank an organization relative to other organizations in the same population. Unlike founders' human capital, though, a new organization's accomplishments (e.g., releasing products or receiving awards) signal the progress that a new organization has already made in resolving the market, technology, and organizational challenges that it faced initially (Spence, 1974; Wasserman, 2003). Because such accomplishments are easily observable, difficult to fake, and indicate that a new organization is likely to be of high quality, the accomplishments of new organizations are likely to be accurate signals that potential partners will use in their decisions about forming ties (Spence, 1974; Weiss, 1995).

Accomplishments may also be a preferred indicator by which potential partners evaluate the legitimacy of a new organization. Through accomplishments such as releasing a product or winning an award, a new organization may raise its legiti-

macy by conforming to the norms of what is proper and desirable among organizations in its population (Aldrich and Fiol, 1994; Rao, 1994). Furthermore, unlike founders' human capital, a new organization's accomplishments clearly indicate the legitimacy of the organization in the relevant context. Such accomplishments may also increase the media's and the informal attention received by a new organization, which may further legitimate the new organization (Pollock and Rindova, 2003). Overall, potential partners are likely to prefer to form ties with high-accomplishment new organizations, regarding such new organizations as of higher quality and more legitimate.

Although potential partners may rank new organizations based on their accomplishments, new organizations are likely to rank their potential partners on the basis of status. Many of their potential partners are likely to be established organizations with a status that has developed over a history of prior affiliations (Podolny, 1994; Podolny and Phillips, 1996), which is a multifaceted and encompassing signal and a beneficial social resource (Podolny, 1993). Accordingly, developed status has been found to be a preferred mechanism by which potential partners evaluate established organizations, having an influence greater than recent performance (Gulati, 1995; Stuart, 1998). Therefore, high-accomplishment new organizations will seek and primarily form ties with high-status partners, leaving low-accomplishment new organizations primarily to form ties with low-status partners.

Hypothesis 4: A new organization and a potential partnering organization are more likely to form a new tie if their organizational accomplishments and status are more similar.

Time and the Relationship between Founders' History and Organizational Accomplishments

Initially, though, new organizations will lack accomplishments. Until there has been sufficient time for accomplishments to be expected, potential partners are likely to judge new organizations by the ties and human capital of their founders. Over time, however, new organizations may be expected to have achieved certain milestones, and the presence or absence of such accomplishments will become a more accurate means of assessing future potential and present legitimacy (Stuart, Hoang, and Hybels, 1999; Higgins and Gulati, 2003; Jensen, 2003). Whereas founders' ties and human capital may help inform potential partners of a new organization's likely ability to resolve various challenges, its accomplishments signal the extent to which these challenges have been resolved. Thus, at the time that accomplishments may be expected, a new organization and a potential partner may each reconsider the appropriateness of forming a tie with the other, even if there is a tie with a founder or their human capital and status are similar. For example, if a new organization whose founders have low human capital achieves exceptional early market success, then the new organization may forgo forming a tie with a low-status potential partner with whom it has previously worked and instead pursue a high-status partner with whom it lacks a prior tie. Although potential partners may continue to use founders'

ties and human capital to locate and evaluate new organizations, their influence on a new organization's initial network position will decline as the new organization delays forming its initial ties, thus increasing the relative influence of accomplishments.

Hypothesis 5: As a new organization ages, its founders' ties and human capital will have a reduced influence on which potential partnering organizations it is likely to form ties with.

The Consequences of an Organization's Initial Position

Once a new organization forms its first ties, it acquires an initial network position, and this initial network position will have a strong influence on the formation of any later network ties that follow. For partners that have already formed a direct tie with the new organization, such developed direct ties are likely to provide privileged access to nuanced, inside information that reveals more about the new organization's current capabilities, resources, and progress than is revealed by the new organization's founders' ties and human capital and recent externally visible organizational accomplishments. Therefore, on the basis of this superior information, potential partners may be especially likely to form another tie with a new organization with whom they already have a developed direct tie.

Hypothesis 6a: Once a new organization has formed its initial ties, the formation of later ties will depend on the organization's developed direct ties.

Through its initial network position, a new organization is also likely to develop indirect ties. Such indirect ties may provide access to the same privileged information as developed direct ties, as the common partner connecting a new organization and a potential partner may be willing to share its inside information (Gulati, 1995; Walker, Kogut, and Shan, 1997; Sorenson and Stuart, 2001). Additionally, potential partners with developed indirect ties to a new organization are also more likely to regard the new organization as legitimate given the recent choice of the common partner to form a tie with the new organization (Galaskiewicz and Wasserman, 1989). Furthermore, a common partner, desiring the trust and honesty facilitated when cliques of partners all form ties with one another, may pressure both a new organization and a potential partner to form a tie with each other (Powell, 1990; Ahuja, 2000a; Bothner, Meadow, and Ozdemir, 2006). Thus, because of the greater availability of accurate information, the stronger perceived legitimacy, and pressures from their common partner, a new organization and a potential partner connected through a developed indirect tie may be especially likely to form a new tie.

Hypothesis 6b: Once a new organization has formed its initial ties, the formation of later ties will depend on the organization's developed indirect ties.

A new organization's initial network position will also confer a status position on the new organization. This developed status, obtained through the organization's own history of prior network affiliations, is likely to be interpreted as a better sig-

nal of a new organization's future potential than its founders' ties and human capital and recent organizational accomplishments because it indicates the quality of the resources and advice that the new organization is receiving from its existing partners (Podolny, 1994; Gulati and Gargiulo, 1999; Chung, Singh, and Lee, 2000; Jensen, 2003). Potential partners are also likely to consider this developed status as a good indicator of a new organization's legitimacy, as the developed status represents an endorsement of the new organization itself by another organization (Podolny, 1994; Jensen, 2003). Because a new organization's developed status is likely to be regarded as an especially accurate indicator of both ability to contribute to a tie and legitimacy, potential partners are likely to show a preference for forming ties with new organizations with high developed status. Therefore, status similarity on the basis of developed status is also likely to have a strong influence on a new organization's formation of later ties.

Hypothesis 6c: Once a new organization has formed its initial ties, the formation of later ties will depend on the organization's developed status.

METHOD

Sample and Data Sources

The research samples were drawn from the population of potential initial and subsequent investment ties between U.S. Internet security ventures and professional investors between 2000 and 2005. These vertical investment ties involve professional investors (e.g., venture capital firms, private equity firms, and corporations) investing in ventures, providing capital and advice in exchange for equity (Gorman and Sahlman, 1989). To improve their investment return, investors typically seek ventures likely to experience substantial growth (Gompers and Lerner, 2001). Because of the difficulties associated with valuing ventures and negotiating the terms of investment ties, ventures typically form investment ties in a staged process of discrete rounds that often involve multiple investors forming ties under the same terms (Gompers, 1995; Sorenson and Stuart, 2001). The primary sample, for testing the hypotheses related to the causes of initial network positions, was thus selected from the population of potential investment ties in each of the focal ventures' first occurring round. Similarly, the secondary sample, for testing the hypotheses related to the consequences of initial network positions, was selected from the population of potential later investment ties in the focal venture, those ties formed as part of the second, third, and subsequent rounds of investment ties. I supplemented these quantitative data with semi-structured field interviews with 21 informants who were the founders or investors of nine ventures in the Internet security industry. I used these interviews to better understand the context of the study and to improve the accuracy and appropriateness of the measurements.

I focused on investment ties for several reasons. First, investment ties are typically the first ties formed by high-technology ventures, such as Internet security ventures, pursuing large market opportunities (Katila, Rosenberger, and Eisenhardt, 2008). Second, investment ties are important

because they increase a young venture's likelihood of having an acquisition or initial public offering (IPO) (Hochberg, Ljungqvist, and Lu, 2007) and ability to have less underpricing in the event of an IPO (Megginson and Weiss, 1991; Stuart, Hoang, and Hybels, 1999; Higgins and Gulati, 2003). Initial investment ties are thus usually the earliest and among the most important ties formed by young ventures.

I chose to study ventures from a single industry, Internet security, to allow more accurate, comparable, and consistent measures of constructs such as founders' human capital and accomplishments. Ventures in the Internet security industry develop software products that are used to secure networks of computers from intrusion by hackers, viruses, and spam. For this study, I defined the Internet security industry as including organizations classified in the VentureXpert database as having one of the following industry codes: Security/Firewall/Encryption Services (VEIC 2721), Internet Security and Transaction Services (VEIC 1561), or Computer Security (VEIC 2675).

I chose the Internet security industry for several reasons. First, because identifying entrepreneurial opportunities within the industry often does not require extensive financial resources, ventures are started by founders with varying degrees of social and human capital. This diversity is evident in the sampled 92 founding teams, among which 54 had a founder who had been a manager at a public company, 45 had a founder with a technical graduate degree, 18 had a founder who had previously started a venture that was either acquired or went public, and 24 had founders with direct ties to one or more investors. Second, low initial product development and marketing costs create natural variance in the timing of when Internet security ventures choose to form their first investment ties. For example, among the ventures for which I have interview data, some took their initial investments within days of their founding, while others delayed their first professional investments until after releasing their first product, often keeping early costs low by using strategies such as locating the venture in their spare bedroom and giving early employees IOUs instead of pay. Third, although initial product development costs are low in the industry, the eventual need to build an expensive enterprise sales force leads most ventures in the industry ultimately to take equity investments. In support of this premise, I identified only 13 Internet security ventures on the 2000–2005 exhibitor lists for NetSec, the key industry conference, that were founded in the U.S. from 2000 through 2002 and had not yet taken an equity investment.

I chose to study ventures that were founded in the three-year period from 2000 through 2002 for several reasons. First, it ensures that a variety of investment periods were included in the sample, including the dot-com bubble, the subsequent crash, and the following normalization of the venture investment market (Gulati and Higgins, 2003). Second, a more recent time period made it easier to find accurate and complete information about the ventures, especially as a number of Internet sites that archive public Web pages had arisen by this time period. Finally, because ventures may take

a few years to raise their first round, I excluded ventures founded since 2002 to avoid sampling bias. The unit of analysis is the possible formation of an investment tie, and so the overall time period of the study extends from 2000 through 2005.

Using the VentureXpert database, I identified 107 ventures that were listed in this database as meeting the criteria of offering products that secure networks of computers from intrusion, being founded in the U.S. from 2000 through 2002, and having received at least one professional investment as of 2005. I then verified that the ventures met these criteria by visiting their Web sites and reading press articles on the ventures. Based on this review, I found that eight of the ventures from the VentureXpert list did not truly meet the stated criteria for various reasons, including raising money prior to 2000 (suggesting they were founded earlier), not having taken any investments, or manufacturing non-Internet security systems such as burglar alarms. After excluding these eight ventures, I collected data on the founders of the remaining 99 ventures, but I was only able to find complete founder data for 92 of the 99 ventures' founders. I used a Kolmogorov-Smirnov (K-S) test to assess the representativeness of the resulting sample of 92 ventures and found no statistically significant differences with respect to founding years of the ventures, the age of the ventures at the time of their first investment, the number of initial investors, or the status of those investors. Thus in the primary sample, I studied the initial tie formation of these 92 focal Internet security ventures. In the secondary study, I studied subsequent tie formations of the 77 of these ventures that raised a later round during the observed time period (2000–2005).

I gathered data from multiple sources. A primary data source was the VentureXpert database, formerly known as Venture Economics. This database includes information on the investment history of ventures (with investments grouped by chronologically ordered rounds) and ventures' location and founding dates collected from venture capitalists and corporate investors through the National Venture Capital Association. The database has been used extensively in prior research and has been found to provide an accurate description of U.S. venture financing (Gompers and Lerner, 1999; Kaplan and Schoar, 2005). A second important source of data were archives of the ventures' early Web sites. I accessed these archived Web sites through the Internet Archive (http://www.archive.org/), a non-profit founded in 1996 that captures snapshots of Web sites at roughly weekly intervals.

As noted earlier, the research samples were drawn from the population of potential investment ties between Internet security ventures founded in the U.S. from 2000 through 2002 and professional investors. Because each venture received investments from only a small number of professional investors, I thus analyzed the formation of ties within sparse networks. Although I could have conducted the analysis using all possible venture-investor dyads and a logistic regression to estimate the effects of a covariate vector on the likelihood of a tie being formed, this approach could have introduced substantial bias into the results for two reasons.

First, this approach would have introduced greater autocorrelation, as each venture and each investor would have been included in the sample a large number of times. This could have led to the possible underestimation of standard errors for the attributes of ventures and investors that did not change between dyads (Krackhardt, 1988; Mizruchi, 1989). Second, using a logistic regression would also have yielded biased estimates because tie formation in sparse networks is a rare event, and a regular logistic regression would tend to underestimate the factors that predict a positive outcome (King and Zeng, 2001).

I therefore addressed dyadic interdependence and rare events using a combination of two techniques, choice-based sampling and rare-event bias correction, which have been used recently in other studies of tie formation in sparse networks (Sorenson and Stuart, 2001; Jensen, 2003; Dushnitsky, 2004). Consistent with these prior studies and to reduce interdependence among the dyads, I used choice-based sampling and included all venture-investor dyads in which investment ties did occur plus a random sample of venture-investor dyads in which investment ties did not occur (Manski and Lerman, 1977; Manski and McFadden, 1981; Lancaster and Imbens, 1996). To construct the choice-based samples, I matched each dyad in which an investment occurred with ten random dyads in which an investment did not occur. To correct for the difference in the proportion of positive outcomes between the choice-based samples and the underlying population of possible dyads, I used the prior-correction technique of Manski and Lerman (1977). See the Appendix for more on the decision to use choice-based sampling and the sampling methodology. Also consistent with prior studies of tie formation in sparse networks (Sorenson and Stuart, 2001; Jensen, 2003; Dusnitsky, 2004), I used the bias-correction estimator developed by King and Zeng (2001) to correct for the presence of rare events. Overall, the primary sample consists of 171 initial investment ties and a matched sample of 1,710 non-investment dyads, while the secondary sample consists of 417 later investment ties and a matched sample of 4,170 non-investment dyads.

Measures

I estimated models of the likelihood that a venture and a professional investor formed a vertical investment tie. Thus the primary dependent variable is a dichotomous variable with a value of one if the investor made an equity investment in the venture as part of the venture's first round of professional investments and zero otherwise. The dependent variable in the secondary analysis is identical, except that it takes on a value of one if an investment was made as part of a second or later round of investments.

For the founder-construct measures, I began by collecting biographies of founding teams from the original, archived versions of the venture Web sites. To ensure that I collected biographies for all founders, I also searched for media coverage mentioning each venture's name and the word "founder." I excluded from the sample ventures for which I could not find founders' biographies.

I used the founders' biographies to determine both their direct and indirect ties. I measured a founder's direct tie by whether a founder had previously founded another venture in which the potential investor had made an equity investment. To determine the presence of founders' direct ties, I first used the founders' biographies to identify any prior ventures that they had previously started. I then used the VentureXpert database to identify the professional investors investing in these prior ventures. Using the same approach, I measured a founder's indirect tie by whether the potential investor had previously co-invested with another professional investor that possessed a direct tie with one or more of a venture's founders. I constructed both tie measures as dichotomous variables, with values of one when a tie existed and zero otherwise.

As part of measuring the similarity between a venture's founders' human capital and an investor's status, I measured an investor's status on the basis of prior affiliations. This approach is consistent with literature on the status of organizations (Podolny, 1994; Jensen, 2003), recent literature on investors' status (Hochberg, Ljungqvist, and Lu, 2007; Hsu and Ziedonis, 2007), and with how the entrepreneurs and investors I interviewed described evaluating the status of other investors. I computed investor status yearly from 2000 through 2005 for each investor as the eigenvector centrality in the co-investment network of all the potential professional investors over the previous five years (Hochberg, Ljungqvist, and Lu, 2007) because it weights each tie by the connected investor's centrality (Bonacich, 1987). I chose the five-year time horizon to ensure that co-investment ties were recent and for consistency with the prior literature on co-investment network centrality (Hochberg, Ljungqvist, and Lu, 2007). The networks included all U.S. investors listed in VentureXpert as being active during the relevant time period. To ensure the robustness of the findings, I repeated the analysis using degree and betweenness centrality, and results (available from the author) were generally comparable.

For founder human capital, I chose two measures that were consistent with both the prior literature and with how the investors I interviewed described evaluating founders: entrepreneurial human capital (i.e., a team's skills and knowledge related to identifying opportunities and launching a venture) and managerial human capital (i.e., a team's skills and knowledge related to leading and growing a venture). Investors generally described these as separate, albeit important, types of human capital. For example, as one investor described a venture's entrepreneurial human capital, "The technical capability seemed pretty solid . . . they seemed to have the right skills to get something done and into the customers' hands," and the team's managerial human capital, "The CEO was a seasoned guy who seemed to be able to manage the raw energy. . . . It was a real guy managing the kindergarten [e.g., the technical founders]." The two measures of human capital also allowed a better test of the theory.

I assessed entrepreneurial human capital using three measures identified by the investors I interviewed and similar to those used in the prior literature. First, because where

founders were educated is indicative of the quality of their intellect, I measured entrepreneurial human capital as the percentage of founders that attended an elite university for either their undergraduate or graduate degree. Following other recent studies (Palmer and Barber, 2001; Westphal and Stern, 2006), I classified elite universities using the designations of Useem and Karabel (1986). Second, I measured entrepreneurial human capital by whether at least one founder had a relevant graduate degree (i.e., a Master's or Ph.D. in either a related science or engineering discipline) (Hsu, 2007), because such specialized education may allow founders to identify unique technical opportunities (Shane, 2000). I measured this as a dichotomous 0/1 variable. Third, because successful serial entrepreneurs have previously demonstrated skills and knowledge related to identifying opportunities and launching ventures (Shane and Stuart, 2002; Hsu, 2007), I measured entrepreneurial human capital as the number of venture-capital-backed startups previously founded by members of the founding team that had either been acquired or gone public. I conducted a factor analysis using the principal factor method with promax rotation. As expected, only one factor had an eigenvalue greater than 1, and all three measures loaded on this single factor with the following loadings: 0.725 (elite universities), 0.461 (graduate degree), and 0.546 (number of prior successful ventures).

I measured managerial human capital using three separate measures, which I also selected based on investors' interviews and prior literature. First, I measured managerial human capital by whether one or more of the team's founders had been a manager at a public company, because being selected for such a position indicates the possession of management skills, and the position itself likely further developed those skills (Beckman, Burton, and O'Reilly, 2007). Second, I measured managerial human capital by whether the founding team was functionally diverse, including at least one founder who had previously managed a group, one who had an engineering background, and one with marketing experience. Such functional diversity indicates that founding teams are more capable of leading and coordinating across the functional domains within the new organization (Schoonhoven, Eisenhardt, and Lyman, 1990; Beckman, Burton, and O'Reilly, 2007). Third, as any prior joint work experience likely allowed founders to develop skills for better communicating and coordinating with each other, I measured managerial human capital by whether two or more of the founders had previously worked together (Eisenhardt and Schoonhoven, 1990; Beckman, Burton, and O'Reilly, 2007). I measured each of these three measures as dichotomous 0/1 variables. As with entrepreneurial human capital, I conducted a factor analysis using the principal factor method with promax rotation. As expected, only one factor had an eigenvalue greater than 1, and the three measures loaded on this single factor with the following loadings: 0.504 (public management experience), 0.997 (functional diversity), and 0.100 (prior coworkers). Though the loading of prior coworkers is somewhat low, I chose to retain it in the factor analysis for theoretical reasons, as its inclusion is supported by the literature and investors' interviews. Overall, the loadings suggest that public management experience

and functional diversity are the strongest determinants of managerial human capital.

Corresponding to the distinction between entrepreneurial and managerial human capital, I used two measures of the similarity between founder human capital and investor status: human capital$_{ENT}$ / status similarity (comparing founder entrepreneurial human capital with investor status) and human capital$_{MAN}$ / status similarity (comparing founder managerial human capital with investor status). Before comparing investor status with founder human capital, I normalized these measures so they ranged from 0 to 1. I measured each similarity measure by taking the ratio of the lower of the two compared values (i.e., either the relevant measure of founder human capital or investor status) and dividing it by the larger of the two values. I chose this ratio-based similarity measure because it is the predominant measure of dyadic similarity in the related literature (Gulati and Gargiulo, 1999; Chung, Singh, and Lee, 2000). This measure also has the property of dampening differences among high-ranking pairs. This dampening is desirable for dyads involving status, because organizational populations generally include relatively few high-status organizations (Benjamin and Podolny, 1999; Podolny, 2001). For example, in my sample only 23 percent of investors had a status above the mean. Were the selected similarity measure not to exhibit this dampening, then even "similar" high-ranking pairs would naturally appear to have less similarity because founders with high human capital are less likely to be able to find a high-status investor whose status exactly matches their level of human capital, especially because investors' geographic and industry preferences may further reduce the likelihood of exact matches. The resulting similarity measure ranges from 0, indicating no similarity, to 1, indicating complete similarity. For dyads in which the compared measures both equal 0, the similarity measure was set to 1, as both the investor and the venture ranked similarly.

I measured the similarity between organizational accomplishments and investor status using two forms of accomplishments, product accomplishments and award accomplishments, which act as different signals of a venture's progress. I measured product accomplishments as the number of products that a venture had released at the time of the focal investment round relative to the number of products released by the other new organizations in the sample when they were the same age. Based on my interviews, I used the number of product releases as a measure of organizational accomplishments because customers often purchase Internet security products in bundles (e.g., suites including anti-virus software, anti-spam systems, firewalls, and intrusion-detection solutions), and ventures that have a more complete product suite are often more accomplished. I chose to use a relative measure of accomplishments, instead of an absolute measure, as ventures form their first investment ties at different ages, and investors are likely to evaluate a venture's accomplishments relative to those of similarly aged ventures. For example, a venture that has released one product (e.g., an intrusion-detection system) during its first year may be considered "high accomplishment" relative to its peers,

while a venture that has only released a single product by its third year may be considered "low accomplishment." I measured a venture's relative product accomplishments as follows:

$$\text{organizational product accomplishments}_v =$$
$$[p_v - \min(\mathbf{p})] / [\max(\mathbf{p}) - \min(\mathbf{p})]$$

where p_v is the number of products the venture had released when it formed the focal round and $\mathbf{p}$ is a vector of the number of products released by the rest of the ventures in the sample when they were the same age. I gathered product release dates from archived versions of the ventures' Web sites and normalized relative product accomplishments across the sample to ensure that they ranged from 0 to 1. I then calculated the measure of organizational product accomplishments and investor status similarity, accomplishments$_{\text{PRODUCT}}$ / status similarity, using the same ratio-based similarity comparison as used for founder human capital and investor status similarity.

I also included a venture's award accomplishments as a second measure of accomplishments that focuses on a venture's market acceptance (Aldrich and Fiol, 1994; Rao, 1994). Receiving an award indicates not only that a venture is known by customers and technical experts but that these third parties consider the venture exceptional. I measured organizational award accomplishments as the number of awards that a venture had received at the time of the focal round relative to the awards received by other ventures in the sample when they were the same age, calculated using the same method as for venture product accomplishments and also normalized to range from 0 to 1. Information on awards, including dates, came from the news and events sections of the ventures' archived Web sites. I then calculated the measure of organizational award accomplishments and investor status similarity, accomplishments$_{\text{AWARD}}$ / status similarity, using the same ratio-based similarity comparison as used for founder human capital and investor status similarity.

I included several control variables. First, I included dummy variables for the calendar years 2000–2005 (using 2002 as the base year) to capture any annual effects that might affect forming investment ties (Gompers and Lerner, 1999). As a robustness check, I reran the models using period effects for the following periods: the bubble (2000), the crash (2001–2002), and the typical period that followed (2003–2005); results were essentially identical to those reported below.

Second, I controlled for investors' geographic and risk preferences. I controlled for the preference of investors to invest in geographically proximate ventures by measuring the distance between the venture and the potential investor (Sorenson and Stuart, 2001). For these calculations, I determined longitudes and latitudes from zip codes. I included the natural log of distance in the models, as the influence of additional distance declines as ventures and potential investors become

farther away from each other (Sorenson and Stuart, 2001). Related to investor risk, I measured syndicate size by the number of investors in each round, because potential investors may incur less risk when investing with large syndicates (Lerner, 1994; Sorenson and Stuart, 2008). Likewise, I controlled for the reduced risk associated with investing in older ventures (Shane and Stuart, 2002; Hsu, 2007) by measuring age as the number of years that a venture had existed at the time of the focal investment round.

Third, I controlled for the strong preferences of investors for ventures in certain stages of development and industries (Gupta and Sapienza, 1992; Shane and Stuart, 2002). I included binary control variables for investor's preferred stage, prior security investment, and prior Internet investment. Investor's preferred stage has a value of one if the investor made the majority of its initial investments when ventures were raising their first round (or in the secondary sample, if the majority of initial investments were made in later rounds). Prior security investment has a value of one if the investor had previously invested in an Internet security venture (i.e., a venture with a VentureXpert classification code of 2721, 1561, or 2675). Likewise, prior Internet investment has a value of one if the investor had previously invested in an Internet venture (i.e., a venture with a VentureXpert classification code of 2800).

I calculated additional measures for the secondary analysis of the consequences of initial network positions. I measured developed direct tie as a binary variable with a value of 1 if the investor had previously invested in the venture and a value of 0 otherwise. Similarly, I measured developed indirect tie as a binary variable with a value of 1 if the investor had previously co-invested with one or more of the venture's previous professional investors and a value of 0 otherwise. Once again using the same ratio-based similarity measure (Gulati and Gargiulo, 1999; Chung, Singh, and Lee, 2000), I measured developed status / status similarity by dividing the lesser of the potential investor's status and the highest status of the existing investors by the greater of these two values. Finally, in the secondary sample, I also introduced round number as a control variable to account for a venture's changing concerns as it takes additional capital.

Statistical Methods

Consistent with prior studies of tie formation in sparse networks (Sorenson and Stuart, 2001; Jensen, 2003; Dushnitsky, 2004), I used logistic regression to estimate the likelihood that a given potential investor forms an investment tie with a given venture as part of the venture's first round (or later rounds) of professional investments. As noted previously, I used Manski and Lerman's (1977) prior-correction technique to correct for the use of choice-based sampling and King and Zeng's (2001) bias-correction estimator to correct for the presence of rare events. Finally, though choice-based sampling reduces the overall interdependence within the samples, each venture still entered the samples multiple times. I therefore report robust standard errors adjusted for clustered observations of ventures (Mizruchi and Stearns, 2001; Jensen, 2003). The rare-event logit estimation and bias cor-

rections were performed using the Zelig package for R (Imai, King, and Lau, 2006).

RESULTS

Table 1 reports descriptive statistics and correlations for the variables for the primary sample, which I used to study the ties that the ventures initially formed with professional investors. By design, an investment occurred in 9 percent of sampled dyads, because ten non-investment dyads were included for every one investment dyad. Table 1 shows a correlation (.67) between accomplishments$_{PRODUCT}$ / status similarity and accomplishments$_{AWARD}$ / status similarity. For this reason, I included only one measure of accomplishments / status similarity in each model presented in table 2. Furthermore, because the models in table 2 contain interaction effects, I also checked the variance inflation factors (VIFs) for the reported models. Across the models, the VIFs of all factors were less than 10, while the mean VIFs for each model were all less than 3.5, further suggesting that multicollinearity is not an issue in the estimates presented in table 2.

Table 2 reports the rare-event logistic regressions predicting the likelihood that a venture and a potential investor form an investment tie as part of the venture's first round of investments. Annual dummy variables using 2002 as the base year were included in all models but were excluded from the table due to space restrictions. Model 1 in table 2 includes the control variables. In hypotheses 1, 2, and 3, I argued that the ties and human capital of a venture's founders have a significant influence on with whom the venture initially forms ties. Model 2 shows results for the addition of the venture's founder ties and human capital. I argued that ventures are more likely to form an investment tie with a potential

Table 1

Descriptive Statistics and Pearson Correlations of Initial Tie Sample

Variable	Mean	S.D.	Min.	Max.	1	2	3	4
1. Investment	0.09	0.29	0.00	1.00				
2. Log(distance)	6.15	2.04	0.00	8.84	−.28			
3. Investor preferred stage	0.96	0.04	0.00	1.00	.00	−.01		
4. Prior Internet investment	0.74	0.44	0.00	1.00	.11	−.08	−.10	
5. Prior security investment	0.29	0.45	0.00	1.00	.16	−.10	−.12	.32
6. Syndicate size	2.37	1.10	1.00	5.00	.00	.01	−.01	.05
7. Age	2.06	1.17	1.00	5.00	.00	.05	−.08	.02
8. Founder direct tie	0.01	0.09	0.00	1.00	.21	−.13	−.01	.05
9. Founder indirect tie	0.14	0.34	0.00	1.00	.11	−.12	−.02	.17
10. Human capital$_{ENT}$ / Status similarity	0.16	0.27	0.00	1.00	.11	−.06	−.03	.07
11. Human capital$_{MAN}$ / Status similarity	0.14	0.26	0.00	1.00	.10	−.07	−.01	.09
12. Accomplishments$_{PRODUCT}$ / Status similarity	0.11	0.26	0.00	1.00	.09	.01	.04	−.06
13. Accomplishments$_{AWARD}$ / Status similarity	0.08	0.26	0.00	1.00	.08	.02	.09	−.21

Variable	5	6	7	8	9	10	11	12
6. Syndicate size	.06							
7. Age	.16	.30						
8. Founder direct tie	.08	.02	−.02					
9. Founder indirect tie	.20	.17	.04	.22				
10. Human capital$_{ENT}$ / Status similarity	.18	.00	−.02	.09	.24			
11. Human capital$_{MAN}$ / Status similarity	.24	.01	.00	.08	.19	.28		
12. Accomplishments$_{PRODUCT}$ / Status similarity	.08	.12	.17	.02	.08	.30	.15	
13. Accomplishments$_{AWARD}$ / Status similarity	−.07	−.02	.02	.04	−.02	.30	.11	.67

Table 2

Rare-event Logit Models of Venture-Investor Initial Tie Formation*

Variable	Model 1	Model 2	Model 3a	Model 3b	Model 4a	Model 4b
(Intercept)	−6.593•••	−7.248•••	−6.026•••	−5.761••	−7.294•••	−7.016•••
	(2.305)	(2.466)	(2.321)	(2.248)	(2.562)	(2.509)
Log(distance)	−0.330•••	−0.310•••	−0.330•••	−0.331•••	−0.321•••	−0.323•••
	(0.041)	(0.043)	(0.041)	(0.041)	(0.043)	(0.042)
Investor preferred stage	1.736	2.249	1.139	0.605	2.070	1.427
	(2.395)	(2.553)	(2.405)	(2.312)	(2.609)	(2.550)
Prior Internet investment	0.630••	0.606••	0.749•••	0.920•••	0.721••	0.935•••
	(0.265)	(0.264)	(0.280)	(0.281)	(0.290)	(0.305)
Prior security investment	0.845•••	0.660•••	0.793•••	0.838•••	0.689•••	0.739•••
	(0.199)	(0.191)	(0.205)	(0.202)	(0.193)	(0.192)
Syndicate size	−0.044	−0.072	−0.072	−0.048	−0.118	−0.090
	(0.151)	(0.155)	(0.144)	(0.150)	(0.152)	(0.152)
Age	0.064	0.089	−0.001	0.012	0.206	0.239
	(0.208)	(0.215)	(0.209)	(0.209)	(0.228)	(0.224)
Founder direct tie		1.783••			2.660•	2.609
		(1.036)			(2.041)	(2.054)
Founder indirect tie		0.003			−0.387	−0.491
		(0.363)			(0.768)	(0.784)
Human capital$_{ENT}$ / Status similarity		0.682••			1.437••	1.601•••
		(0.342)			(0.682)	(0.638)
Human capital$_{MAN}$ / Status similarity		0.424			1.563••	1.729••
		(0.390)			(0.834)	(0.810)
Accomplishments$_{PRODUCT}$ / Status similarity			1.199•••		1.050•••	
			(0.320)		(0.330)	
Accomplishments$_{AWARD}$ / Status similarity				1.407•••		1.439•••
				(0.316)		(0.355)
Founder direct tie × Age					−1.565••	−1.639••
					(0.889)	(0.909)
Founder indirect tie × Age					0.221	0.290
					(0.297)	(0.313)
Human capital$_{ENT}$ / Status similarity × Age					−0.577••	−0.701••
					(0.328)	(0.311)
Human capital$_{MAN}$ / Status similarity × Age					−0.661•	−0.760••
					(0.409)	(0.405)
Log-likelihood	−495.0	−481.7	−487.5	−485.3	−469.6	−466.2
Pseudo-R^2	0.1361•••	0.1594•••	0.1492•••	0.1531•••	0.1805•••	0.1864•••

• $p < .10$; •• $p < .05$; ••• $p < .01$; one-tailed tests for independent variables; two-tailed tests for control variables.
* Standard errors are in parentheses. Models are based on a sample of 1,881 dyads, with investments occurring in 171 of these dyads. All models include unreported annual effects. A model's significance is relative to the intercept model (not shown) for model 1 and relative to the appropriate preceding model for the other models (e.g., model 3a in the case of 4a).

investor if there exists either a founder direct tie (H1) or a founder indirect tie (H2) between them. The coefficient for founder direct tie is positive and significant in model 2, marginally significant in the full model 4a (controlling for product accomplishments), and approaching significance ($p \approx .102$) in the full model 4b (controlling for award accomplishments). Thus the evidence supports hypothesis 1, although it is modest. With regard to founder indirect tie, the coefficient is not significant in either model 2 or in the various full models. The evidence thus does not support hypothesis 2. In addition, I argued in hypothesis 3 that a venture and a potential investor are more likely to form a tie if the venture founders' human capital and the potential investor's status are highly similar. To test this hypothesis, I introduced two measures of human capital / status similarity in model 2. Human capital$_{ENT}$ / status similarity (the measure incorporating the founders' entrepreneurial human capital) is positive and significant in model 2, as well as in the full models. Similarly, although human capi-

tal$_{MAN}$ / status similarity (the measure incorporating the founders' managerial human capital) is not significant in model 2, it is positive and significant in the later full models controlling for the influence of age and accomplishments. Thus the results support hypothesis 3 for both types of founders' human capital.

In hypothesis 4, I argued that with whom a venture forms an initial tie is driven by its organizational accomplishments. To test this hypothesis, I introduced two measures (accomplishments$_{PRODUCT}$ / status similarity and accomplishments$_{AWARD}$ / status similarity) of the similarity between a venture's accomplishments and an investor's status in models 3a and 3b, respectively. As hypothesized, the coefficient for accomplishments$_{PRODUCT}$ / status similarity is positive and significant in both model 3a and the full model 4a. Similarly, the coefficient for accomplishments$_{AWARD}$ / status similarity is positive and significant in both models 3b and 4b. Thus I find evidence supporting hypothesis 4 for both types of accomplishments.

In hypothesis 5, I argued that as ventures age, founders' ties and human capital will have less effect on with whom they are likely to form initial ties. In models 4a and 4b, I therefore interacted the measures of founder ties and human capital—founder direct tie, founder indirect tie, human capital$_{ENT}$ / status similarity, and human capital$_{MAN}$ / status similarity—with the venture's age at the time of the potential tie (model 4a includes accomplishments$_{PRODUCT}$ / status similarity, while model 4b includes accomplishments$_{AWARD}$ / status similarity). As the coefficient for the interaction of founder direct tie and age is negative and significant in both models 4a and 4b, I find that the influence of founder direct ties fades with time. The interaction of founder indirect tie and age is non-significant in both models 4a and 4b, suggesting that regardless of when a new organization forms its initial ties, its founder indirect ties do not have a significant influence on which ties are formed. With regard to human capital$_{ENT}$ / status similarity, the interaction with age is significant in both the full model with accomplishments$_{PRODUCT}$ / status similarity (model 4a) and the full model with accomplishments$_{AWARD}$ / status similarity (model 4b). For human capital$_{MAN}$ / status similarity, the interaction with age is marginally significant in the full model with accomplishments$_{PRODUCT}$ / status similarity (model 4a), and significant at the $p < .05$ level in the full model with accomplishments$_{AWARD}$ / status similarity (model 4b). Overall, the evidence supports hypothesis 5 for both founder direct ties and human capital / status similarity.

I performed additional robustness checks to verify the results for hypothesis 5 (for reasons of space, results are not shown but are available from the author). First, to confirm that the fading of founder ties and human capital is driven by the growing expectation of accomplishments as a venture ages, and not by the simple presence of accomplishments, I reran models 4a and 4b, interacting the relevant coefficients with organizational product (award) accomplishments instead of with age. Second, to confirm the robust influence of accomplishments / status similarity over time, I ran variants of models 4a and 4b that included interactions of the measures with the venture's age. As expected, none of these interactions

were significant, and collectively these tests support hypothesis 5.

Because a venture's accomplishments and its decision of when to have an investment could be influenced by founders' ties and human capital (e.g., founders with few ties and low human capital might delay raising their initial round until after obtaining distinguishing accomplishments) and this might bias the results, I used Hausman's (1978) method to test the endogeneity of accomplishments$_{PRODUCT}$ / status similarity, accomplishments$_{AWARD}$ / status similarity, and age. To do so, I first estimated these measures in terms of founder direct tie, founder indirect tie, founder entrepreneurial human capital, founder managerial human capital, and the venture's age (age was not used in the estimation of itself). I then included the residuals from these estimates as explanatory variables in models 4a and 4b. In all cases, the corresponding coefficients were not statistically significant. This suggests that the models do not exhibit bias due to endogeneity, and so a two-stage selection model is not necessary (Hausman, 1978; Wooldridge, 2003: 506). Overall, the observed lack of endogeneity supports prior studies that have found that even founders with high human capital often make poor choices about which markets to enter (Eisenhardt and Schoonhoven, 1990) and that their ventures often grow and survive at rates similar to those of ventures whose founders have less human capital (Baum and Silverman, 2004).

To better understand the relative impact of founder ties, founder human capital, and organizational accomplishments over time, I graphed in figure 1 the expected probability of tie formation under different conditions using model 4a from table 2. To calculate the expected probabilities of a tie between a hypothetical venture and a hypothetical professional investor, I assumed that the venture and the investor are in the same zip code [log(Distance) = 0], the investor primarily initially invests in ventures when they raise their first round (investor preferred stage = 1), and that the investor has previously invested in both Internet and Internet security ventures (prior Internet investment = 1 and prior security investment = 1). To determine the impact of each independent variable, I set the other independent variables to 0.

Figure 1 shows that during a venture's first year, founder direct ties have a dominant influence on the probability of a tie forming in a given venture-investor dyad and make the formation of a tie roughly five times more likely. Though less influential, human capital$_{ENT}$ / status similarity, human capital$_{MAN}$ / status similarity, and accomplishments$_{PRODUCT}$ / status similarity also have strong influences on the likelihood of a tie forming during a venture's first year, with each making the formation of a tie roughly three times more likely when similarity = 1. By a venture's second year, however, the impact of the founder-related variables almost completely fades, while the impact of organizational product accomplishments remains strong. This continues over time, with organizational product accomplishments thus becoming the driving determinant of initial tie formation.

Figure 1. Probability of initial tie formation in a venture-investor dyad.*
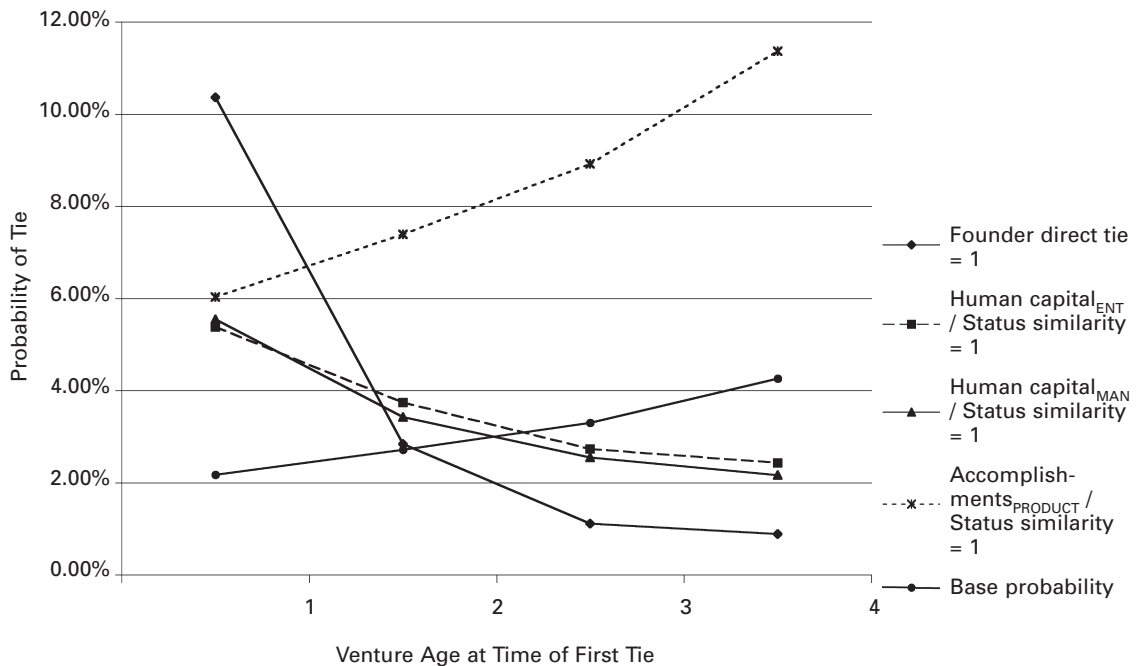
* Depicts the expected probability of a tie formation, $E(Y = 1|X_i)$, using model 4a from table 2.

Table 3 reports descriptive statistics and correlations for the secondary sample, which I used to study the consequences of initial network positions on subsequent ties between ventures and professional investors. Because correlations between some variables exceed .40 and the models in table 4 include interaction effects, I checked the variance inflation factors (VIFs) for the factors presented in these models. In the initial analysis of these models, the interactions of age with human capital$_{ENT}$ / status similarity and human capital$_{MAN}$ / status similarity had VIFs of between 10 and 12. Because this suggests that multicollinearity due to this interaction term might bias the results, I centered age at 0 for the analysis of the formation of later ties. Tables 3 and 4 include this centered age, and as expected, the VIFs for all models in table 4 are less than 10 when run with the centered age.

Table 4 reports the rare-event logistic regressions predicting the likelihood of a venture and an investor forming a tie following the venture's first round of investments. Both annual dummy variables and round dummy variables were included in all models but were excluded from the table. Similarly, to conserve space, I only include in table 4 models run with accomplishments$_{PRODUCT}$ / status similarity. The results are nearly identical for models with accomplishments$_{AWARD}$ / status similarity once developed ties and status are controlled for. Model 5 shows results for the control variables. Model 6 adds the variables and interactions that were significant for the formation of initial ties. Results for these variables in table 4 resemble those of model 4a in table 2, with a few notable exceptions. First, the influence of founder direct ties and founder human capital do not appear to fade with time, as the interactions of founder direct tie, human capital$_{ENT}$ /

Table 3

Descriptive Statistics and Pearson Correlations of Later Tie Sample

Variable	Mean	S.D.	Min.	Max.	1	2	3	4	5	6
1. Investment	0.09	0.29	0.00	1.00						
2. Round number	3.02	1.09	2.00	8.00	.00					
3. Log(distance)	6.17	2.10	0.00	8.84	−.22	−.01				
4. Investor preferred stage	0.89	0.10	0.00	1.00	.06	−.56	−.05			
5. Prior Internet investment	0.75	0.43	0.00	1.00	.11	−.01	−.05	.20		
6. Prior security investment	0.32	0.47	0.00	1.00	.35	.03	−.14	.10	.29	
7. Syndicate size	3.27	1.49	1.00	7.00	.00	.21	−.03	−.08	−.04	−.03
8. Age*	0.00	1.14	−2.27	2.73	.00	.49	−.01	−.24	.00	.08
9. Founder direct tie	0.01	0.09	0.00	1.00	.23	.04	−.15	−.01	.05	.10
10. Human capital$_{ENT}$ / Status similarity	0.15	0.24	0.00	1.00	.18	.03	−.10	.09	.17	.20
11. Human capital$_{MAN}$ / Status similarity	0.12	0.24	0.00	1.00	.17	−.03	−.06	.06	.12	.19
12. Accomplishments$_{PRODUCT}$ / Status similarity	0.15	0.23	0.00	1.00	.14	.12	−.06	.03	.21	.25
13. Accomplishments$_{AWARD}$ / Status similarity	0.10	0.21	0.00	1.00	.12	.16	−.06	−.02	.10	.17
14. Developed direct tie	0.06	0.24	0.00	1.00	.79	.03	−.24	.04	.11	.37
15. Developed indirect tie	0.34	0.47	0.00	1.00	.36	.09	−.19	.08	.25	.37
16. Developed status / Status similarity	0.23	0.32	0.00	1.00	.26	.00	−.11	.05	.21	.25

Variable	7	8	9	10	11	12	13	14	15
8. Age*	.01								
9. Founder direct tie	.00	.00							
10. Human capital$_{ENT}$ / Status similarity	.02	.06	.06						
11. Human capital$_{MAN}$ / Status similarity	.01	.00	.06	.29					
12. Accomplishments$_{PRODUCT}$ / Status similarity	.06	.14	.02	.38	.31				
13. Accomplishments$_{AWARD}$ / Status similarity	01	.21	.00	.32	.22	.53			
14. Developed direct tie	−.01	.02	.23	.16	.16	.12	.12		
15. Developed indirect tie	.10	.07	.12	.31	.33	.34	.20	.36	
16. Developed status / Status similarity	−.05	.00	.12	.29	.45	.28	.18	.31	.46

* Age was centered at 0 to reduce multicollinearity in the models in table 4.

status similarity, and human capital$_{MAN}$ / status similarity with age are not significant (these results are robust even when age is not centered). Second, accomplishments$_{PRODUCT}$ / status similarity and accomplishments$_{AWARD}$ / status similarity no longer have a significant influence once developed ties and status are controlled for.

In hypotheses 6a, 6b, and 6c, I argued that the subsequent evolution of a venture's network position is determined by its developed ties and the status they confer. Model 9 provides evidence supporting hypotheses 6a and 6b, as the coefficients for developed direct tie and developed indirect tie are both highly significant. Additionally, the coefficients for both measures are large relative to the coefficients for human capital$_{ENT}$ / status similarity, human capital$_{MAN}$ / status similarity, and accomplishments$_{PRODUCT}$ / status similarity (these coefficients can all be compared, as the measures range from 0 to 1). Furthermore, their inclusion in model 7 yields a jump in the pseudo-R^2 from 0.2773 to 0.5906. Overall, the results support hypotheses 6a and 6b and suggest that the formation of later ties is primarily driven by a new organization's developed direct and indirect ties.

But the findings do not support hypothesis 6c, that developed status / status similarity will improve the likelihood of later ties forming. Instead, the negative and significant coefficient in the full model 9 shows that developed status / status

Table 4

Rare-event Logit Models of Venture-Investor Later Tie Formation*

Variable	Model 5	Model 6	Model 7	Model 8	Model 9
(Intercept)	−6.844•••	−6.837•••	−6.762•••	−7.047•••	−6.556•••
	(0.909)	(0.948)	(1.251)	(0.954)	(1.254)
Log(distance)	−0.235•••	−0.204•••	−0.092••	−0.192•••	−0.094••
	(0.025)	(0.025)	(0.043)	(0.026)	(0.043)
Investor preferred stage	0.962	0.795	−0.044	0.851	−0.204
	(0.841)	(0.892)	(1.231)	(0.908)	(1.242)
Prior Internet investment	0.025	−0.213	−0.365	−0.359•	−0.337
	(0.206)	(0.216)	(0.284)	(0.214)	(0.285)
Prior security investment	2.576•••	2.440•••	0.908•••	2.372•••	0.904•••
	(0.167)	(0.176)	(0.212)	(0.179)	(0.211)
Age†	0.043	0.111	0.227	0.174	0.191
	(0.129)	(0.142)	(0.165)	(0.143)	(0.163)
Syndicate size	0.000	−0.008	0.064	0.006	0.051
	(0.067)	(0.069)	(0.090)	(0.068)	(0.091)
Founder direct tie		3.204•••	2.715•••	3.094•••	2.864•••
		(0.648)	(0.826)	(0.692)	(0.793)
Human capital$_{ENT}$ / Status similarity		0.862•••	0.688••	0.721•••	0.854••
		(0.239)	(0.384)	(0.255)	(0.395)
Human capital$_{MAN}$ / Status similarity		0.864•••	0.287	0.283	0.741••
		(0.220)	(0.354)	(0.252)	(0.396)
Accomplishments$_{PRODUCT}$ / Status similarity		0.224	0.425	0.137	0.410
		(0.273)	(0.362)	(0.281)	(0.349)
Founder direct tie × Age		0.045	−0.022	−0.015	0.088
		(0.361)	(0.669)	(0.397)	(0.652)
Human capital$_{ENT}$ / Status similarity × Age		−0.180	−0.185	−0.193	−0.193
		(0.204)	(0.345)	(0.220)	(0.350)
Human capital$_{MAN}$ / Status similarity × Age		−0.092	−0.046	−0.112	0.014
		(0.193)	(0.310)	(0.198)	(0.300)
Developed direct tie			2.874•••		3.328•••
			(0.546)		(0.569)
Developed indirect tie			0.982•••		1.175•••
			(0.226)		(0.234)
Developed status / Status similarity				1.188•••	−1.038•••
				(0.165)	(0.353)
Log-likelihood	−1062.1	−1009.9	−572.1	−985.5	−566.6
Pseudo-R²	0.2399•••	0.2773•••	0.5906•••	0.2947•••	0.5945•••

• $p < .10$; •• $p < .05$; ••• $p < .01$; one-tailed tests for independent variables; two-tailed tests for control variables.

* Standard errors are in parentheses. Models are based on a sample of 4,587 dyads, with investments occurring in 417 of these dyads. All models include unreported annual effects. A model's significance is relative to the intercept model (not shown) for model 5 and relative to the appropriate preceding model for the other models.

† Age was centered at 0 to reduce multicollinearity in the models.

similarity decreases the likelihood of later tie formation. To better understand this unexpected finding, I conducted an additional analysis. For the investment dyads involving new investors (i.e., developed direct tie = 0), I ran a t-test comparing the status of the existing investors with the status of the new investor. This test revealed that, with a statistical significance of $p < .01$, new investors have a lower status than the highest status of the existing investors. As an additional robustness check, I reran the models in table 4 using the average (instead of the highest) status of the existing investors, and results were essentially identical to those reported in table 4. Drawing on my interviews with entrepreneurs and investors, I offer a likely explanation for this finding in the discussion.

DISCUSSION

This paper contributes several findings to interorganizational network theory. Prior literature has shown how the network

positions of established organizations evolve over time through tie repetition around direct ties, tie transitivity around indirect ties, and status similarity (Podolny, 1994; Gulati and Gargiulo, 1999; Sorenson and Stuart, 2001). Yet the determinants of an organization's initial network position have remained unclear. This paper addresses this gap and contributes the insight that there are two paths by which organizations establish their initial network positions—one path involving the ties and human capital of a new organization's founders, and the other path involving the accomplishments of the new organization since its founding.

Through the first of these paths, new organizations obtain their initial network positions by drawing on the ties and human capital of their founders, but only if they form their first ties soon after their founding. Thus, whereas the formation of ties by established organizations has largely been attributed to organizational characteristics, such as past organizational ties and past organizational status (see Rosenkopf, Metiu, and George, 2001, for a notable exception), the results of this study show that many new organizations form their initial ties primarily on the basis of the individual attributes of their founders, and new organizations draw on the direct ties of their founders to engage in tie repetition with potential partners (Podolny, 1994; Gulati, 1995; Baum et al., 2005). New organizations are also likely to form ties on the basis of their founders' human capital and its similarity with the status of potential partners (Podolny, 1994; Gulati and Gargiulo, 1999). Overall, through this first path, new organizations may convert the individual social and human capital of their founders to organizational social capital in the form of initial network positions.

Organizational accomplishments are a second path through which new organizations may establish their initial network positions. With regard to accomplishments, prior literature has generally found that accomplishments have only a minor influence on which ties established organizations are likely to form (Gulati, 1995; Stuart, 1998). In contrast, the results of this study show that accomplishments have a prominent role in determining how organizations establish their initial network positions, especially when a new organization delays forming its first ties. Through this second path, new organizations achieve their initial network positions on the basis of their accomplishments, and high-accomplishment new organizations are more likely to form ties with high-status partners, while low-accomplishment new organizations are more likely to form ties with low-status partners. In short, accomplishments allow organizations to convert the actions of their founders (e.g., developing the right products) into organizational social capital. Overall, in showing that some new organizations obtain their initial network positions by leveraging the individual histories of their founders, while others draw on their organizational accomplishments, this paper contributes to the network literature the insight that there are sharp differences in the causes of the initial network positions of different organizations.

The Influence of Ties, Human Capital, Accomplishments, and Status over Time

This paper also provides insight into how the mechanisms influencing a new organization's early tie formation change over time. Prior research has generally found that the influence of a diversifying organization's prior ties remains robust over time (Jensen, 2003), though the influence of prior status fades the longer an organization remains in a market (Stuart, Hoang, and Hybels, 1999; Higgins and Gulati, 2003; Jensen, 2003). For new organizations, though, the influence of both the founders' direct ties and human capital fades as a new organization delays forming its first ties. I attribute this initial fading, as well as the non-influence of founders' indirect ties, to the tenuous relationship between a founding team's ties and human capital and the new organization's ability to overcome its initial challenges (Eisenhardt and Schoonhoven, 1990; Baum and Silverman, 2004).

One unexpected result is that once a new organization has formed its initial ties, the influence of founders' direct ties and human capital reemerge, and both factors influence the formation of any later ties that follow. I attribute this reemergence to the concurrent influence of a new organization's newly developed ties, which indicate success in convincing partners either that a new organization has resolved the challenges that it initially faced or that it has the potential to do so. Thus it appears that once developed ties are available as a primary indicator of quality and legitimacy, potential partners are again willing to consider founders' direct ties and human capital as supporting indicators. This suggests that founders' ties and human capital provide information distinct from that provided by developed direct and indirect ties and are therefore valuable, albeit sensitive mechanisms for new organizations to convey quality and legitimacy.

At the same time, although accomplishments are the primary determinant of initial ties for new organizations that delay forming their initial ties, accomplishments no longer have a statistically significant influence as soon as these initial ties are formed. Thus, once a new organization has established its initial network position, the consequences of these initial network ties are substantial. The results show a strong path-dependency in the evolution of network positions, as the formation of later ties is primarily determined by a new organization's developed direct and indirect ties (David, 1985; Walker, Kogut, and Shan, 1997; Marquis, 2003; Baum et al., 2005). Furthermore, the non-significant influence of accomplishments on the formation of later ties suggests that potential partners perceive accomplishments as providing little information of value beyond that already provided by a new organization's developed ties. Thus accomplishments are also a sensitive indicator of a new organization's quality and legitimacy, having a substantial influence only during the brief period from when distinguishing accomplishments is possible until a new organization has formed its initial ties. Overall, the sensitive nature of founders' ties, founders' human capital, and organizational accomplishments suggests that founders wishing to imprint their organization's network position through either their past history (i.e., their ties and human

capital) or their present actions (i.e., helping their organizations achieve distinguishing accomplishments) have specific and narrow windows for doing so.

Additionally, this paper contributes to the prior literature on the premium that entrepreneurs place on having high-status partners (Podolny, 1993; Hsu, 2004). Although prior literature has found that organizations are most likely to form a tie if they exhibit status similarity (Podolny, 1994; Chung, Singh, and Lee, 2000), results of this study indicate that a new organization's later ties actually exhibit status dissimilarity, such that later partners are most likely to be of a different status than prior partners. My interviews offer a likely explanation for this status dissimilarity. The entrepreneurs I interviewed said that although they often sought high-status investors in their early rounds, later they were primarily concerned with the valuation that an investor offered. In the words of one entrepreneur, "[at that point] you are after the highest valuation. Because that builds value in the company and that means less dilution for everyone involved." These interviews therefore suggest that status dissimilarity in later ties emerges from the combination of entrepreneurs' placing less emphasis on having high-status investors and low-status investors' being willing to invest at higher valuations. Overall, this finding suggests that entrepreneurs are discriminating about when they are willing to pay a premium for high-status partners and that, for investors, the benefits of having high status are restricted to certain situations.

Implications for Entrepreneurs

My findings have clear implications for entrepreneurs seeking investments from high-status, well-connected investors. First, the strong consequences of initial ties suggest that a venture's initial round of investments is a unique opportunity and that even though low-status investors may offer to invest at a higher valuation (Hsu, 2004), such investors will likely constrain a venture's ability to attract higher-status investors later. Accordingly, entrepreneurs wishing eventually to have high-status investors should seek them initially. Second, to obtain these high-status investors, my findings suggest that entrepreneurs should vary their strategies according to their prior network connectedness and human capital. Well-connected entrepreneurs with high human capital may benefit from forming initial ties soon after founding their organization, as this allows them to reap the benefits of investments quickly (e.g., capital, advice, status) without endangering their network position should their venture fail to achieve distinguishing accomplishments quickly. In contrast, poorly connected entrepreneurs with less human capital may benefit from initially focusing on attaining distinguishing accomplishments, delaying the pursuit of investors until after achieving such accomplishments. Overall, my findings are encouraging for entrepreneurs, as they suggest that all entrepreneurs have the potential for receiving investments from desirable investors.

Network Dynamics, Individuals, and Network Development Strategies

This paper also has high-level implications for the dynamics of a variety of different types of networks. Prior literature on the formation of interorganizational network ties has generally explored the formation of horizontal alliance ties (Podolny, 1994; Gulati, 1995; Sorenson and Stuart, 2001) and the formation of vertical and horizontal board interlock ties (Mizruchi, 1996; Kono et al., 1998; Marquis, 2003). This work often explains tie formation in these settings using the logics of information availability and legitimacy. In this paper, I have built on these tie formation logics and extended them to explain the formation of a new organization's initial ties, empirically testing the developed theory in the context of a third type of network tie—vertical investment ties involving one organization's making an equity investment in another organization. Thus this research offers confirmation that, in settings in which uncertainty about potential partners is high and organizations are concerned with the legitimacy of their ties, the formation of various forms of interorganizational network ties, including alliance ties, board interlock ties, and investment ties, is often driven by these common logics regardless of the ties' exact type—that is, whether they are initial ties in a network or ongoing ones, and whether they are horizontal or vertical ties.

Furthermore, given the uniqueness of the dataset, this paper provides insight into the fundamental, underlying source of these interorganizational ties. Specifically, interorganizational network ties generally come from one of three sources: the histories of individuals at an organization, the accomplishments of the organization, and the organization's past ties and status. Moreover, an organization's past ties and status (the third source) also have their origins in individual histories and organizational accomplishments. At a fundamental level, this research suggests that individual-level characteristics (i.e., network ties, human capital) and actions (e.g., actions leading to organizational accomplishments) ultimately underlie many of the dynamics observed in the formation and evolution of interorganizational networks.

Finally, this research contributes to the broader network literature the idea of network development strategies, or courses of action that may be taken to improve an actor's (e.g., an organization's or individual's) network position during periods of low network determinism in which prior networks place less constraint on the formation of new ties. Although prior research has offered a normative perspective on which network positions actors should seek to occupy (Burt, 1992; Podolny, 1993; Ahuja, 2000a), literature on the development of network positions has largely taken a positive, structural determinism perspective that affords the choices of actors little role and instead emphasizes the primacy of established network structure and the status that this structure confers (Podolny, 1994; Gulati, 1995; Sorenson and Stuart, 2001; for an exception, see Ozcan and Eisenhardt's 2009 study of strategic action in portfolio formation). Congruent with this structural determinism perspective, results indicate that there are periods in which network determinism appears to domi-

nate the development of an actor's network (e.g., soon after a new organization has formed its first ties) and that actors' choices have less influence during such periods. But the findings of this study diverge from much of this literature in that there are also periods of low network determinism in which the choices of actors have a great impact on the development of networks, such as during the formation of initial ties. Accordingly, such periods allow actors to engage in network development strategies that help improve their network positions. In this research, I have identified such strategies, related to when entrepreneurs should form their new organization's initial ties. Looking forward, this research suggests that future studies of network dynamics may benefit from challenging traditional assumptions of network determinism by exploring whether there are other windows of low network determinism and identifying network development strategies for exploiting such opportunities. An organization's future network may thus depend more on when in its early life ties are formed than scholars have previously recognized.

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APPENDIX: Choice-Based Sampling Motivation and Methodology

As noted in the methods section, interdependence among dyads due to the inclusion of each venture and each investor many, many times is a key source of possible bias in studies of tie formation in sparse networks. Although this interdependence is a form of autocorrelation, it differs from the form of autocorrelation more frequently encountered in panel data in that it arises from two sources: the repeat inclusion of both ventures and investors (Krackhardt, 1988). Accordingly, traditional econometric techniques for addressing autocorrelation in panel data, such as random effects and fixed effects, are inappropriate in this context. Random effects are only appropriate in contexts involving a single source of interdependence and are thus inappropriate for reducing autocorrelation among network dyads (Gulati and Gargiulo, 1999). Similarly, although fixed effects could address this autocorrelation, its use would preclude estimating important covariates that do not change across dyads (Gulati and Gargiulo, 1999).

Accordingly, and consistent with prior studies of tie formation in sparse networks (Sorenson and Stuart, 2001; Jensen, 2003; Dushnitsky, 2004), I used choice-based sampling to reduce interdependence among the venture-investor dyads (Manski and Lerman, 1977; Manski and McFadden, 1981; Lancaster and Imbens, 1996). I included in the samples all venture-investor dyads in which investment ties occurred, plus random matched samples of venture-investor dyads in which investment ties did not occur. By including only a subset of all possible venture-investor dyads, I was able to reduce the interdependence among the dyads, because each venture and each investor were included fewer times (Sorenson and Stuart, 2001). For example, in the primary sample of initial tie formation, each venture appeared in the sample an average of 20.45 times (instead of 659.3 times), and each investor appeared in the sample an average of 1.961 times (instead of 40.88 times). Furthermore, this reduction in interdependence came at a minimal price in terms of the consistency and efficiency of the estimates, so long as the matched non-event sample was of sufficient size and the appropriate bias correction was applied to the estimated models (Lancaster and Imbens, 1996; King and Zeng, 2001).

To construct the choice-based samples, I matched each dyad in which an investment occurred with ten random dyads in which an investment did not occur. Simulations have shown that this ratio is very conservative, such that the marginal contribution of additional non-occurring dyads to the accuracy of the estimated results is minimal (King and Zeng, 2001). For the primary sample exploring the causes of initial network positions, each matched dyad was created using the same venture and year as in the corresponding occurring dyad, but randomly selecting a matched investor from among those that made a first-round investment in another venture in the same year. For the

secondary sample, I matched on the criterion that investors had made a later-round investment in that year. For example, in the case of Battery Ventures making a first-round investment in Arbor Networks in 2000, I included in the primary (first-round) sample ten matched dyads, each of which paired Arbor Networks with a different investor randomly selected from the set of 1,042 investors that made first-round investments during the year 2000. Restricting the set of possible matched investors to those that made a similar investment in the same year improves the accuracy of the results by restricting comparisons to feasible investors that are participating in the venture-investment market of interest in a given year (King and Zeng, 2001).

Finally, I used Manski and Lerman's (1977) prior-correction technique to correct for the difference in the proportion of positive outcomes between the choice-based samples and the underlying populations of possible dyads. An alternative approach would have been to use a weighted exogeneous sampling maximum-likelihood estimator (WESMLE) (Manski and Lerman, 1977). Though WESMLE is generally less prone to misspecification for large samples, it is less appropriate for small samples as it is asymptotically less efficient than prior correction in such situations (Scott and Wild, 1986; Xie and Manski, 1988). Because the primary sample size was relatively small at only 171 occurring investments, I chose to use prior correction.