Who Takes You to the Dance?
How Funding Partners Influence Innovative Activity in Young Firms

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Abstract

Drawing on institutional theory, we examine how the institutional logics of different types of funding partners influence young firms and their search for innovations. We test our hypotheses in a longitudinal study of a complete population of ventures in the minimally invasive surgical device industry in the U.S. Intriguingly, we find that types of funding partners vary significantly from one another. Specifically while they all provide resources, their institutional logics differ. Venture capitalists pick young firms with significant patented technologies, and help firms launch products, and high-status VCs strengthen both the patenting and product innovations of young firms. In contrast, while corporate venture capitalists and government agencies also select patent-intensive firms, these types of partners are less effective in helping ventures during the relationship. While these partners often have impressive technical and commercial resources for innovation, their institutional logics – i.e., taken-for granted norms, structures and practices - constrain how effectively young firms can access their resources. Our results extend the institutional logics literature to inter-organizational relationships, and suggest that the choice among types of funding partners may have unanticipated effects on firm innovation beyond the financial resources gained through the relationship.

Innovation is at the heart of the performance of many new technology-based firms. The ability to create technical breakthroughs and turn them into commercial products is central to their survival and success. Yet since new firms usually need external resources to create and accelerate innovation, they often form relationships with investors to gain resources. Research and the popular press frequently focus on venture capitalists (VCs) in this role (Gulati and Higgins, 2003; Hallen, Katila et al, 2014; Pahnke et al., 2015). But new firms, particularly technology-focused ones, often have choices among types of funding partners, including the government and corporate venture capitalists (CVCs). Indeed, the sheer volume of money invested in new firms by non-VC organizations is significant. For example, CVC investment represented almost a third of all U.S. venture capital funding—about a billion dollars—in the first quarter of 2014 (CB Insight, 2014). Moreover, these different types of investors all typically offer useful technical and commercial resources to new firms. But while many types of partners can provide these resources, these types are not homogeneous. This raises the question of whether types of partners might be related to venture innovation. Institutional theory sheds light on this question.

Although much institutional theory research focuses on established firms, a stream of institutional work has emerged to look at new firms. This work centers on the effects of institutions on young firm choices. It looks at how institutions influence how new firms get started (Sine and Lee, 2009; Hiatt et al., 2009) and are organized (Burton and Beckman, 2007; Powell and Sandholtz, 2012). Some recent work at the nexus of institutions and new firms also delves more deeply into the process of how institutions influence young firms, and points to institutional logic – i.e., taken-for-granted understandings of what is meaningful and appropriate in a setting – as a link between organizations and their actions (Glynn and Lounsbury, 2005; Thornton, Ocasio, and Lounsbury, 2012).

Institutional logics encompass a coherent set of assumptions and values about what is perceived as meaningful (i.e. rational and necessary), and appropriate for an organization to do (Thornton et al., 2012). Institutional logics are deeply embedded in organizational members' cognition and preferences, and influence how members of organizations interpret and act in their relationships with others. Institutional logics matter because the *configuration* of attributes within an institutional logic can offer a more accurate and complete understanding of firm actions than simpler explanations like resources and incentives alone. Further, in contrast to constructs that focus only on individual organizations (e.g., organization's logic, culture, or capabilities), the fact that institutional logics permeate a group of organizations allows analysis of *classes* or types of organizations. Altogether, a focus on institutional logics draws attention to a configuration of variables that characterizes a particular type of organizations and their actions.

Despite the prior insights of the institutional logics perspective, several open questions relevant for new firms remain. While some empirical work describes how changes in institutional logics in academic book publishing (Thornton, 2004), retailing (Eisenhardt, 1988) and banking (Marquis and Lounsbury, 2007) alter the actions of organizations including their compensation policies and executive succession, much of this literature focuses on larger societal logics (e.g. market or growth logic) rather than the specific logics represented by institutional actors that interact with young firms. Yet, we argue that different types of partners may bring distinct institutional logics to bear in their interactions with young firms leading to differences in young firm actions. For example, types of partners differ in their values and expectations about the appropriate processes for running a new firm, and may in turn influence the advice provided to, choices made by, and performance of young firms. Taken together, how the institutional logics of particular partners influence young firm choices is not well understood. That is a gap that we address.

Building on the existing work on institutions and young firms, our purpose is to examine how ties to funding partners influence the innovations of young firms. Specifically, we ask: *How are funding ties with different types of partners related to technical and commercial innovation in young firms?* We define funding ties as the formal relationships of young firms to organizations that provide non-debt financing, and focus on three types of partners – VCs, CVCs, and government agencies – that commonly finance young U.S. firms. A key advantage of this focus is that it enables us to explore the implications for innovation of three distinct institutional logics that are anchored in the ideal institutional types of professions, corporations, and the state, respectively. Since a partner's institutional logic is likely to be especially influential for the outcomes of a lower power alter (Pfeffer and Salancik, 1978), such as a new firm in a funding relationship, this is an ideal setting to explore the influence of institutional logics on partners. We test our hypotheses using the complete population of 198 minimally invasive surgical (MIS) device ventures in the U.S. over a 22-year period. We supplement these data with extensive fieldwork.

We contribute at the nexus of institutional theory and entrepreneurship. Prior research emphasizes how larger societal or market logics shape the actions of focal organizations (Glynn and Lounsbury, 2005; Pache and Santos, 2013; Almandoz, 2014). We contribute the insight that the distinctive institutional logics of types of partners can influence significant outcomes of the new firms with whom they partner. Some partner types enhance innovation while others are much less effective. Specifically, we find partners to be surprisingly similar in their ability to select ventures (i.e. pick 'homeruns',) but substantially different in their actions during the relationship. Our work points to differences in institutional logics across partner types that influence differences in relationship interactions, and can ultimately explain critical venture outcomes.

In particular, VCs are strikingly more successful in providing additional value to venture commercialization, while CVC and NIH partners add very little beyond selecting technologically skilled new firms. One explanation is of course simply that VCs may have foresight to select ventures that are closer to commercialization. However, our empirical analyses on MIS firms (difference-in-differences analysis with matched samples and a rich control set, as well as robustness tests including a full-sample fixed effects analysis) suggest that this is probably not the chief explanation. We find no significant differences in the investment opportunities that VCs get relative to other investors (i.e. VCs appear to have no differential foresight). Rather, a more likely explanation that emerges from our data is that VCs exert a stronger and better influence *during* the relationship. Relative to other types of funding partners and consistent with their professional institutional logic, VCs have a closer advisor relationship with the venture, better paced and more motivating milestones, greater power and influence, and better understanding of the commercialization process. Taken together, all of these differences (related to VCs' institutional logic) are likely to explain why venture innovation is most significantly related to VC funding.

THEORETICAL BACKGROUND AND HYPOTHESES

Institutions and Young Firms

Institutional theory emphasizes how the actions of organizations and individuals within them are shaped by what is perceived as proper, rational, and necessary (Tolbert et al., 2011). Although much institutional theory research centers on how norms and shared expectations influence the actions of established firms, a stream of institutional work has started to look at new firms. This work delves more deeply into the process of how institutions influence young firms, and points to *institutional logics* as a link between organizations and their actions (Marquis and Lounsbury, 2007; Thornton, Ocasio, and Lounsbury, 2012). Research indicates that institutional logics underpin the aims and values of an organization, and influence how the organization operates internally and interacts externally (Thornton and Ocasio, 2008; Marquis and Lounsbury, 2007). As taken-for-granted assumptions and practices, institutional logics are deeply embedded in organizational members' cognition and preference about what is appropriate and meaningful, and influence how members of organizations "perceive, pay attention to, evaluate, and respond to environmental stimuli" (Almandoz, 2014: 443). Institutional logics are therefore the lens through which organizational members view reality.

Institutional logics become manifest in a *configuration of attributes* that fit together, and, in turn, these coherent sets of attributes render logics apparent (Glynn, 2000). Thornton et al.'s (2012) research on institutional logics suggests that organizations develop a *basis of norms* – i.e., underlying rules about membership, authority, and legitimacy. Organizations also develop a *basis of strategy* – i.e., how the organization's members view their identity and strengths (Ocasio, 1997; Glynn, 2008), and a *basis of attention* – i.e., assumptions that members make about how to succeed, and so which issues require attention. These attributes of institutional logics link assumptions and values with actions.[1]

Empirical work has also started to examine institutions, their institutional logics, and young firms. One strand addresses institutions and *founding* of new firms. A significant finding is that founding rates of new firms are higher when there is greater normative acceptance of new enterprises (Sine and Lee, 2009). Almandoz (2014) further focuses on bank founders as carriers of logics, and finds that their prior embeddedness in a particular logic imprints them, influences the decisions they make and affects their entrepreneurial success (successful foundings). For example, a

[1] We draw from Thornton et al. (2012) and personal communication with the authors to create the categorization of basic elements of institutional logics appropriate for our setting.

background in finance influenced the cognitive structures of founders such that they emphasized financial considerations and gave less weight to community ones. Altogether, the key point is that the institutional environment, whether intentionally or not, often shapes how new firms come into being.

A second strand looks at existing institutions as key *templates* for new firm organizing and strategy. For example, Benner and Ranganathan (2013) show that firms that were in the process of entering a new technical field (VoIP) were perceived as having better chances to succeed the more similar their prior institutional logic and form were vis-à-vis that of the new field. Other research also points to a link between logics and resistance to adopt templates foreign to a logic's core assumptions (Battilana and Dorado, 2010). Taken together, the core idea is that institutionalized design blueprints—even when uncertain to offer any survival advantage—often shape the organizational form that a venture takes, or is expected to take.

Yet despite its insights, this literature emphasizes broad field-level logics and leaves open the issue of whether young firm actions can also be traced to the institutional logics of their *partners*. Vasudeva et al. (2012) offer some evidence from established firms suggestive of this mechanism. They find that a partner's institutional origins in a particular country can affect the focal established firm's ability to combine resources with that partner. Importantly, this issue also relates to calls for research to unravel the mechanisms underlying the influences of partners on new firms during their relationship (e.g., Stuart and Sorenson, 2007). Developed below, our argument is that deeply embedded attributes of institutional logics give rise to differences in norms, strategies, and attention that collectively affect how partners act in relationships, and thus, influence their new-firm partners.

Institutional Logics and Young Firm Innovation

We propose hypotheses regarding how three institutional logics of partner organizations influence innovative activity in new firms that they fund. We study VCs, CVCs, and the government - each is highly selective, provides commercial, financial, and technical resources, and has incentives to encourage technical and commercial innovation. Yet each also has a distinct institutional logic anchored in the ideal logics of a *profession, corporation,* and the *state,* respectively. As summarized in Table 1, focus on the professionalism of the craft and the client relationship is prevalent in venture capital, focus on corporate performance and hierarchy is characteristic of corporate venture capital, and focus on fairness and common good permeates government agencies. Together, these factors are likely to influence choices of their young-firm partners that drive their innovation.

---Insert Table 1 about here---

Venture Capital and Professional Logic. Venture capitalists are professionals in private equity firms that specialize in financing young firms with high growth potential. They select these ventures on behalf of institutional investors, and try to guide entrepreneurs to exits with positive returns (Hellmann and Puri, 2000). Given these aims, VCs have incentives to encourage technical and commercial innovation to achieve novel products based on a unique IP foundation. They and their contacts often also have substantial commercial and technical resources. Yet, as we argue below, VCs' professional institutional logic makes commercial innovation especially likely.

The basis of norms for VCs – i.e. membership criteria, legitimacy and authority structure – is likely to influence venture innovation. The craft of a VC is embodied in individuals, rather than in organizational hierarchies and procedures. VCs often have similar educational (i.e., undergraduate technical degree with an MBA or PhD from an elite school) and managerial (i.e., at least 5 years in executive positions) experiences. While they typically have connections to technologists, VCs are usually not themselves highly technical, and may follow technology fads

(Guler, 2007; Sorenson and Stuart, 2008). Many of our informants who struggled to develop technology looked to their VC investors for guidance, but were often frustrated in how little useful advice they received. A startup engineer described how he approached a VC "*with an optimal [technical] solution,"* but *"they didn't recognize it."* Another interviewee added, *"Explaining the day to day, [priorities] for design and development - they don't want to hear it, and they are not going to understand it if you tell them."* Taken together, the educational and managerial backgrounds of VC professionals make them more valuable for commercial and less valuable for technical innovation.

VC legitimacy is derived from a successful track record of investments, reinforced by awards such as Top Investor (Midas), as well as from the perceived exclusivity of the profession (Hallen, and Pahnke, 2015). Despite their exclusivity, VCs are more accurately quasi-professionals because they, like book editors, lack any formal certification into the profession (Thornton, 2004). Rather, the VC profession is learned through socialization such as by apprenticeship and step-by-step promotion to partner. Building external networks, venture-management expertise, and often industry expertise are key parts of this socialization. Overall, the sources of VC legitimacy favor the development of commercial, but not necessarily technical, innovation in young firms.

Institutionalized authority structures are also likely to influence venture innovation. VC firms are traditionally organized as *partnerships*. VCs are typically top decision makers at the partner-level, and have significant autonomy over their investments (Hallen and Eisenhardt, 2012). Because VC partners value direct contact, and emphasize *"call anytime"* relationships, entrepreneurs get to receive advice and *"deal with the decision-maker right off the bat"* which can directly boost innovation. Another practice rooted in history is that VC partners take board seats, and ratify key decisions such as venture's major resource commitments (Hallen et al., 2014) even when they are not majority shareholders. Given their disproportionate authority and what some interviewees describe as an "autocratic style," VCs thus have substantial opportunities to influence major decisions such as technical and product development. But the logic can also backfire if VCs influence technology decisions beyond their immediate expertise. An engineer illustrates:

I was the creative engineer that was going to help adapt the base technology idea to the new, crazy opportunity that they [VCs and the board] saw… It felt like they thought they had a vision but in reality they switched –every other month. At the time, as an engineer, I thought it was pretty cool. I didn't have to publish anything, or do any of the dirty work…we were always filling in sexy new things….I got to do things that got everybody excited. And I never had to do the real work. In this sense it was almost to a negative that they [VCs] were involved.

Altogether, traced backed to their professional norms, VC behaviors are likely to be more helpful for commercial and less helpful for technical innovation.

The basis of strategy - i.e., how VCs perceive their identity and strengths - is also likely to influence venture innovation. Given their professionalism, VCs view themselves as skilled *business advisors* - able to translate technical insights into successful products. Consistent with this identity, VCs do the "*heavy lifting: team building, developing strategy, active board participation, and even interim management."* Because commercial and venture expertise so heavily underlies their professional identity, VCs prefer to solve product problems, not those in technology. A VC described, *"The CEO emailed me last night with a very specific product question. I emailed back saying that I do not know how to answer that question for you. But if I were you, I would ask myself the following five [high-level, product market] questions and then I listed the questions."* When asked whether he thought this approach was effective, the VC agreed and told us that the founder *"emails back immediately and says, wow, I did not even think [to ask] three of those."*

Reflecting their professional identity, VCs often take professional pride in advising. Rather than simply select high-quality ventures and then leave them alone, VCs perceive themselves as making a difference in the success of young firms, particularly for management and market understanding. In fact, many VCs see themselves as *co-creators* of new enterprises that "make a difference" (Graebner and Eisenhardt, 2004). Consistent with advising and co-creation, each VC professional normally oversees only 6 to 12 firms at a time and prefers to invest in firms within driving distance (Gompers and Lerner, 2004). This enables VCs to have frequent face-to-face interactions with entrepreneurs that are typical of the close client relationships of other professionals such as lawyers, doctors, and accountants. Illustrating this close relationship, one VC described how he pushed for a pivot in a firm's product strategy that *"prevented them from getting into a wrong path."* Altogether, because their identity is tied to being a professional business advisor, VCs are especially helpful for commercial innovation.

VCs also typically use their *business expertise* as the basis for advocating for formal processes such as product development and other management systems (Hochberg et al., 2007). As Sine and David (2010) note, many of these practices - including their content, timing, and organization - are taken for granted by VC professionals, and deeply embedded as to what is appropriate to do. One institutionalized VC practice is very often to replace a founder-CEO with a professional manager after several stages of product development. This professionalization of management is likely to speed up product development as founders (especially technical ones) may not feel comfortable with sales and marketing, or understand their optimal customer and rather would "sell to anybody who would pay the least bit of attention to them" (Wasserman and Flynn, 2007). Although perhaps not by intent, formalization of management processes is likely to help the young firm structure product development, target the right customers, and thus further commercial innovation. Overall, the discipline from VC professional logic is well-aligned with the structure shown to aid product development (Brown and Eisenhardt, 1997; Katila and Chen, 2008) although it may be misaligned with technical innovation as it constrains the free-form process underlying successful creative work (Clark, 1987).

VCs also view their *network of professional contacts* as a key strength. For example, a VC described how entrepreneurs used his network for advice about customers, "*The [firm] knows they can call us about almost anything. And if I don't know it, I can say 'Go call so and so and tell them that you're working with me'."* An entrepreneur illustrated regarding hires, "*When a CEO needs a VP of R&D or a VP of regulatory quality assurance, they can go to the VC [to get] a list of people that they worked with in the past who are really good and that they recommend. So that's a very practical kind of thing, which is done much more by the VCs than the other investors."* Overall, the assistance of VCs in connecting to advice and hiring networks adds to the formalization of the venture, which, in turn, particularly helps commercial innovation.

The basis of VC attention – i.e., assumptions about how to succeed and so where to focus – is also likely to influence venture innovation. According to ingrained routines within venture capital, VCs manage the relationship through attention to helping ventures achieve milestones that relate to progress toward timely liquidation of the VC fund. A serial entrepreneur told us, *"VCs, their number one concern, …'how much money do you want from me and how do I get my money back'*." An institutionalized practice calls for VC funds to be liquidated at the end of a fixed, ten-year term with VCs often raising successor funds by the midpoint of the existing fund's term (Gilson, 2003). This pressure to perform in a rhythmic and timely manner is an impetus for milestones such as product progress tied with the young firm's readiness for an exit event. All VCs we interviewed had adopted routine, time-paced practices to hit this schedule. One VC described, *"We have a strategy off-site once a year, a 3-4 day event. We ask the entrepreneur to prepare material [about the product portfolio], we bring outside consultants for them to think about product development, we also talk about other questions that are more operationally oriented."* Another VC asked her firms to *"present at regular intervals –redo their pitch to avoid only seeing a company when they raise money."* For entrepreneurs, regular milestones discipline product development such as when *"prior to a board meeting, there's this big push to get stuff done"* (Feld and Ramsinghawi, 2012: 124). Overall, the goal-setting and rhythm that VCs require are well-aligned with practices that enhance commercial innovation (Brown and Eisenhardt, 1997). But while time-paced deadlines and milestones were useful for commercial development, many entrepreneurs saw them as unduly constraining more technical work. One entrepreneur described, *"Sometimes it takes poking around for a few years and learning about the clinical space and trying to understand where the tools you made are most useful. When you've got 50 million bucks of VC funding hanging over you and you've got 3 million dollars a month going out the door, you can't really do that."* Another offered that VC ties are *"not about exploration."* Overall, since the time frames are often longer and the discovery process is more open-ended (Clark, 1987), time-pacing by VCs may not enhance or might even damage technical innovation.

Finally, VCs attend to the institutionalized milestones of *staged financing* (Guler, 2007). A VC described the process to us: *"You invest to get to a prototype... And then, you raise the next round, and it's to take the prototype to a commercializable device."* Staged financing pushes ventures to complete milestones that relate to commercial innovation like a prototype (Series A), product and customer proof points (Series B), and market launch (Series C) as a way to manage (Dorf and Byers, 2005). While beneficial for commercial innovation, the time horizon for staged financing is often too short for significant technical innovation. Together, attending to well-known milestones and time-paced discipline help ventures progress on commercial but less on technical innovation.

Overall, VCs have incentives to encourage technical and commercial innovation as their compensation is tied to their ventures' success which depends on unique technologies embodied in novel products (Hellmann, 2000). They and their contacts also have significant commercial and technical resources. But, their professional institutional logic – business craft as a valued skill, substantial power and authority, deep personal engagement with entrepreneurs, business advisor identity, attention to financial and managerial discipline, and taken-for-granted milestones for ventures – particularly favor commercial innovation. Holding other factors constant, we propose:

H1a. New firms with more funding relationships with venture capitalists will achieve less technical innovation than new firms without them.
H1b. New firms with more funding relationships with venture capitalists will achieve more commercial innovation than new firms without them.

Corporate Venture Capital and Corporate Logic. Corporate venture capitalists are the new firm-investing arms of corporations. CVCs seek strategic advantages for their parent corporations through investing in new firms that provide a window on novel technologies, products, and potential acquisitions (Hitt, 2002; Katila et al., 2008). To a lesser extent, CVCs also seek superior financial returns for the corporation (Hallen et al., 2014). Given these aims, CVCs have incentives to encourage their venture partners to achieve innovation. Further, corporations often have substantial financial, technical, and commercial resources to assist ventures in doing so (Winston-Smith 2009; Park and Steensma 2012). Yet, as we argue below, despite aligned incentives and significant relevant resources, the institutional logic of corporations makes the innovation outcomes of their venture partners somewhat problematic to achieve.

The basis of norms for CVCs – i.e., membership criteria, authority structure, and legitimacy - is likely to influence the innovation of young firms. CVC units are typically comprised of 3 to 30 corporate employees, often reporting to the CTO. CVC executives frequently have experience within the corporation such as business-unit roles (Siegel, Siegel and MacMillan, 1988), and may have technical expertise. They typically are knowledgeable about the corporation's resources such as R&D experts, sales channels and manufacturing facilities (Dushnitsky and Lenox, 2006). A CVC said, *"I took the job because I believed that startups needed help navigating the corporate organization."* But since CVC executives are embedded within a corporate hierarchy, and must coordinate with corporate and business units to access resources for ventures, they have limited authority which may diminish their actual usefulness for ventures.

Since entrepreneurs are usually attracted to particular corporations, not individual CVC executives, CVC legitimacy stems from the prestige and success of the corporation. An entrepreneur illustrates, *"Amazing company…their distribution element – fantastic. Their reps: Honest, intelligent, everywhere."* A CVC executive adds, *"We can bring a lot of market validation to an early stage company in terms of 'yes, we've checked this out'…we know the technology is real and that isn't necessarily what traditional venture firms [can] do."* But while it is usually easy to access resources in a VC tie through the focal VC, it is challenging with CVCs. Corporations with CVC units are often very large. They typically use an M-form or even a matrix with many dispersed units that have their own aims (Chandler, 1962; Galunic and Eisenhardt, 2001; Gaba and Joseph, 2013) such that internal cooperation can be difficult (Martin and Eisenhardt, 2010). Corporate logic further guides who has authority to make decisions (Thornton and Ocasio, 1999), and while these authority structures are taken for granted inside the organization, they are often confusing to outsiders. As one entrepreneur said, *"Who is the decision maker? Is it any one person or is it somebody you may not talk to early in the game?"* Similarly, an implication of corporate institutional logic is that processes for gaining resources are complex. One entrepreneur described how this complexity delayed his progress, *"Slow as molasses: resources need to get approved, technical decisions involve modifications in contracts…they can't get anything done. And their hierarchy-- it's just a pain."* And while corporations have excellent technical resources, many interviewees were puzzled by the difficulty of accessing them. One founder said, *"[Corporate engineers], all they want to do is get into fights about [technology], because they feel threatened, what they have done isn't good enough, kind of thing."* Commercial development was a similar friction as another founder described, *"What surprised me the most is that* *the business units weren't involved in market development or helping [us] understand the market - because that's what I would hope to get from a strategic [CVC] partner. They know the customers much better than we do."* The key point is that while helpful resources exist within corporations, dispersed authority, complex and slow organizational processes, and internal conflicts within their institutional logic complicate venture access to these resources.

The basis of strategy - i.e., how CVCs perceive their identity and strengths – is also likely to influence venture innovation. As carriers of corporate logic, CVC executives typically see themselves as *scouts* for new technologies, products, and potential acquisitions, and *brokers* between business units and ventures (Hallen et al., 2014; Wadhwa and Kotha 2006). A strength is their knowledge of the corporation – i.e., what is going on, who is doing it, and where the corporation is going – and matching that knowledge with venture investments. Yet CVCs may not broker effectively because influence, power, and action traditionally lie within business units in big corporations. As a further consequence, serendipity may be relevant. A founder illustrates, *"One of the VPs was walking down and stopped the low level business development guys [I was hanging out with them trying to once again move the deal] and said 'Hey, what's going on with [that deal] I thought we did that deal?' Of course the deal wasn't made and he was like 'Oh, I guess we better do that deal.' And a month later, the deal was done."* Thus, CVCs may not be sufficiently central in an often complex internal corporate communication network to have sufficient ability or awareness to "put all the pieces together."

To attract ventures, CVCs often maintain distance as suggested by the "sharks dilemma" to avoid scaring off entrepreneurs with threats of corporate dominance (Katila et al., 2008; Diestre and Rajagopalan, 2012). CVC executives often go to great lengths to convince entrepreneurs that the venture will be at arm's length, or as one CVC executive said, *"not in the pocket of the corporation."*

While this distance may enable tie formation, it makes it more difficult for entrepreneurs and CVC executives to identify which corporate resources might actually help the new firms. It is common practice that CVC executives often do not take board seats (Maula, et al., 2005), as a CVC executive noted, "*None of us would lead a deal….and few of us would go onto the board.*" Yet this practice further diminishes influence on and understanding of technical and product strategies –key topics at venture board meetings (Garg and Eisenhardt, 2013). These attributes of the corporate institutional logic impede the communication and cooperation such that ventures are less able to access corporate resources, and CVCs are less able to understand which corporate resources and ties will be most valuable. Altogether, traced backed to their strategy within the corporate logic, CVCs may be ineffective for enhancing the technical and commercial innovation of their venture partners.

The basis of attention for CVCs – i.e., assumptions about how to succeed and so where to focus – can also influence venture innovation. CVC executives perceive success as tied to making venture investments that pay off strategically and perhaps financially for the corporation. *"The way [big corporations] renew, you buy technology and drop it into this huge distribution team and then you battle over market share,"* described an informant. So unlike VCs, CVC executives are less likely to pay attention to helping ventures grow. Consistent with this view, a founder told us, *"They were definitely looking into what we were doing but they were much pretty hands-off in terms of their development and strategy... there wasn't really anyone pushing for the fundamental business side of things."* Indeed, a major focus is to ensure that venture innovations fit with the products of the corporation; *"The strategics are trying to build a portfolio, they're trying to build their business. They want to have a product that supports their brand."* But, these integration efforts may take entrepreneurs away from realizing their own product visions. Further, the corporate strategy may change such that the venture is no longer in the "sweet spot" of the corporation, and may lead CVCs to ignore such a venture.

Another key assumption that guides CVCs' perception of where to focus is *time horizon.* Unlike the rapid, time-paced liquidation of VC funds, CVCs market themselves as "patient capital." So while CVCs provide staged financing like VCs, their focus and related time horizon is tied to their corporation's long-term, strategic needs. In contrast with VCs whose professional logic directs attention to disciplined processes and milestones, the corporate logic puts less attention on the formalization of startup activities that is linked to high-performing commercial innovation.

Overall, CVCs have incentives to encourage the technical and commercial innovation of ventures, and corporations typically possess significant resources that are useful for venture innovation. But, their corporate institutional logic – dispersed authority, complex and slow decision making, internally conflicting goals, focus on corporate strategic aims and long time horizon – are unlikely to enhance venture innovation. Since CVCs often maintain distance from ventures such as by not taking board seats, they are also often far from influencing venture decision making, especially as compared with VCs. Holding other factors constant, we propose:

H2a. New firms with more funding relationships with corporate venture capitalists will achieve less technical innovation than firms without them.
H2b. New firms with more funding relationships with corporate venture capitalists will achieve less commercial innovation than firms without them.

Government Agencies and State Logic. Government agencies as funding partners are public-sector bureaucracies with one or more mandates on behalf of citizens. The primary government agency for funding MIS device firms is the National Institutes of Health (NIH). The NIH is organized around application areas and diseases, and has funded many medical breakthroughs. A key aim of NIH is to improve public health. In its venture funding, NIH seeks technical innovations that advance science, and commercial innovations that turn technical innovations into useful products. Thus, NIH officials have an incentive to encourage their grantees to pursue both technical and commercial innovations, and NIH itself has immense technical resources and commercial understanding (e.g., FDA approval process) to help them do so (Toole, 2012). Yet as we argue, NIH's institutional logic makes only technical innovation especially likely.

The basis of norms at the NIH – i.e., membership criteria, authority structures, and legitimacy – is likely to influence venture innovation. The focal person is the program officer who is often a Ph.D. scientist with an academic background. Unlike their VC and CVC counterparts, scientific credentials are critical for program officers, and other experiences are desirable, but not typical. A program officer assembles review panels composed of non-governmental scientific experts. Together, this panel and the program officer have the authority to designate which ventures will receive funding. Consistent with a state logic, program officials rely on well-documented procedures to ensure fairness, transparency, and diverse access to funds in selecting firms, and appropriate expenditures by funded firms. Several interviewees (both with NIH funding and without) praised its academic peer review process and merit-based evaluation by scientists as a "stamp of legitimacy" for the young firm. In contrast to the perception of VCs as faddish (Sorenson and Stuart, 2008), the legitimacy of NIH as a high-status funding source stems from the prestige of NIH science, the selectivity of its funding, and its careful merit-based analysis of grant applications (Wessner, 2008). Although focus on scientific credibility is potentially useful for technical innovation, entrepreneurs reported that the grant process slowed commercial innovation because *"aims that were put on paper 9 months ago may not be relevant anymore."* One elaborated this misfit:

We put in a very clinically based [proposal]. You look at the review committee and there's not a single clinician on there. So if I tell [reviewers] what I do to develop products, it doesn't sound like the kind of things they do in their labs. For example, milestones and the projects are not quite the same. You have to frame things in a way that looks a little more basic science for them to wrap their heads around and get excited about what we're doing. And then morph that into what we're used to doing which is product development and hopefully have enough flexibility and have the funds ready to do what we need to do.

At NIH, a deeply embedded norm is scientific evaluation that drives legitimacy. Thorough peer review of proposals is the *"gold standard,"* and because the reviewers are *"the experts", "there is* *no need to question their decision."* But given time lags, this norm is often misaligned with the fast-moving commercial development. The two-tier authority structure is also a potential hindrance. Because entrepreneurs cannot talk to the reviewers directly, program officer becomes the focal point of contact. The overall effect is that the institutionalized process of evaluating applicants chiefly on scientific merit, while perhaps beneficial for technical innovation, may hinder commercial innovation.

The basis of strategy - i.e., how NIH officials perceive their identity and strengths – is also likely to influence venture innovation. Program officers see themselves as facilitators of *"interactions at the scientific level,"* and have technical expertise that can be helpful to venture innovation. Indeed, program officers offered examples of how they mentored grantees based on their expertise - typically by spotting a discrepancy in the firm's application. For example, a program officer described a venture that he ultimately funded, *"Something was off in the original proposal. I sat down with the company on multiple phone conversations and thoroughly went through this with them."* Unlike VCs, program officers regard themselves as technical experts who actively mentor applicants on how to spin their business ideas into science-focused grant applications that will be favorably reviewed.

Program officers also regard themselves as *stewards* of public funds. Thus, they attempt to fund geographically diverse ventures in the districts of Congressional members. This helps to ensure that grantees reflect the entire country, but it also makes the hands-on, active engagement of VCs infeasible. Thus while this practice makes sense from a state logic, it distances program officers from their ventures, and makes guidance difficult. As stewards of public funds, program officers also emphasize egalitarian access to resources once ventures are funded. This pursuit of equality leads to "cookie-cutter" activities like "one size fits all" conferences where entrepreneurs learn in lock-step about topics like FDA approval. But, if entrepreneurs want tailored access to NIH resources that might "fast-track" their innovations, they have no clear path through NIH.

The basis of attention for program officers – i.e., assumptions about how to succeed and so where to focus - are likely to influence venture innovation as well. NIH and its program officers typically believe that successful innovation requires *scientific autonomy.* In contrast to VCs who often have weekly face-to-face meetings with entrepreneurs, NIH officials broadly share the belief that intense monitoring of new firms is unnecessary, and even counter-productive. It is likely to impede creative science, and is fundamentally misaligned with the logic of the NIH. A program administrator describes, *"We are spending billions of dollars on projects – what are they producing? They produce knowledge. We fund inquiry. Following up after funding would question and undermine the whole system."* Rather, success is seen as stemming from encouraging outstanding applicants with promising projects to apply and be accepted for funding. In fact, NIH encourages long-term funding to allow investigators to "concentrate on their research for 3 to 4 years unimpeded" (Wyngaarden, 1987: 871). This approach is consistent with the belief that autonomy and freedom fuel scientific discovery but is misaligned with high-performing commercial innovation that benefits from on-going joint problem-solving efforts, advice, and monitoring (Marion et al., 2012). Our interviewees also indicated that government oversight was inconsistent with growing ventures and was, *"incredibly passive"* and *"likely to disappear with months on end without any response."* The central point is that emphasis on scientific autonomy may aid technical innovation, but limit commercial innovation.

NIH program officers also focus on *selection*. They actively attend to attracting many and diverse grant applications to ensure a wide applicant pool, mentoring them to write successful proposals, and assembling review panels that ensure open, merit-based selection (Wessner, 2008).

For example, an interviewee described a multi-state bus tour through under-represented states to promote awareness of government funding. Thus, program officers focus attention on the selection of excellent entrepreneurs and projects, and give less time to monitoring post-funding. While unlike VCs, this practice fits the NIH belief that autonomy is central to scientific discovery.

Program officers also pay attention to what they see as the *public good.* In particular, rather than benefits to corporate shareholders or VC investors, their emphasis is on scientific advances that may significantly improve public health. Consistent with this view, NIH funding supports projects rather than the entire enterprise. In fact, many young firms are funded more than once for separate projects. While the project model is well-suited to support technical innovation, it is less useful for commercial innovation (Azoulay et al., 2011). A medical device entrepreneur illustrated, *"The downside in my mind is that with NIH grants - they're very specific about what you can do…You can't do marketing work with it."* Consistent with the NIH perception of the public good, NIH (like most government agencies) also does not take equity positions in new firms. While such non-dilutive funding can be attractive to entrepreneurs, it also creates a distant and less influential relationship with the new firm as compared with a VC who usually has a board seat and a close relationship. Nonetheless, distance fits with the NIH belief in autonomy for carefully selected grantees.

Overall, NIH and its program officers have incentives to encourage technical and commercial innovation because the success of NIH depends on cutting-edge technologies embodied in commercial innovations that enhance public health. NIH also possesses substantial scientific and commercial (e.g., related to FDA approval) resources that are useful for venture innovation. Yet, the state institutional logic of NIH, – science emphasis, egalitarian access, application but not relationship mentoring, physical distance to grantees, and no-equity funding - may particularly favor creative tasks associated with technical innovation. Holding everything else constant, we propose:

H3a. New firms with more funding relationships with government agencies will achieve more technical innovation than firms without them.
H3b. New firms with more funding relationships with government agencies will achieve less commercial innovation than firms without them.

METHODS

We analyze the relationship between funding partners and venture innovation over a 22-year period from 1986 to 2007. Our sample is the population of U.S. medical device firms that were founded to develop products for minimally invasive surgery (MIS). We chose the MIS device sector because it has many new firms, multiple types of investors (Kruger, 2005; Rapoport, 1990a, b), and particularly reliable measures of technical and commercial innovation. We also chose MIS devices because the government's role as a gate-keeper in commercialization (i.e. mandatory FDA approval) enables us to limit investment partners' potential influence on commercialization through avenues outside the focal relationship. The ability to rule out such potential influences (e.g. network connections and the influence of reputation suggested by Stuart et al., 1999) is likely to make it easier to separate selection and treatment in our setting. We also chose the sector because MIS devices are significant for health care - they reduce patient trauma and healing time by the use of tiny incisions. We begin the sample in 1986, the year in which the first minimally invasive surgical procedure was performed in the U.S. (Mack, 2001), and end with the firms founded in 2003 but continue data collection through 2007 or until the firm declares bankruptcy, is acquired, or goes public. A strength of our study is its use of a complete population of new firms since the inception of the industry sector.

Because the MIS device sector is not clearly defined by standard industrial classifications, we triangulate data from several sources to develop a comprehensive and accurate database. Our first source is survey data from a medical device industry intelligence firm, Windhover Information.

This provides a list of all firms with financial transactions in the sector such as financing, alliances, joint ventures, IPOs, bankruptcies, and acquisitions. Second, we integrate these data with membership lists and conference proceedings from relevant trade organizations such as the American College of Surgeons, International Society for Minimally Invasive Cardiac Surgery, and Medical Device Manufacturer's Association in order to include new firms without financial transactions. Third, we use the National Institutes of Health's Medical Subject Heading (MESH) classification to identify keywords related to MIS devices based on their usage in medical publications, and then search Lexis Nexis and Google to identify firms that use any of these keywords in their business or product descriptions. This enables capture of new firms that lack financial transactions and membership in professional societies.

By combining these databases that rely on complementary sources, we compiled a list of 639 MIS device firms. Firms that did not meet sample criteria were excluded. We dropped 192 firms because they did not develop MIS devices, but rather were solely manufacturing or distribution firms, another 73 firms because they were non-U.S., and finally dropped firms that were subsidiaries of larger companies or were public. As a last step, we consulted two industry specialists who verified the accuracy of our final list of 198 firms.

Our primary data sources for funding partners are four fundraising databases. For VC and CVC funding relationships, we used VentureSource and VentureXpert. These databases rely on distinct yet complementary data sources. Entrepreneurs provide the VentureSource data, investors are the source of the VentureXpert data, and both databases cross-check their data with archival sources. Further, the databases are complementary because they emphasize different funding stages. VentureSource has particularly accurate data on early rounds, whereas VentureXpert's strength is later funding rounds. We build on methodology employed by other researchers to combine the databases (Kaplan, Sensoy, and Strömberg, 2002; Lerner, 1995). When there were missing data or discrepancies between the two databases, we turned to archival sources, including Lexis Nexis, to obtain data and resolve differences. For NIH's research and SBIR funding relationships, we used the Federal Government's FedSpending and the Small Business Innovation Research (SBIR) program databases, respectively. The data are compiled from the Federal Procurement Data System, the Federal Assistance Award Data System, and the Small Business Administration records and provide an accurate and comprehensive list of grants awarded by government agencies.

We also collected data on technical innovations from the Delphion Patent Database and USPTO, and for commercial innovations from the FDA's 510(k) and PMA databases that track medical device applications. As described later, we supplement these data with information from other sources (e.g., The Corporate Technology Directory, ABI/Inform Global, The Leadership Library, Who Owns Whom North America, and One Source North America Business database). The result is a unique database on 198 MIS device ventures over 22 years.

We supplemented the primary archival data with *interviews*. We interviewed over 40 industry informants including entrepreneurs, VCs, CVCs, government administrators and review panel members, as well as device engineers, surgeons, FDA regulators, and industry experts. We interviewed founders and employees in early stage and late stage startups, some successful and others not. We triangulated these interviews by talking to funding partners from all three logics. The interviews lasted between 20 and 75 minutes, and occurred between February 2007 and June 2014. We used two interview protocols, one for entrepreneurs and one for funding partners. These protocols included chronological questions about how and why funding ties formed (or not); how technology and products were included in investment talks; how, when and what type of guidance was given and requested; how communication and monitoring were done; how and what resources were mobilized through funding partners; and how partners and funding targets differed. This fieldwork sharpened our theoretical arguments, strengthened our understanding of causal mechanisms, and helped interpret results. We also drew upon case studies of the financing of several MIS device ventures (Rapoport, 1990a, 1990b).

Measures

Innovation. We examined two innovation outcomes. We measured technical innovation using patented technologies (*patents*) and commercial innovation using product approvals (*products*) by each firm yearly. Patents are an appropriate measure of technical innovation because they are an especially strong defense against misappropriation of IP in the medical device industry (Cohen, Nelson, and Walsh, 2000), and are, according to our interviewees, a major intermediate step in the creation of a new MIS device. Product approvals are an appropriate measure of commercial innovation because FDA approval to market a device demonstrates feasibility, effectiveness, and innovativeness of the product, and medical devices cannot be sold in the U.S. without this approval. A new product introduction typically closely follows FDA approval.

We collected annual data on patents that each firm had applied for (and later received), and on product approvals for each firm. There are two types of FDA device approvals: 510(k) and PMA. The type of approval depends on the novelty and the potential safety risks of the device. Devices that are substantively similar to previously approved ones qualify for a 510(k) approval. Radically novel devices require a PMA approval but they are relatively rare in the MIS device sector (about 2% of product approvals). We combine the two types of approvals, and also run the results with 510(k) approvals only, with consistent results. In all, the sample firms received 2,647 patents and 931 FDA approvals during the study period.

Funding partners. We operationalized three independent variables to measure funding relationships. We measured the new firm's *venture capital funding relationship* with a binary variable set to one if the new firm received a venture capital investment in a year and zero otherwise. Because prominent VCs may be particularly likely to influence innovation because they may have better connections and more powerful influence, we also assessed how a relationship with a high-status VC may influence innovation differently in a sensitivity analysis. We used the VC's eigenvector centrality in venture capital syndication networks to assess its prominence (Bonacich, 1987) and measured *high-status VC partner* with a binary variable set to one when at least one of the top 30 most high-status VCs invested in the new firm's funding round, and zero otherwise.

We measured the new firm's *corporate venture capital funding relationship* with a binary variable set to one if the new firm received a corporate venture capital investment in a year and zero otherwise. We coded investment partners as corporate if they provide equity (not loans or public offerings) and were non-financial firms. In a sensitivity analysis, we also assessed if a *related CVC partner* affected innovation differently, expecting that their competitive interests might make them particularly passive. CVCs were coded as related if they operated in the same 2-digit industry as the venture (Palepu, 1985), and zero otherwise.

We measured the new firm's *government funding relationship* with a binary variable set to one if the new firm received federal funds from the National Institutes of Health (NIH) in a year and zero otherwise. We included both NIH's research and SBIR grants that the focal firm received, and analyzed their aggregate and separate effects.

Finally, we created two related yearly measures for the independent variables above: *number of funding relationships* with a partner, and *total amount of funding received* from the partner.

Controls. Because the availability of financial resources may influence a young firm's innovation (Cohen, 1995), we controlled for *funding amount* by the total inflation-adjusted investment by all funding partners in each firm annually. This variable was measured in millions of U.S. dollars, and logged to mitigate skew.

We controlled for the new firm's *geographic location* in an innovation-rich region because local infrastructural and cultural differences may influence a young firm's innovation performance. Since our data indicate that innovation hubs in MIS devices include the traditional entrepreneurially dense regions of San Francisco and Boston as well as the Minneapolis and Orange County regions, we included these four region controls. We measured location by an unreported binary variable coded as one if the new firm was headquartered in one of the metropolitan area zip codes associated with one of the four hubs and zero otherwise. In alternate tests, we included metropolitan statistical area (MSA) fixed effects (a dummy variable that equals one if the young firm is located in a particular MSA and zero otherwise) as controls to capture differences in local resource availability (Samila and Sorenson, 2010) and our results held.

Because longer-tenured firms can have more experience in innovating, we controlled for *firm age* in years between the year the new firm began operations and the current year. We also collected *firm size* data, measured by number of employees yearly, but these data were available for a subset of 30 firms only. Because firm age and size are highly correlated, we used firm age as the control. In the equations which predict product approvals, we also included the new firm's *patents* as a control. We obtained the data on control variables from ZoomInfo, VentureXpert, VentureSource, The Corporate Technology Directory, and Lexis Nexis. We also cross-checked with each firm's current and archived websites (archive.org) when available.

We also controlled for the *founding team*, expecting that a venture with accomplished founders would be more likely to innovate because particular founder backgrounds (MD, PhD) could help types of innovation, and more experienced teams in general may have learned to innovate more predictably (Beckman et al., 2007). More details of the founding team measures and mechanisms are provided in the Appendix.

Finally, we included controls for *temporal effects* that might contribute to innovation outcomes, such as macroeconomic conditions, beyond our other controls. We operationalized these effects by unreported yearly dummy variables for 1986-2007. Since the sample size is reduced in our difference-in-differences models, we use a continuous year measure. We also considered *temporal factors common to each match.* Like Short and Toffel (2010), we included dummy variables indicating each year before, during, and after the match year to capture any changes in resource availability, like government administration shifts. Original results held.

Statistical Methods

Because we focus on the effects of 'treatment' (funding tie), a statistical challenge is to show that differences in innovation can be attributed to the treatment, and not to other factors such as selection to a particular treatment. Types of funding partners may affect new firm innovation because they (1) pick innovative new firms more effectively (*selection*), (2) better help new firms be innovative during the relationship (*treatment*), or (3) both.[2]

Difference-in-Differences. We account for selection bias by using several approaches. The primary method is *difference-in-differences analysis* (Abadie, 2005; Short and Toffel, 2010; Smith and Todd, 2005). We chose this method because it yields separate estimates for selection and treatment effects, allows us to compare the effects of treatments over time across the matched treated and (counterfactual) comparison firms, and is robust when two firms are not a perfect match

[2] In a randomized experiment – the ideal approach to evaluate treatment effects – randomization takes care of many threats to causal inference. Because each firm is randomly assigned to a treatment or control group, the two groups look alike on average and selection bias is eliminated. But randomization is unavailable to us, and so we use a quasi-experimental design that facilitates causal inference by focusing on a population of firms over time, and by attempting to make the treatment and comparison groups comparable by matching and including a rich control set.

in initial performance but their performance trends are parallel.

The first step is to identify a treatment, and a group that received the treatment and a "control group" (comparison) that did not. The second step is to calculate the differences in outcomes before and after the treatment for both groups. The third step is to calculate the difference in these two numbers - i.e., difference-in-differences across these two groups (Bertrand, Duflo, and Mullainathan, 2004). To test whether a treatment changed the performance trajectory of a firm, we estimate: $y_{it} = \beta_0 + \beta_1\ treat_i + \beta_2\ after_{t-1} + \beta_3\ treat_i{*}after_{t-1} + controls_{it-1} + e_{it-1}$

where y_{it} is the firm i's performance in year t, $treat_i$ equals one if new firm i formed a focal type of funding relationship and zero if it did not, and $after_{t-1}$ equals one if the current year is after the treated firm received funding, and zero for the years before it. For the analysis, we identify a 'control' group that would have been 'eligible' for the same type of funding, but did not form the tie. So, we create a sample of *matched pairs of firms.* The aim is to find matching firms that are as close as possible to treated firms so that they can be used to estimate the counterfactual, i.e., the firm that received funding should not differ from its paired firm that did not, in ways that are relevant for the outcome.

To build our matched sample and following Shadish et al. (2002), we first theorized about how our ventures were selected to a treatment (funding tie), and then used the constructed criteria to form matched pairs of firms that were comparable, except for the tie. Since our focus is innovation, those firm characteristics that could drive a difference also in innovation performance were relevant. We conducted interviews with funding partners and entrepreneurs about partner selection. We asked funding partners about their selection criteria for investing in new firms, rejected firms, and firms which rejected their offers. We asked entrepreneurs about their funding partners, investors that rejected them, and investors whom they rejected. These interviews revealed that prospective partners are strategic in their tie formation. Also, contrary to popular wisdom, VCs are not the investor of choice for all entrepreneurs. Some entrepreneurs either did not pursue or turned down VC investment, usually to retain more control. Most important, interviewees converged on a few key criteria for determining whether funding relationships form. As a result, we matched firms on geographical location, founding year and patenting as the interviews suggested, and in sensitivity analyses added matching also on the quality of the founding team and technology. Details of matching are provided in the Appendix. Altogether, we create matched pairs of firms that have ties with VCs (36 pairs, 432 firm-years), CVCs (66 pairs, 792 firm-years), and NIH (17 pairs, 204 firm-years observations).

Firm Fixed Effects. While difference-in-differences analysis pays attention to selection bias, like all methods, it is not perfect. Increasingly accurate matching comes with a price: firms that do not have a match in the data are dropped, and so the findings may not generalize to a larger population. To account for these issues, we use a second statistical approach, full-population *firm fixed effects* analysis (Hausman et al., 1984; Benner and Tushman, 2002), as an alternative to matching (Imai and Kim, 2012). Because fixed effects drops firms that lack variation in the dependent variable, we also use random effects and Generalized Estimating Equations (GEE) regression method, which accounts for auto-correlation that may arise because each firm is measured repeatedly across multiple years (Liang et al., 1986). Our findings are highly consistent. As has become common in venture funding studies (Li and Prabhala, 2007), we report difference-in-differences as our main analysis.

In all models, the data consist of a panel of observations on firm-years. To further facilitate causal inference, we lag independent and control variables by one year. Because our dependent variable is counts of innovation, we use Negative Binomial regression (Poisson regression findings are consistent).

RESULTS

Table 2 reports descriptive statistics and correlations. New firms typically received a patent each year, and an approval for a new device every other year. While many firms formed a tie with a VC (73%), a CVC (36%), or the NIH (12%), a significant number (23%) never received funding from any of these sources. Overall, the independent variables show considerable variance and the correlation matrix indicates low correlations among them. The exception is the correlation between VC partner and the amount of funding received (r=.67). Consequently, we entered these variables both separately and simultaneously, but the results were unaffected by the choice. We also obtained the variance inflation factors (VIFs) for all independent variables (Menard, 2001), and these were less than 5.0, the recommended cut-off value, indicating that the variables are unrelated.

---Insert Tables 2-10 and Figures 1-12 about here---

Table 3 presents the difference-in-differences analysis for the effects of *VC funding partners* on the innovation of new firms. Models 1 and 3 include the control variables only. Consistent with the rest of our analyses, we find that new firms receive more patents (technical innovation) when they have more funding (funding amount), and more product approvals (commercial innovation) when they have more patents (technical innovation) and are older (age).

Models 2 and 4 introduce VC partner effects on patent and product approvals, respectively. We argued that new firms with funding partners steeped in the professional logic of VCs were likely to achieve less technical innovation (H1a) and more commercial innovation (H1b) than firms without these relationships. To test the hypotheses, we assessed the coefficient for the interaction term between VC partner and after investment variables in models 2 and 4, respectively. This coefficient is positive but not significant in model 2, and positive and significant ($p < .05$) in model

4, The results thus show that ties with VCs have no significant effect on technical innovation (H1a), but help *yield* significant commercial innovation during the relationship (H1b). Further, the positive and significant ($p < .05$) coefficient for VC partner in model 2, and the lack of significance for the same coefficient in model 4 show that VCs *select* new firms with strong (prospects for) technical innovation but lack the ability to select firms that have superior commercial innovation. Altogether, the results confirm the importance of separating the selection and treatment effects in evaluating the influence of partners on new firms.

Table 4 examines *CVC funding partners*. We argued that new firms with partners steeped in the corporate logic are less likely to achieve both technical and commercial innovation (H2a,b). The coefficient for the interaction term between CVC partner and after investment variables is not significant in either model but the coefficient for CVC partner in model 2 is positive and significant. In a sensitivity test that further refined our matching (details below), the coefficient for the interaction term on patenting becomes negative and significant, suggesting support for H2a. Together, the results show that CVCs select new firms with strong technical innovation (patents), but that these ties may have a weak negative (or no) influence on technical, and no influence on commercial innovation outcomes of ventures.

Table 5 examines *government* (NIH) *funding partners*. To test hypotheses 3a and 3b, that new firms with funding ties steeped in the state logic are more likely to achieve technical and less likely to achieve commercial innovation, we assessed the coefficient for the interaction term between NIH partner and after investment variables. Unexpectedly, the coefficient is negative and significant ($p < .001$) in model 2 and positive but not significant in model 4, failing to support the hypotheses. Together, the results show that NIH *selects* to form ties with new firms with more technical innovation (patents), but that their ties unexpectedly *yield* a lower likelihood of technical innovation and no effect on commercial innovation.

We also confirmed all findings with an alternative specification of hypothesized variables - i.e., total yearly funding received from each partner type, rather than a binary or count variable. As described in more detail below, we also confirm the results for our hypotheses by redefining matches, increasing the richness of the control set, and adding firm fixed effects.

Sensitivity Analyses. We examined the *robustness* of our *difference-in-differences analysis*. First, we used alternative *matches* to deal with potential remaining differences between the treatment v. control groups. Our original matches were based on geographic location, founding year, and patenting, but our interviews suggested two added selection criteria - *founding team* and *technology quality*. Despite the reduction in sample sizes when these two criteria were added (see Appendix), our original findings were confirmed. The only exception is the coefficient for CVC funding ties that now has a statistically significant negative effect on venture patenting in a model as expected in H2a. Second, we added variables to control for any remaining differences, including whether a young firm was funded by a *prominent VC* and the *availability of resources* for the MIS sector from each type of funding partner in a particular year, with consistent results. Finally, because alternative matches and controls do not capture unobservable characteristics that may be relevant, we examined *firm fixed effects* in the difference-in-differences analyses. Given the many variables, it is unsurprising that some equations did not converge, but the main result patterns were consistently supported. In summary, our main findings are robust to several added controls, matching criteria, and models with alternative specifications.

We confirmed these results with alternative statistical analyses that use the *entire population*, not just matched firms. First, we ran fixed effects, random effects and GEE regressions in the full population. This enables a more complete analysis of the counterfactual (non-treated) firms and inclusion of comprehensive control variables including founding team characteristics and year dummies. These analyses yield results that strongly paralleled our original findings (see Tables 6, 7). Second, we explicitly attempted to model the selection process (rather than 'controlled out' selection to resemble randomization) using a two-stage *instrumental variables approach* (Li and Prabhala, 2007; Wallsten, 2000). Although the lack of strong instruments was limiting, these tests support our main findings. Third, we verified that the matched samples were representative of the full population by using t-tests on key observable variables (results available from the authors). We then examined potential scope conditions for the institutional logics' influence.

Scope Conditions: Funding Partners. We explored the *heterogeneity of funding partners* within each type. To probe H1, we analyzed whether ties with *high status* VC firms differed from ties with low status ones. In table 8, we observe that ties with high status VCs positively and significantly influence *both* technical and commercial innovation during the relationship ($p < .05$).

To probe H2, we analyzed whether ties with *related* CVC firms differed from ties with unrelated ones. In table 9, we find that ties with related CVCs decrease the technical innovation of the new firm relative to unrelated CVCs ($p < .05$).

To further understand H3 and the unexpected negative influence of ties with NIH on the technical innovation of ventures, we analyzed whether ties with NIH-SBIR differ from those with NIH-research. The results in table 10 indicate no significant differences between the two groups. We return to these results in the Discussion.

Scope Conditions: Industry Life Cycle. We also compared the influence of the logics over the *life-cycle of the MIS sector* to gain insight into whether the influence of a particular logic depends on the environment. Since institutions may have stronger, more consistent effects during stable periods (Barley and Tolbert, 1997), we compared the funding partner logics in two time periods, i.e. less stable pre-1995 vs. more stable post-1995 periods in the MIS device sector. We used 1995 because it is a breakpoint – i.e., the MIS procedure was a radical departure from historical surgical practice, and adoption was slow for its first decade. In fact, early writings described MIS as a "surgical heresy" and a "passing fad." While a few lead user-surgeons adopted the practice early, most others delayed until patients "created the industry" by "demanding" the procedure in the early 1990s (Park and Lee, 2011). Short courses were then created to train surgeons, and the first MIS courses were added to residency programs. Our interviews and sector historians document that the MIS device sector became more stable and established post-1995.

Our quantitative findings reflect this historical account. The positive influence of the VC logic on commercial innovation becomes more pronounced during this later stable period, reinforcing our main findings. Altogether, we find that institutional influences seem more influential as environments stabilize.

Scope Conditions: Logic Combinations. While our primary analyses focus on each partner type while holding the effects of other partners constant, we analyzed whether institutional logics clash when young firms receive funding from multiple types of funding partners. Indeed, research suggests that incompatible logics may hurt venture performance (Battilana and Dorado, 2010). Over half of our VC-funded ventures formed a CVC tie, and one in ten had both VC and NIH ties. While our main results held in these sensitivity tests, they also indicate that simultaneous VC and NIH funding (i.e. partners with very different institutional logics - Pache and Santos, 2010) lower both technical and commercial innovation. In contrast, simultaneous VC and CVC funding increased technical innovation. One reason may be that the professional and corporate logics complement each other with appropriate checks and balances (Hallen et al., 2014), and so reward hybridization of institutional logics. In contrast, professional and state institutional logics create too many conflicting demands that lower innovation.

We also considered logic combinations that occur over time due to *temporal preferences*. For example, perhaps NIH invests earlier, in riskier ventures (Wallsten, 2000). If so, its ability to influence innovation could be systematically different from partner types that act later. To assess this, we examined the funding histories of each firm. We found that some firms took government funding before turning to VCs and CVCs while others took VC funding and then turned to the government later. Some firms never received funding at all, while other firms took funding from only one partner type. In all, we found that ventures pursued a variety of funding strategies, many of which avoided VCs (see also Chatterji, 2009 for similar findings), and that there is no pattern of early investment such as by NIH or VCs, or late investment such as by CVCs. Thus, it is unlikely that timing differences explain our results, but an interesting future path is to examine whether a particular temporal order of co-investors makes a difference, and how entrepreneurs in general deal with these competing logics and the associated demands.

DISCUSSION

Our central insight is that the institutional logic of partners can influence the innovation of new firms. By studying the population of MIS device ventures since sector inception, we observe that ties with particular types of funding partners lead to major innovation differences even when the partners offer relevant resources, are highly selective, and have incentives to encourage innovation. So while prior research examines alters with the *same* institutional logic, our work points to *differences* in the institutional logics of partners that influence the interactions and outcomes of ties with young firms.

A key finding is that ties with VCs are particularly effective. Influenced by professional norms for deep engagement with client-entrepreneurs by highly skilled professionals, and strong identity as a professional advisor for business skills, VCs actively and even aggressively work with their entrepreneurial partners to achieve product innovations. This is further enhanced by institutionalized practices like staged financing, board seats, and 10-year funds that address VCs' professional obligations to investors. These and other attributes (e.g., decision making autonomy consistent with being a professional, simplicity of the partnership organizational structure, etc.) comprise a professional institutional logic. Collectively, these attributes ensure ready access to VC resources such that entrepreneurs and their commercial innovation efforts benefit.

By contrast, ties with CVCs are much less effective. A key insight is that, consistent with the corporate institutional logic, corporations rely on a complex division of labor and strategic goals to succeed such that cooperation is challenging and decision-making authority is dispersed. This dispersed structure and the identity of CVCs as scouts who support corporate growth (not venture growth), means that business unit executives often do not value assisting new firms as a priority. As a CVC executive noted, *"In an engineering organization, the first reaction is 'We can do that. Give us a budget and we'll go build one'…So in corporate settings the business units may not quite buy into what you are [as the CVC] doing".* CVC executives also believe that they need to create distance between themselves and the venture, which keeps them off venture boards and makes them more passive, distant, and less influential partners. Collectively, these and other attributes create a coherent corporate logic, but one that is less likely to channel the resources, mentoring and discipline needed for venture innovation.

Finally, ties with NIH are a particularly striking example of how a partner's institutional logic can restrain resource access even when those resources are significant and access is mutually beneficial. Influenced by their identity as mentors who promote fair and widespread access to public funds, NIH program officers emphasize active selection of new firms, but are then passive during ties. A potential consequence of extreme emphasis on selection could be that entrepreneurs may already have all the technical results they hope to get when they receive funding for a specific project – aka "priming the pump" - which yields little technical innovation during the tie because it is hard to go back to exploration and push further when it *"feels like the work has already been done."*

In addition, while a state logic involves fair and democratic access to resources, it also leads to a "cookie-cutter" approach during ties such as "one-size-fits-all" conferences where entrepreneurs learn in lock-step. But, if entrepreneurs want tailored access to the immense NIH resources, they have no path. One entrepreneur told us that, since her NIH program officers became so passive during ties, she was *"unsure of the actual power*" that these officers held. Consistent with Sine et al. (2006), she offered that such uncertainty about who is in charge and who can provide NIH resources impeded her development efforts. Similarly, funding geographically diverse ventures in many Congressional districts makes sense in a state logic. But, it also makes the effective, hands-on engagement of VCs unlikely. The norms of science add to the passivity during ties because of the attendant belief that autonomy fuels scientific discovery. These and other attributes (e.g., bureaucratic rules like rigid expense categories (Wessner, 2008), project (not firm) funding, merit-based expert panels, etc.) create a coherent state logic. But, they also make the NIH a passive partner embedded in a state institutional logic such that ventures have difficulty accessing NIH's impressive resources. Thus while we expected that NIH's approach of highly autonomous entrepreneurs would encourage scientific discovery and greater technical innovation, our findings indicate that it does not.

Institutional Theory: More than Incentives, Resources, and Power

We contribute to institutional theory by extending the domain of institutional logics to partners in a relationship. Prior research shows that institutional logics affect the activities and outcomes of focal organizations (Thornton, et al., 2012; Marquis and Lounsbury, 2007). By studying partnerships in an ideal setting in which organizations with mature institutional logics interact with new firms with nascent logics and limited power, we extend institutional theory. We show that the institutional logics of types of organizations can influence the outcomes of their partners, not just their own outcomes. While prior work on institutions and young firms has focused on larger societal logics and their influence on ventures (Thornton, 2004; Eisenhardt, 1988) , our contribution is to show how a logic represented by a particular class of institutional actors (i.e., type of partner) is significantly related to young firm choices and outcomes.

There are, however, alternative explanations. One is that simpler concepts such as *resources* or *incentives* can explain the results. While simpler concepts are appealing, they are not sufficient explanations. For example, CVCs have (in principle) access to substantial resources to improve the commercial and technical innovation of new firms. These resources may even be superior to those of VCs in many situations. Yet, the various attributes that comprise the corporate institutional logic (e.g., dispersed business units, fragmented authority, long-time horizon) impede access to those resources, and for related CVCs, particularly heighten the danger of misappropriating intellectual property (i.e., "swimming with sharks") and so limit mutual interest in deep engagement. Thus, institutional logic provides a more accurate prediction than simpler concepts like resources, and is consistent with the decline of CVC units that is empirically observed (Gaba and Dokko, 2013).

Incentives of funding partners could also be an alternative explanation, but our data suggest that something more than incentives alone is driving our results. For example, NIH-SBIR has a Congressional mandate to encourage the commercial innovation of ventures based on their technical innovations. Consistent with this mandate, it uses staged grants to achieve these outcomes, and encourages reporting of both patents and products. In other words, NIH-SBIR has incentives to encourage both types of innovation. Yet, its state logic impedes the ability of NIH program officers to engage in the hands-on, venture-specific behaviors that VCs effectively use to actually achieve innovation. While the "hands-off" approach may work for basic university science, it is ineffective for the commercial innovation that is central to the mission of NIH-SBIR and is even less effective relative to other types of funding partners for technical innovation.

Declining *incentives of new firms* to innovate as they gain funding partners could also be an alternative explanation, but again this explanation seems insufficient. Corporate governance literature suggests that when employee ownership is diluted and transferred to distant outsiders, executives become more motivated to build personal empires, and less motivated to develop technology (Aghion et al., 2009; Kim et al. 2008). But while such incentives may arise in established corporations, they are less germane to new firms. Since innovation is at the heart of venture success (rather than an option or an after-thought; Katila et al., 2012) and ventures are typically resource-constrained (Baker and Nelson, 2005), empire building without innovation seems unlikely. Our empirical tests further confirmed that reduced incentives related to diluted equity as new funding partners are added is an unlikely explanation alone. Since government partners typically do not take an equity share like CVCs and especially VCs do, we would expect the potential negative effect of ownership dilution on innovation to be strongest for VC-funded firms, and weakest for the NIH-funded. Instead, our results show the opposite.

A related incentives explanation is that perhaps ownership of technologies (rather than the entire firm) explains reduced innovation. This could be the case in project-based funding by government, for example. But our data do not support this explanation: all technical inventions in our sample were owned and patented by the venture (and only 2% of these inventions were co-assigned to a public entity). Our interviews also confirm that there is no pattern of state ownership of MIS technologies. Another incentives explanation is that perhaps VC-funded entrepreneurs have *more* incentives to innovate because VCs monitor them more, thus possibly explaining why their ventures achieve more innovation. But using a test developed by Aghion et al. (2009), we find that this explanation also does not fully explain our findings: While market competition (and its related discipline) should substitute for VC-driven monitoring over time, we find the opposite, i.e., VC influence on innovation intensifies over time. Altogether, these arguments and analyses support a more complex explanation attributable to differences in the institutional logics of funding partners rather than simply incentives as an explanation of our findings.

Another alternative explanation is *power*. For example, high-status VCs are often powerful, even autocratic, and so better able to influence ventures than other types of funding partners. But while these power differences are likely to exist, they are largely attributable to differences in institutional logics. Thus, a key reason why VCs are so powerful is that they are local equity investors who have board seats and engage in frequent interactions with entrepreneurs. In contrast, both NIH and CVCs are constrained from these activities by their institutional logics. For example, NIH purposefully funds projects throughout the U.S., and does not take equity, thus limiting power of ventures. Overall, our findings indicate that institutional logic captures a configuration of attributes that more accurately describes interactions between partners, and better predicts venture innovation than simpler constructs such as resources, incentives and power.

Finally, some partner types may have better *foresight* regarding which ventures will be innovative (beyond what we controlled for), and that they use this foresight in making their funding decisions. This may be true. But given their specialized technical, engineering and market expertise that typically exceeds that of the VCs', we would expect that corporate and possibly government investors (not VCs) have such foresight. So the foresight explanation is not fully compelling. In addition, since our setting includes the FDA as a key gate-keeper in the product approval process, foresight by VC partners regarding which products will become commercial successes, as suggested by Stuart et al (1999), is an unlikely explanation. Indeed, our empirical data show *no* significant differences in the investment opportunities of VCs relative to other investors.

We began by asking how types of funding partners might influence the innovation that is at the heart of venture success in technology-based sectors. We find that types of funding partners are *not* created equal. While partner types similarly select technically innovative ventures, they differ in their treatment once a tie is formed. We conclude by noting practical implications for entrepreneurs. Generally speaking, entrepreneurs should focus first on creating innovations to obtain funding. Since VCs, CVCs, and NIH all select ventures based on the venture's patents, extensive technical innovation creates funding flexibility. But later, the path to commercial innovation and ultimately revenue is different during the relationship –i.e., ventures with ties to VCs move more effectively down that path. Indeed, ties with the U.S. government may even impede technical innovation. Ironically for entrepreneurs then, the least expensive funding with the fewest strings may counter-intuitively be most limiting for long-term innovation success.

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Table 1. Institutional Logics of VCs, CVCs, and the NIH

	VC	CVC	NIH
Attributes	Professional logic	Corporate logic	State logic
<u>**Basis of norms**</u>			
Membership Criteria	• Educational credentials • Managerial experience	• Executive experience, usually within the corporation	• Scientific credentials
Legitimacy	• Prestige of successful investment track record	• Prestige of corporation driven by commercial and technical success	• Prestige of government science • Selectivity of funding
Authority Structure	• Partnership with simple hierarchy • Partners with high decision-making authority	• Complex hierarchy of business units and corporate office • Dispersed authority with slow decision making and internal conflict	• Panel of scientific experts led by program officer with high decision making authority
<u>**Basis of strategy**</u>			
Identity	• Highly involved professional business advisor to entrepreneur-clients • Co-creator of difference-making ventures	• Corporate scout for technologies and products • Broker between ventures and corporation	• Mentor for the application process • Steward of public funds
Strengths	• Ability to formalize processes • Network of professional contacts	• Knowledge of the corporation • Knowledge of the industry	• Careful merit-based, scientific evaluation • Technical and commercial (e.g. clinical trials) resources of NIH
<u>**Basis of attention**</u>			
Assumptions: how to succeed	• Close personal relationships with clients	• Portfolio of high-quality strategic investments for the corporation • To a lesser degree, financial returns	• Scientific autonomy for high-quality entrepreneurs
Assumptions: where to focus	• Routinized and rhythmic timetables for venture progress • Milestones of staged financing	• Distant time horizon of patient capital • Fit of investments with corporate strategy	• Selection of high-quality entrepreneurs • Selection of projects to promote public good

Table 2. Descriptive Statistics and Correlations

	Variable	Mean	Std. Dev.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1.	Patents	1.23	3.07															
2.	Products	0.48	1.28	0.25														
3.	VC Partner	2.06	4.56	0.13	0.10													
4.	CVC Partner	0.14	0.54	0.04	0.05	0.50												
5.	Government Partner	0.05	0.31	0.01	0.06	0.06	0.02											
6.	High-Status VC Partner	0.11	0.31	0.20	0.09	0.13	0.02	0.04										
7.	Firm Age	6.93	4.57	-0.05	0.05	0.00	0.04	-0.01	-0.12									
8.	Funding Amount (logged)	0.38	6.24	0.13	0.07	0.67	0.34	0.19	0.15	-0.04								
9.	Founding Team Size	1.23	0.50	0.02	-0.04	-0.05	-0.04	-0.01	0.00	-0.06	-0.05							
10.	Entrepreneurial Experience	1.48	3.78	-0.05	-0.07	0.00	0.02	-0.02	-0.01	0.00	0.01	0.11						
11.	Work Experience	2.52	3.50	0.04	-0.03	0.03	0.03	-0.03	0.04	-0.05	0.00	-0.02	0.11					
12.	Managerial Experience	2.31	3.60	0.07	0.00	0.01	0.02	-0.01	0.03	-0.02	-0.02	0.00	0.09	0.88				
13.	Academic Experience	0.17	0.38	0.05	0.10	-0.03	-0.06	0.15	-0.04	-0.02	0.04	0.11	0.16	0.09	0.12			
14.	MD Founder	0.25	0.43	0.15	-0.04	0.04	0.00	0.02	0.14	-0.10	0.09	0.23	0.09	0.08	0.14	0.33		
15.	PhD Founder	0.27	0.45	0.02	0.15	-0.02	-0.04	0.21	-0.11	0.03	0.03	-0.07	0.04	-0.21	-0.17	0.22	0.06	
16.	MBA Founder	0.10	0.30	0.06	-0.02	0.00	0.04	-0.05	0.02	-0.04	-0.01	0.05	-0.01	0.08	0.14	-0.12	-0.01	-0.17

N=1,299 firm-years

Table 3. GEE Negative Binomial Difference-in-Differences Analysis for VC vs. non-VC Funded Firms

Dependent Variable	Patents		Products	
Variable	**Model 1**	**Model 2**	**Model 3**	**Model 4**
Intercept	58.29***	43.01**	83.21***	74.22***
	(14.73)	(14.98)	(20.03)	(20.29)
VC Partner		0.21**		0.01
		(0.09)		(0.13)
After Treatment		-0.88**		-2.55**
		(0.33)		(1.03)
VC Partner x After Treatment		0.18		2.38**
		(0.35)		(1.04)
CVC Partner	0.00	-0.03	0.11	0.09
	(0.06)	(0.06)	(0.07)	(0.07)
Government Partner	0.58***	0.66***	0.07	0.14
	(0.16)	(0.17)	(0.23)	(0.23)
Patents			0.08***	0.08***
			(0.01)	(0.01)
Firm Age	0.01	0.00	0.05***	0.05***
	(0.01)	(0.01)	(0.01)	(0.01)
Funding Amount (logged)	0.04***	0.04***	0.01	0.01
	(0.01)	(0.01)	(0.01)	(0.01)
Wald chi-square	151.30	190.40	150.14	149.96

* $p < .10$; ** $p < .05$; *** $p < .001$; two-tailed tests.
Standard errors are in parentheses. All models include unreported year and geography effects. N=432 firm-years

Table 4. GEE Negative Binomial Difference-in-Differences Analysis for CVC vs. non-CVC Funded Firms

Dependent Variable	Patents		Products	
Variable	**Model 1**	**Model 2**	**Model 3**	**Model 4**
Intercept	17.41	-9.07	94.55***	76.88**
	(13.69)	(19.68)	(17.73)	(24.15)
CVC Partner		0.83***		-0.12
		(0.11)		(0.13)
After Treatment		0.24*		-0.05
		(0.13)		(0.15)
CVC Partner x After Treatment		-0.19		0.11
		(0.16)		(0.19)
VC Partner	0.78***	0.67***	0.28*	0.14
	(0.12)	(0.14)	(0.16)	(0.19)
Government Partner	1.26***	0.42**	0.20	0.36
	(0.17)	(0.21)	(0.23)	(0.25)
Patents			0.08***	0.14***
			(0.01)	(0.01)
Firm Age	-0.01	-0.02**	0.05***	0.07***
	(0.01)	(0.01)	(0.01)	(0.01)
Funding Amount (logged)	0.01	0.02*	0.01	0.01
	(0.01)	(0.01)	(0.01)	(0.01)
Wald chi-square	386.41	478.06	186.00	218.03

* p < .10; ** p < .05; *** p < .001; two-tailed tests.
Standard errors are in parentheses. All models include unreported year and geography effects.
N=792 firm-years

Table 5. GEE Negative Binomial Difference-in-Differences Analysis for NIH vs. non-NIH Funded Firms

Dependent Variable	Patents		Products	
Variable	**Model 1**	**Model 2**	**Model 3**	**Model 4**
Intercept	13.83	-27.82	96.18***	251.20***
	(13.60)	(37.31)	(17.74)	(47.46)
Government Partner		1.68***		0.14
		(0.23)		(0.34)
After Treatment		0.52**		1.07***
		(0.26)		(0.31)
Government Partner x After Treatment		-1.02***		0.02
		(0.28)		(0.36)
VC Partner	0.45***	-0.71**	0.21	-0.33
	(0.12)	(0.22)	(0.16)	(0.28)
CVC Partner	0.11	0.50**	0.22	1.28***
	(0.11)	(0.23)	(0.15)	(0.28)
Patents			0.08***	0.03**
			(0.01)	(0.02)
Firm Age	-0.01	0.03**	0.05***	0.08***
	(0.01)	(0.02)	(0.01)	(0.02)
Funding Amount (logged)	0.03***	0.05**	0.01	-0.02
	(0.01)	(0.02)	(0.01)	(0.02)
Wald chi-square	329.07	145.08	184.28	117.49

* p < .10; ** p < .05; *** p < .001; two-tailed tests.
Standard errors are in parentheses. All models include unreported year and geography effects. N=204 firm-years

Table 6. Negative Binomial Analysis of Patents with Founding Team Data

	M1-M5: GEE			M6: Random Effects			M7: Fixed effects
Variable	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7
Intercept	72.83***	70.51***	74.70***	72.65***	71.67***	-84.43**	-121.68
	(17.75)	(17.76)	(17.75)	(17.75)	(17.76)	(28.05)	(419.61)
Number of VC Partners		0.03**			0.02**	0.02**	0.02*
		(0.01)			(0.01)	(0.01)	(0.01)
Number of CVC Partners			0.12**		0.06	-0.06	-0.07
			(0.06)		(0.07)	(0.08)	(0.08)
Number of Government Partners				-0.17	-0.15	-0.18	-0.23*
				(0.13)	(0.13)	(0.13)	(0.13)
Number of High-Status VC Partners	0.95***	0.92***	0.96***	0.95***	0.93***	0.74***	0.64***
	(0.11)	(0.11)	(0.11)	(0.11)	(0.11)	(0.12)	(0.13)
Firm Age	0.01	0.01	0.01	0.01	0.01	-0.04**	-0.06***
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.02)
Funding Amount (logged)	0.05***	0.03***	0.04***	0.05***	0.03***	0.02**	0.02**
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
Founding Team Size	-0.1	-0.08	-0.10	-0.10	-0.08	-1.51**	-7.69
	(0.36)	(0.36)	(0.36)	(0.36)	(0.36)	(0.68)	(627.56)
Founding Team Size Squared	0.01	0.01	0.01	0.01	0.01	0.39**	2.47
	(0.09)	(0.09)	(0.10)	(0.10)	(0.10)	(0.18)	(209.19)
Entrepreneurial Experience	-0.06***	-0.06***	-0.06***	-0.06***	-0.06***	-0.01	-0.01
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.03)	(0.04)
Managerial Experience	0.01	0.01	0.01	0.01	0.01	-0.04**	-0.05**
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.02)	(0.02)
Academic Position	0.05	0.09	0.06	0.07	0.10	0.57**	0.90**
	(0.11)	(0.11)	(0.11)	(0.11)	(0.11)	(0.25)	(0.32)
MD	0.59***	0.58***	0.58***	0.58***	0.57***	0.53**	0.41
	(0.09)	(0.09)	(0.09)	(0.09)	(0.09)	(0.20)	(0.25)
PhD	0.42***	0.41***	0.42***	0.44***	0.43***	0.36*	0.48*
	(0.09)	(0.09)	(0.09)	(0.09)	(0.10)	(0.21)	(0.28)
MBA	0.58***	0.57***	0.58***	0.58***	0.57***	0.00	0.08
	(0.12)	(0.13)	(0.13)	(0.12)	(0.13)	(0.27)	(0.36)
Wald chi-square	349.76	354.71	353.35	349.27	355.09	124.31	107.35

* p < .10; ** p < .05; *** p < .001; two-tailed tests.

Standard errors are in parentheses. All models include unreported year and geography effects. N=1299 firm-years

Table 7. Negative Binomial Analysis of Products with Founding Team Data

	M1-M5: GEE			M6: Random Effects		M7: Fixed effects	
Variable	**Model 1**	**Model 2**	**Model 3**	**Model 4**	**Model 5**	**Model 6**	**Model 7**
Intercept	7.78	9.13	8.8	7.8	9.24	-115.78**	2.59
	(24.99)	(24.94)	(24.97)	(24.99)	(24.95)	-36.22	(19.95)
Number of VC Partners		0.03**			0.03**	0.04**	0.02**
		(0.01)			(0.01)	-0.01	(0.01)
Number of CVC Partners			0.08		0.003	0.09	0.03
			(0.08)		(0.09)	-0.1	(0.06)
Number of Government Partners				0.01	0.02	(0.07)	-0.02
				(0.14)	(0.14)	-0.14	(0.10)
Number of High-Status VC Partners	0.73***	0.70***	0.73***	0.73***	0.70***	0.39**	0.75***
	(0.15)	(0.15)	(0.15)	(0.15)	(0.15)	-0.17	(0.11)
Patents	0.10***	0.10***	0.10***	0.10***	0.10***	0.02*	0.08***
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	-0.01	(0.01)
Firm Age	0.02	0.02	0.02	0.02	0.02	(0.01)	0.02**
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	-0.02	(0.01)
Funding Amount (logged)	0.02**	0.002	0.01*	0.02**	0.001	0.00	0.00
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	-0.01	(0.01)
Founding Team Size	3.17**	3.11**	3.18**	3.17**	3.11**	1.17	2.25**
	(1.37)	(1.37)	(1.37)	(1.37)	(1.37)	-1.04	(1.02)
Founding Team Size Squared	-0.99**	-0.97**	-0.99**	-0.99**	-0.97**	(0.35)	-0.70**
	(0.44)	(0.44)	(0.44)	(0.44)	(0.44)	-0.27	(0.32)
Entrepreneurial Experience	-0.13***	-0.13***	-0.13***	-0.13***	-0.13***	(0.06)	-0.12***
	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)	-0.04	(0.03)
Managerial Experience	0.03**	0.03*	0.03**	0.03**	0.03*	0.02	0.02*
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	-0.03	(0.01)
Academic Position	0.60***	0.65***	0.61***	0.60***	0.64***	0.39	0.69***
	(0.14)	(0.15)	(0.15)	(0.15)	(0.15)	-0.33	(0.11)
MD	-0.48***	-0.47**	-0.48***	-0.48***	-0.47**	(0.20)	-0.62***
	(0.14)	(0.14)	(0.14)	(0.14)	(0.14)	-0.3	(0.12)
PhD	0.55***	0.54***	0.55***	0.55***	0.54***	0.24	0.59***
	(0.12)	(0.12)	(0.12)	(0.12)	(0.12)	-0.31	(0.10)
MBA	0.01	0.02	0.01	0.01	0.02	-0.75**	-0.12
	(0.18)	(0.18)	(0.18)	(0.18)	(0.18)	-0.38	(0.16)
Wald chi-square	197.18	203.24	197.83	197.24	203.47	61.96	374.33

* p < .10; ** p < .05; *** p < .001; two-tailed tests.

Standard errors are in parentheses. All models include unreported year and geography effects. N=1299 firm-years

Table 8. GEE Negative Binomial Difference-in-Differences Analysis for High-Status VC vs. Other VC Funded Firms

Dependent Variable	Patents		Products	
Variable	**Model 1**	**Model 2**	**Model 3**	**Model 4**
Intercept	-54.13	-76.68**	247.00***	236.41***
	(33.84)	(36.75)	(49.78)	(51.52)
High Status VC Partner		0.70**		0.07
		(0.26)		(0.31)
After Treatment		0.53**		-0.16
		(0.26)		(0.33)
High Status VC Partner x After Treatment		0.76**		0.98**
		(0.32)		(0.44)
CVC Partner	0.40*	0.22	-1.29**	-1.35**
	(0.23)	(0.25)	(0.47)	(0.46)
Government Partner	0.24	0.70	0.47	0.70
	(0.56)	(0.57)	(0.76)	(0.78)
Patents			0.14***	0.09**
			(0.03)	(0.03)
Firm Age	0.00	-0.01	-0.04	-0.04
	(0.02)	(0.02)	(0.03)	(0.03)
Funding Amount (logged)	0.04***	0.02*	0.02	0.01
	(0.01)	(0.01)	(0.02)	(0.02)
Wald chi-square	65.12	162.4	76.36	92.34

* p < .10; ** p < .05; *** p < .001; two-tailed tests.
Standard errors are in parentheses. All models include unreported year and geography effects. N=373 firm-years

Table 9. GEE Negative Binomial Difference-in-Differences Analysis for Related CVC vs. Non-Related CVC Funded Firms

Dependent Variable	Patents		Products	
Intercept	283.39***	301.99***	347.76***	342.90***
	(64.35)	(68.61)	(78.33)	(80.90)
Related CVC Partner		0.43		-0.05
		(0.32)		(0.40)
After Treatment		0.98**		-0.08
		(0.35)		(0.43)
Related CVC Partner x After Treatment		-1.00**		0.01
		(0.47)		(0.60)
VC Partner	-0.32	-0.34	-0.66	-0.65
	(0.39)	(0.40)	(0.51)	(0.52)
Government Partner	-0.25	-0.23	-2.48**	-2.48**
	(0.50)	(0.50)	(1.11)	(1.11)
Patents			0.12**	0.13**
			(0.04)	(0.04)
Firm Age	0.11***	0.08**	0.10**	0.10**
	(0.03)	(0.03)	(0.04)	(0.04)
Funding Amount (logged)	0.07**	0.07**	0.02	0.02
	(0.03)	(0.03)	(0.04)	(0.04)
Wald chi-square	63.36	65.03	37.71	37.88

* $p < .10$; ** $p < .05$; *** $p < .001$; two-tailed tests.
Standard errors are in parentheses. All models include unreported year and geography effects. N=143 firm-years

Table 10. GEE Negative Binomial Difference-in-Differences Analysis for NIH-SBIR vs. NIH-Research Funded Firms

Dependent Variable	Patents		Products	
Variable	**Model 1**	**Model 2**	**Model 3**	**Model 4**
Intercept	-58.38	-126.86	-173.72	159.03
	(79.97)	(106.31)	(141.55)	(228.30)
NIH-SBIR Partner		-0.39		1.74*
		(0.44)		(0.90)
After Treatment		-0.84*		-0.49
		(0.43)		(0.94)
NIH-SBIR Partner x After Treatment		0.56		0.97
		(0.55)		(1.04)
VC Partner	-0.2	-0.29	-1.60**	-1.31*
	(0.38)	(0.40)	(0.61)	(0.68)
CVC Partner	0.78*	0.70*	-0.09	-0.04
	(0.41)	(0.41)	(0.75)	(0.77)
Patents			0.16*	0.17*
			(0.08)	(0.09)
Firm Age	-0.02	-0.02	-0.03	0.01
	(0.04)	(0.04)	(0.07)	(0.08)
Funding Amount (logged)	0.04	0.06*	-0.01	0.00
	(0.03)	(0.03)	(0.04)	(0.05)
Wald chi-square	17.70	20.08	40.15	39.61

* p < .10; ** p < .05; *** p < .001; two-tailed tests.
Standard errors are in parentheses. All models include unreported year and geography effects. N=96 firm-years

Appendix

Founding team. Since prior work suggests that the background of the firm's founder(s) may influence innovation, especially in the medical device industry, we also examine founder effects in additional analyses for a subset of the sample for which we could obtain these data. We use ABI/Inform Global, The Leadership Library, and One Source North America Business database as our data sources. We compiled biographies for the founder(s) of each firm, and then two researchers coded them for the variables of interest. Each biography was coded with 95% concurrence, and discrepancies were resolved by recoding together. For firms with multiple founders, we use both average and aggregate values, with similar results. We collected biographical data on the founders of 123 ventures in the sample. Results for this smaller dataset are consistent with the full-sample findings (198 firms), and also reveal interesting observations about the influence of founders. We also use founding team data as additional matching criteria in difference-in-differences analyses.

Consistent with other studies (Eisenhardt and Schoonhoven, 1990; Chen et al., 2010), we collected variables related to the size, educational background, and professional experience of the founding team. We control for the *size* and *educational background* of the founding team because prior research indicates that mid-sized teams and those with higher education may be more likely to excel at innovation (Maurer and Ebers, 2006; Shane, 2000). We measure team size by the count of founders, and educational background with three dummy variables set to 1 if one or more of the founders had an *MBA, MD*, or *PhD degree,* respectively, and otherwise 0.

We control for founders' *managerial experience* expecting that experienced managers may facilitate innovation because they have learned how to do so (Beckman, Burton, and O'Reilly, 2007; Chatterji, 2009; Rothwell et al., 1974). We measure managerial experience by the count of management positions (VP level or above) that the founder(s) held previously. We control for the *entrepreneurial experience* because such experience may benefit innovation (Hsu and Ziedonis, 2013 Stuart et al., 1999) but also be detrimental if entrepreneurs reflexively apply old practices (Eesley and Roberts, 2012). We measure this experience by the number of companies started previously by the founder(s). We control for *academic experience* because scientific advances may spur innovation (Chatterji, 2009), and measure such experience by a dummy variable that is set to 1 if a founder held an academic position and 0 otherwise.

Using the variables above, we analyze the influence of the founding team in a full-sample analysis. This permits a more detailed analysis of founding team characteristics and year effects that may affect innovation beyond what we can control in the difference-in-differences analysis.

These models indicate that founding teams with MD and MBA degrees patent more, and mid-sized teams and those with prior academic background gain more product approvals than teams that lack these attributes. The results also show that founders low in entrepreneurial experience are high-performing. The finding is consistent with that of prior work (Eesley and Roberts, 2012) that suggests that when the context of entrepreneurial activity changes (e.g., innovation), accumulated experience is not necessarily helpful. Interestingly, an MD founder has a positive effect on patents but a negative effect on product approvals. Although surprising, this result is similar to recent findings on medical product firms that note MD's as significant user-innovators (Chatterji and Fabrizio, 2012; Winston-Smith and Shah 2013) but often ineffective managers of new firms (Zenios, Burns and Katila, 2013). Overall, these results add insights about the effects of founders on innovation and confirm our main findings.

Matching. In our analyses, we matched firms on geographical location, founding year and patenting: *Geographical location* – i.e., some partners (e.g. VCs) have a preference to fund firms within a driving distance while others (e.g. NIH) prefer a geographical spread. Entrepreneurs also differ in their partner preferences based on location, and in the opportunities to be funded that may depend on regional availability of funding. Because geographical location drives selection *and* innovation, as noted above, it was important to match firms located in the same geographical region.

Founding year – i.e., interviewees often talked about temporal effects that contributed to the likelihood of tie formation, such as year-to-year variations in capital. Many entrepreneurs noted how funding can be scarce and then plentiful. All partner types (VC, CVC and NIH) experienced funding fluctuations, many out of sync from each other. Because temporal effects may also influence innovation, it was important to match firms in the same founding year cohort.

Patenting – i.e., both investors and entrepreneurs noted that ties were more likely to form when the new firm had a strong patent portfolio. For example, NIH program officers said that it was in the grant applicant's best interest to patent before submitting. Similarly, interviewees said that VCs used the new firm's patenting as an investment criterion. Overall, our three matching criteria are aligned with prior work on ventures that often uses geography, founding year and patenting as the matching criteria (Hsu, 2006; Lerner, 1999; Fitza, Matusik, and Mosakowski, 2009; Wallsten, 2000).

For our difference-in-differences analysis, we created three matched samples, one for each partner type (VC, CVC, NIH). For each sample, we construct a matched 'comparison' group of new firms based on geography, founding year, and patenting, as per above. We identify a firm with a specific type of funding partner and then identify a matched firm without that partner type. Following Short and Toffel (2010), we designate the former's funding year as the "match year" for the matched group of firms, and repeat this process for all firms funded by that partner type. Our analysis includes observations three years before and after the match year.

We consider two matching methods, propensity score matching (PSM) and coarsened exact matching (CEM). First, we implement PSM which replicates a mini-randomized experiment by summarizing all covariates into one scalar (the probability of being treated), and matches treated and non-treated observations based on propensity scores (Stuart, 2010). But because our sample size is relatively small, many models did not converge. Thus, we follow Rubin's (1997) suggestion to use exact matching instead. Because prior work shows that requiring exact matches often leads to many observations not being matched and larger bias (an issue in our relatively small sample), than if the matches are more inexact but more observations remain (Rosenbaum and Rubin, 1985; Stuart, 2010), we use CEM which can be used for exact matching on broader ranges of variables such as variable categories (Iacus, King and Porro, 2012). Based on prior work (Hsu, 2006), we use a CEM procedure in which for each firm that formed a relationship with a particular funding partner (i.e. "treated firm"), we attempt to find a firm that matches exactly on each criterion ("non-treated firm"). If we cannot identify an exact match, we first relax the non-treated firm's founding year to match the year before or after that of the treated firm. If there is still no match, we relax geographical region to a nearby region, and then the number of patents to be within three and subsequently within five of the focal firm (unless the firm had no patenting, in which case we only match with other non-patenting firms). If, after relaxing these criteria, there is still no match, we drop the treated firm from the analysis and proceed to match the next treated firm. We focus on matching firms that received VC (or high-status VC) funding in the first round and other types of funding in any round. Further, we experimented with matched samples that included non-funded firms and those that did not. If firms that receive no funding are low-quality firms, excluding these firms from the "control group" would make our test more conservative. In contrast, if these firms were particularly strong firms and did not seek funding for some other reason, excluding them would bias the results. We formed the matched samples in both ways with similar results, and report the results with non-funded firms excluded.

Additional matching criteria. In sensitivity analysis, we added two criteria, i.e. founding team and technology quality to refine matching. *Founding team* – i.e., some interviewees mentioned that who the founders were influenced the likelihood of tie formation. For example, some VC partners preferred to fund entrepreneurs with prior managerial experience while an NIH program officer told us that it was important to have a "technical" expert such as a Ph.D. in the team. Similarly, a few entrepreneurs stated partner preferences tied to their career path. A first-time founder we interviewed wanted to have a more nurturing relationship and so chose to be funded by a VC partner - whereas a few entrepreneurs with more experience felt they needed less advice and sought other types of funding partners. Because founder experience may also be related to innovation, it was important to choose matching firms with similar founding teams (we matched on whether members of the founding teams had an MD, Ph.D., and managerial experience) to identify pairs of new firms that had similar chances of being funded by a particular type of partner. This criterion was used in a robustness test on a smaller subsample of matches for which founding team data were available, and our results held.

Technology quality – i.e., because the venture's patented technologies may vary in their value, and because some funding partners (such as NIH) may better foresee the future value of a particular technology, we attempted to match firms based on their citation-weighted patents (self-citations excluded) for the patents received during the first 3 years of the company (Trajtenberg, 1990). Patent citations may capture differences in the quality of the venture's technology not captured by the other matching criteria (Katila and Chen, 2008). Because technology quality can also influence product approvals, we attempted to choose matching firms with similar levels of citation-weighted patenting to identify pairs of new firms that had similar chances of being funded by a particular partner type. Because the results of this matching are similar to the original matching but sample size is reduced, we report original matching based on patents in the main analyses.