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# Do Venture Capitalists Affect Commercialization Strategies at Start-ups?

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## ABSTRACT

I empirically study the effect of venture capital (VC) on product development and commercialization strategy of start-up organizations. In doing so, I segment entrant commercialization strategies into two camps according to competitive effect: to "cooperate" is to license-out technology or be acquired, while to "compete" is to develop technology independently. Building on the work of Gans, Hsu, and Stern (2000) on the drivers of entrant commercialization strategy, this paper examines the direct and indirect effects of VC on product development and competition. I start with two important determinants of start-up commercialization strategy: (1) the entrant's relative investment cost of acquiring and controlling complementary assets needed to successfully commercialize its innovation, and (2) the entrant's ability to effectively protect its intellectual property. I then test a novel sample of 118 technology-based projects divided almost evenly between two mechanisms of entrepreneurial finance. These two mechanisms differ in institutional detail in ways that allow a quasi-experiment of the effect of VC on start-up commercialization strategy. The U.S. Small Business Innovative Research (SBIR) program provides a grant to R&D without taking equity in a start-up or changing the corporate governance of project development. In contrast, VCs take an equity stake and participate in corporate governance in exchange for capital. Neither of these financing mechanisms, however, alters the underlying complementary asset or intellectual property regime associated with the project. Two main findings about the commercialization strategy and product market effects of venture capital emerge: (1) VC-backing skews commercialization strategies across industries toward cooperating, and (2) VCs make their portfolio firms more sensitive to the business environment.



*Keywords*: innovation, commercialization, venture capital, cooperation, competition, complementary assets, intellectual property rights.

## I. Introduction

This paper examines how financing by venture capital (VC) changes the commercialization path of projects developed by its portfolio firms, a prospect that would have important market structure and business policy implications. For example, if venture-backed companies are more likely to be a source of innovative projects or products that can be acquired or accessed by established companies, incumbent firms would treat these firms differently than if venture-backed companies were likely to compete against them in the product market. To emphasize these market structure effects, we categorize entrant commercialization strategies into one of two groups: to "cooperate" or to "compete." A contractually based, cooperative strategy for the entrant involves earning returns from an innovation by licensing out its technology or participating in a merger or acquisition. A competition strategy entails an independent effort of commercializing a technology. While the former strategy may diffuse the incumbent's competitive threat from entrants, the latter can mean heightened competition in the product market for the incumbent.

In addition to the differential product market competition effects of entrant commercialization strategy, the industry incumbent might also alter its own research and development policy in response to which "type" of entrant (cooperating or competing) it faces (Gans and Stern, 2000a). The existing literature on VC has not, for the most part, studied the effect of financing modes on product-level outcomes and development and instead has focused on the role of VCs in alleviating information asymmetries (e.g., Gompers and Lerner, 1999).[1]

One difficulty of empirically studying the effect of financing mechanism on commercialization strategy is establishing an appropriate benchmark to evaluate whether the commercialization strategies that we observe by venture-backed firms is relatively more or less frequent than we might expect. To address this challenge, we assembled a novel data set of technical projects that were primarily funded by one of two financing sources—venture capital and the US Small Business Innovative Research (SBIR) program—to empirically test hypotheses about product

[1] Hellman and Puri (2000) and Gans, Hsu, and Stern (2000) are notable exceptions.

market implications of VC. Due to certain institutional features of these two means of entrepreneurial finance, (discussed briefly below and in more depth in Section II) we establish the sub-sample of SBIR-backed firms as a benchmark by which to evaluate the product market effects of venture-backed firms.

Venture capital represents an important source of organized financing for young, high-tech companies. Start-ups and young firms "pay" for this capital with equity stakes in their firm and allow venture capitalists to take active management positions in their firm. Venture capitalists are thought to aid the development of fledgling firms through both capital infusions as well as through active management, which is facilitated through a venture capitalist's network of contacts and experience in corporate governance (Gorman and Sahlman, 1989; Bygrave and Timmons, 1992).

This system of developing commercial high-tech products can be contrasted with another mechanism of financing innovation in the US. The Small Business Innovation Research (SBIR) program is a US federal government subsidy program started in 1982 for small businesses. Funds for the program are provided by various federal agencies, which must set aside a specific percentage of its federal R&D budget for the program. The SBIR program represents the single largest source of R&D for small firms in the US, with approximately $1B in grants annually since 1997 and over $7B between 1983-97. The grant is very "hands-off," with little to no federal oversight during the technology development process. In exchange for technology grants, federal agencies do not receive equity stakes in the firms.

This paper exploits the similarities and differences of these two modes of entrepreneurial finance to explore how VCs affect entrant commercialization strategy. The analysis begins by building on the insights of Teece (1986) and Gan, Hsu, and Stern (hereafter, "GHS", 2000) on technology strategy. More specifically, GHS (2000) find empirical evidence for the relationship between variation in the economic environment that start-ups face and their strategy in earning returns from their innovation. When the start-up faces a weak intellectual property regime, but can acquire complementary assets for commercialization at relatively low cost, entrants will tend to compete against established companies due to appropriation risks associated with negotiating out-sourced development of its technology. On the other hand, when the start-up faces a strong intellectual property regime, but face a high cost in controlling complementary assets, start-ups will seek a contractually-based cooperative solution wherein it licenses out its technology or participates in a merger or acquisition due to its resulting exchange position. Low transaction costs in identifying and bargaining with incumbent organizations will also make cooperation more likely.

Working from this analytic framework, the present study examines the role of VC in shaping a start-up's commercialization strategy. In particular, I address two questions: (1) do venture capitalists skew the choice of commercialization strategy for entrant firms? and (2) are venture-financed firms more sensitive to the business environment? A VC's impact on its portfolio firms' commercialization strategy may come through two means: (1) the venture capitalist's position as an information intermediary across its network of contacts may offer opportunities for cooperation that might otherwise not exist. As well, (2) the VC, through participation in a firm's board of directors, can exert a disciplinary role on inventor-entrepreneurs who may otherwise tend to compromise profit maximization for control of technology development.

A novel data set that includes a sub-sample of projects financed by the SBIR program is matched with projects financed by venture capital. By exploiting key institutional features of these two programs, we run a quasi-experiment that isolates the incremental impact of venture capitalists on project commercialization strategy. Because projects funded by the SBIR program face the same underlying complementary asset and intellectual property (IP) regime as projects funded by venture capitalists, the underlying forces that shape an entrant's commercialization strategy remain unaltered. In addition, because the SBIR program provides a subsidy to R&D without taking an equity stake in the organization, corporate governance and commercialization strategy in SBIR-backed organizations are as they were before the subsidy. In contrast, venture capitalists routinely take at least one seat on the board of directors of the organization it backs. Because venture financing changes the corporate governance of project development in the organization, while SBIR funding entails no such change, we can effectively isolate the effect of venture capital on project commercialization strategy.

The proposition that venture-backed firms are skewed toward a cooperative strategy is confirmed in the empirical evidence, with venture-backing making cooperation more likely. This result challenges conventional wisdom that VC as a financing institution will usher in a wave of product market competition against incumbents. For example, consider the following quote by Chesbrough (1998, p. 19): “When such venture capital is readily available, it allows new firms to enter the industry, by making high risk/high reward positions available for talented managers and engineers...Correspondingly, when there is relatively little external capital available for new venture formation, incumbent firms are not confronted with the prospect of losing people or customers to new start-up competitors."

A second, though weaker, result is that VCs seem to make their portfolio companies more sensitive to the business environment, exacerbating the effect of a given regime of appropriability and complementary assets on the likelihood of cooperation. This finding is consistent with the notion that VCs play an important role in bringing strategically important external information to the start-up.

By matching SBIR and VC projects on key observable characteristics and confining the sampled projects to five high-tech sectors to control for technological opportunity, we set up a quasi-experiment to isolate the effect of VC on commercialization strategy. There are, however, two prominent alternative explanations for the results: First, there may be a process of unobserved selection such that VCs are selecting “good” ventures relative to the SBIR sample. However, it is unlikely that VCs are selecting ventures based on commercialization strategy (I present statistical evidence on VC interaction effects with determinants of commercialization strategy in the empirical results). Even if VCs did select ventures based on strategy, however, conventional wisdom suggests that the bias would go the other way, that VCs attempt to select projects that are more likely to result in a competitor company through an initial public offering (*Venture Economics*, 1988).

The second alternative explanation for the results is that VC-backed firms are of fundamentally higher quality than SBIR-backed firms. In order for this explanation to be convincing, however, there must be some reason to believe that higher quality ventures are more likely to adopt a cooperative commercialization strategy. There is no *prima facie* reason to believe this; as well, the set of sampled SBIR firms had all successfully commercialized a product. Therefore this sample consists of a reasonable comparison to VC-backed firms relative to a sample of, say, self-financed firms.

The rest of the paper is organized as follows: Section II describes important institutional differences and similarities between venture and SBIR financing of technology projects as a prelude to the empirical methodology used in this paper. Sections III and IV develop hypotheses on how VCs impact the commercialization strategy of start-ups. Section IV describes the methodology and data of this study, and Section V presents the empirical results. Section VI concludes.

## II. Two Methods of Entrepreneurial Finance

In contrast to two previous studies which have primarily been concerned with evaluating the SBIR as a public program, (Lerner, 1999; Wallsten 1998), my purpose is to use SBIR-backed projects as a benchmark by which to evaluate the incremental effect of the *non-financing* role of venture capitalists. Instead of focusing on the role of these financing institutions in allocating entrepreneurial finance *per se*, I focus instead on their structural differences in assisting entrepreneurs develop their enterprise. As such, this section proceeds in three stages. Part one surveys the literature on the role of venture capitalists in financing and developing projects. Part two describes the important institutional features of the SBIR program as a means of financing technology-based projects. Finally, part three argues that the important institutional similarities and differences of these two financing mechanisms can be exploited in a powerful quasi-experiment to empirically isolate the role of venture capitalists in commercialization strategies of start-ups.

A. *What do Venture Capitalists Do?*

*Background.* Venture capitalists raise capital for their funds from both institutions (including pension funds, insurance companies, and universities) and highly-capitalized individuals.[2] These funds, which are invested in start-ups in exchange for equity in ventures, are typically liquidated after seven to ten years (though up to a three year extension can be granted).[3] VCs therefore use this time horizon when evaluating investment opportunities.

In an industry survey, Gorman and Sahlman (1989) found that VCs spend a considerable amount of their time and resources actively monitoring their investments. For example, lead VC firms make an average of 19 site visits per year to the firms they finance and spend 100 hours per year in direct contact with the company. Despite this active monitoring, the success rate of VC investments is far from perfect. One study (Venture Economics, 1988) found that 34.5% of a sample of VC investments between 1969-85 resulted in partial or complete losses while 6.8% of the investments returned over ten times the initial capital.

Much of the VC literature has emphasized the oversight role of VCs in new venture development (Gomper and Lerner, 1999). This paper, while acknowledging that the VC monitoring role is important, puts forth two additional roles that VC's play in helping their portfolio firms succeed. First, VCs may constrain the behavior of inventor-entrepreneurs and focus them on product development for commercialization success (Roberts, 1991). In addition, venture capitalists actively network with individuals and firms external to the portfolio firm, and help their ventures access the labor and capital markets (Hellman and Puri, 1999; Bygrave and Timmons, 1992). Moreover, these latter two roles are linked: as a result of being in a position as an information intermediary, VCs are able to guide entrepreneurs on product development and commercialization strategy, particularly as a result of participating in the firm's corporate governance. Each of the three functions and roles of VCs is discussed in turn.

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[2] Capital inflows to- and investments made by- the venture capital industry have grown quickly, with $36.5B in investments to start-up companies in 1999, a figure that eclipses aggregate venture investments into start-ups for the previous three years (VentureOne web site, www.v1.com). There is a great deal of cyclicality in the inflows to the industry, however (Gompers and Lerner, 1999).

[3] For a discussion of the legal structure of the limited partnership form of venture capital organization, the most frequent form for venture capitalists, see Sahlman (1990), pp. 489-90.

*Information Asymmetries*. An entrepreneur may have the incentive to misrepresent his technology's probability of success in the case of exchanging an equity stake for capital. In addition, entrepreneurs typically cannot offer collateral, as their assets are knowledge-based and intangible. Providers of private capital realize these potential agency problems, and demand a risk premium for their capital (Jensen and Meckling, 1976).

Because entrepreneurs typically have better information about the likelihood of success of their project than the venture capitalist, a potential adverse selection problem exists. Indeed, Amit *et al.* (1997) argue that venture capitalists exist precisely because they develop specialized skills to select and monitor entrepreneurial projects which reduce information-based market failures. Researchers have identified two mechanisms by which venture capitalists cope with information asymmetries: syndication of investments (Lerner, 1994) and disbursing funding in stages, which depend on VC evaluation prior to each new round of investment (Gompers, 1995). More generally, financial contracts between VCs and entrepreneurs include multiple covenants aimed at addressing incentive and information asymmetry problems (Sahlman, 1990; Kaplan and Strömberg, 2000).

*Focusing on Product Development.* A much less developed branch of the empirical literature on the role of venture capitalists is focusing entrepreneurs on product development and curtailing the tendencies of inventor-entrepreneurs to "excessively" control product development and commercialization strategy. Empire builders are entrepreneurs who would rather retain corporate control over the commercialization process of their technology, even if it meant (*ex-post*) less profits. Under this view, a key role of venture capitalists is to make the start-up organization more sensitive to the business environment and to guide the entrepreneur away from his empire-building tendencies to control development of the technology at the cost of commercial success. Roberts (1991, p. 146) has described the phenomenon: "Some entrepreneurs want little or no equity financing at the outset because they wish to retain a maximum amount of ownership and control." This is sometimes coupled with what Roberts (1991, p. 328) describes as "founder's disease," the inability of founding CEOs to grow in managerial and leadership capacity as rapidly as the firm's size. Few studies have empirically examined the role of venture capitalists in counteracting entrepreneurial control and founder's disease.

One such study is by Lerner (1995). He looked for evidence on the responsiveness of VCs in their role as board members in their portfolio companies when there was a greater need for corporate oversight. He found that an average of 1.75 venture capitalists were added to the board between financing rounds when the firm's CEO was replaced in the interval, whereas between other rounds, only 0.24 venture directors were added. This finding seems to establish the sensitivity of efforts placed toward monitoring as a function of when it is most needed. Lerner does not, however, directly relate the oversight role of venture capitalists to the product development process or to organizational commercialization strategy. Hellman and Puri (1999) come closer. They find that VCs are more likely to bring outsiders into the position of CEO when the firm is in a "bad" state (when the firm is not public and it has no products on the market). Otherwise, Hellman and Puri find that VCs help shape human resource policies and encourage their portfolio firms to use professional recruiting agencies to hire key personnel.

*Venture Capitalists as Information Intermediaries*. Researchers in both financial economics (Megginson and Weiss, 1991) and organizational sociology (Stuart, *et al.*, 1999) have emphasized the "certification" role that venture capitalist's play in informing investment bankers of the underlying quality of their portfolio firms. In the latter study, the researchers find that the more uncertain is a technology, the more outside evaluators such as investment banks rely on the status of the firm's affiliates, such as venture capitalists, to infer quality. VCs may also have a more direct role in the information intermediation process by identifying and facilitating cooperative product market opportunities (Burt, 1992; Aoki, 1998; GHS, 2000). Indeed, Kleiner Perkins, a leading venture capital firm boasts on its web site that it has facilitated over 100 alliances among its portfolio firms.

The venture capital literature has emphasized the monitoring role of venture capitalists as it relates to tackling information asymmetries rather than the role of venture capitalists as overseers of entrepreneurial empire building who can change the commercialization path of a technology. As well, the empirical literature on how venture capitalists, through information-intermediation, may affect product market outcomes is limited. These gaps in the literature motivate the research questions in this paper.

B. *The Small Business Innovative Research (SBIR) Program*

*Background*. The SBIR program is administered through the Small Business Association (SBA), and American-owned, independent firms with 500 or fewer employees are eligible. Proposals are peer-reviewed, and funds are awarded competitively.[4] The SBIR program is a very "hands-off" R&D program in that the federal government neither takes an equity stake in exchange for the grant nor receives any control rights over technology development.

A USGAO (1995) report summarizes the three-fold legislative goals of the SBIR program: (a) to increase the rate of commercialization of innovations derived from Federal research, (b) to enhance the "competitiveness" of small firms in technology-intensive industries; and (c) to enhance the participation of small firms as well as women and minority-owned businesses in the Federal contracting process.[5]

The selection mechanism for SBIR has traditionally been on technical merit, though commercialization potential is increasingly becoming an important selection criteria (USGAO, 1995). Companies seem to participate in the SBIR program for a multitude of reasons, ranging from straightforwardly seeking a subsidy to internal R&D expenditure to validating a project for internal political reasons.[6] In addition, SBIR recipients can receive multiple grants for related areas of R&D.

C. *Exploiting Differences in these Financing Mechanisms*

By examining technical projects that have been funded primarily by VC on the one hand, and primarily by the SBIR program on the other, we expect to isolate the effect of key sources of

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[4] There are two rounds of potential awards. The maximum phase I award, earmarked for proof of concept and idea development, is $100,000. For the period 1991-93, for all 11 participating federal agencies, the average ratio of funded Phase I proposals to proposals received was 13.3% (USGAO, 1995). Phase II awards are capped at $750,000 and is a grant for developing a technology and exploring its commercial potential. Only those firms with a Phase I award are considered for a Phase II award.

[5] Economically, public subsidies for technology development in small firms may be justified for several reasons. First, R&D by small, innovative firms is believed to generate positive knowledge spillovers (Jaffe, 1986). Left on their own, these firms would likely under-invest relative to the socially optimal level due to their inability to appropriate the full value of their invention (Arrow, 1962).

[6] I reached this conclusion as a result of field-based interviews with approximately 25 executives at SBIR firms during the pilot phase of this research project.

variation on the commercialization strategy of the start-up organization. The source of project finance is independent of two important drivers of commercialization strategy: the ability of entrants to exclude others from exploiting the entrant's technology for commercial gain and the feasibility of start-ups to acquire and control the necessary complementary assets for commercial success (GHS, 2000). At the same time, the financing mechanisms *do* vary in the corporate governance of project development and in ownership stakes in the firm. The purpose of this sub-section is to explore the comparability of VC- and SBIR-backed projects.

Venture capitalists select the firms they wish to fund by reviewing business plans, which consider both the technical and commercial merits of an idea; meanwhile, SBIR program administrators select projects based on a peer-review process. These peers, however, are not necessarily experts in commercializing technology—they are typically technologists or academics evaluating the technical merits of a project proposal and whether the proposal matches the government agency's Request for Proposals (RFPs). Despite this difference in selection mechanism, VC-backed enterprises have not necessarily been more successful commercially. For example, Lerner (1999) provides empirical evidence that SBIR firms performed better commercially than matched VC-backed firms if the SBIR organization was located in a zip code that had high levels of early-stage venture capital activity. He interprets this result as indicative that SBIR awards play an important role in certifying firm quality to the private investment community for future rounds of financing.

A second important difference between the financing mechanisms is the industrial representation of their investments. Venture capitalists tend to concentrate their investments in a much narrower range of technical projects—particularly in the communications and information technology sectors—relative to the SBIR program.[7] While the SBIR program finances a wider distribution of R&D projects, there is empirical evidence that the selection mechanism favors funding infra-marginal rather than marginal projects (Wallsten, 1998; Gans and Stern, 1999). This bias in SBIR project selection would tend to narrow any gap in the quality of projects funded between the SBIR program and venture capitalists. In addition, as further discussed in the methodology

[7] For venture capital statistics on investments by industrial area, see the Pricewaterhouse-Coopers "Money Tree" web site: http://204.198.129.80/index.asp (accessed 6/15/00). In addition, Gans and Stern (1999) construct Gini coefficients showing that VC investments are skew relative to private R&D expenditures.

section of this paper, in compiling my sample, I selected projects from five high-tech industrial segments that have drawn interest from both venture capitalists and SBIR program administrators in an effort to mitigate the importance of these technological opportunity selection effects.

Despite these differences in selecting projects between the two financing mechanisms, there are many similarities in the inputs to- and characteristics of- the SBIR and VC financed projects. First, the selectivity of projects from a numerical standpoint is similar: about 1% of business plans proposed to venture capitalists gets funded—versus approximately 5% for Phase II SBIR grants. In addition to the approximate age similarities between successful VC- and SBIR-funded projects, the levels of funding for successful VC and SBIR recipients have not been that different historically (Lerner, 1999). Through 1995, the average VC investment in a firm was approximately $2M (Gompers, 1995). Meanwhile, because successful SBIR recipients typically receive multiple Phase II awards for technology development, the average project gets funded at roughly the same level.

In sum, the comparability of the SBIR program as a different, but similar mode of entrepreneurial finance than venture capital provides a natural setting in which to study the incremental effect of venture capital on product development and commercialization strategy.

## III. What Determines the Optimal Commercialization Strategy for Start-ups?

This section introduces a contingency framework for entrant commercialization strategy. While GHS (2000) present a theory-to-evidence study of this phenomenon, that paper is not focused on the role of VC on project management. Their framework is an important prelude to this study, however, as venture capitalists operate in an environment in which the dynamics of competition between entrants and incumbents will importantly shape the realm of possible exit strategies for their investments. This section therefore reviews the drivers of start-up strategy proposed by GHS (2000) and Gans and Stern (2000b).

A. *Introduction*

Researchers have noted the productivity of small, entrepreneurial firms in generating ideas and technical advances that become the basis for valuable innovations (Acs and Audretsch, 1988). Despite their innovativeness, these firms are not always the ones profiting from their technological inventions, largely due to their inability to control complementary assets and prevent others from expropriating the value of their inventions (Teece, 1986). In this Teecean framework, established firms are better able relative to small firms to commercialize technologies because of their control over important complementary assets.

Another stream of research has emphasized a contractually-based "ideas market" mechanism by which the entrepreneurial organization can appropriate the value of its invention by bargaining with established companies to transfer control over the development of its technology (Salant, 1984; Anton and Yao, 1994; Gans and Stern, 2000a). This position stands in contrast with the classical mechanism of Schumpeterian competition in which the market power of incumbent monopolists is destroyed through a "perennial gale of creative destruction" by entrepreneurial organizations (Schumpeter, 1942).

Clearly, an ideas market is not always enabled, however; otherwise entrants would uniformly earn returns from their invention by selling control of their technology to established firms. Doing so would avoid duplication of research effort and allow a division of labor by which entrants invent and incumbents commercialize.

B. *Commercialization Strategy: Competitors vs. Cooperators*

In order to capture and study the implications of stylized start-up commercialization strategies, I partition them into two camps. I term an entrant a "competitor" if it has decided to remain independent in its commercialization strategy, deciding not to merge with another company and not licensing out its technology for potential development by another firm. Entrants not taking a competitor strategy are "cooperators." This is a useful partitioning of the world from a product market point of view since it separates strategies which reinforce market power of entrenched firms (cooperator) from those that destroy market power (competitor).[8]

The impact of a merger or acquisition of a small firm on product market competition is clear: ownership and control rights to the technology are transferred to the acquiring firm. The competitive implications of out-licensed technologies are less clear. While firms sometimes license out their technology patents only for specific applications, the licensor does not necessarily retain control rights over the subsequent product—and in this sense reinforces market power of the entrenched firm. Having mapped some business policy decisions onto product market competition space, I now delve into more details about the determinants of commercialization strategy.

C. *Dual Drivers of Commercialization Strategy*

*Appropriability Regime*. The first dimension of the framework is an appropriability regime, which "refers to the environmental factors, excluding firm and market structure, that govern an innovator's ability to capture the profits generated by an innovation" (Teece, 1986, p. 287). This dimension is an important determinant of entrant commercialization strategy because the decision to negotiate with established firms to commercialize an innovation would depend on capturing the economic value of its innovation. This proposition is illustrated by Arrow's (1962) "disclosure effect" dilemma: if an entrepreneur tries to sell rights to his innovation, a potential buyer does not know how to value it. However, if the entrepreneur discloses the idea to the buyer, the buyer may no longer be interested in paying for the idea since he now knows it. Such appropriability problems are particularly acute when the intellectual property regime is weak. When the disclosure effect is particularly strong, organizations will have a difficult time contracting out their technologies for development.

[8] While engaging in strategic alliances also "softens" product competition, the competitive implications of engaging in a strategic alliance on the one hand, and licensing out a technology or being acquired on the other, are distinct. By engaging in a strategic alliance, a start-up organization does not necessarily lose control over the development of its technology. Even in the case of a joint venture, a third party is established in which each alliance partner retains some control over the resulting entity. A secondary motivation for treating alliances differently is because very few small organizations are able to remain entirely independent in its operations—and adopting the more expansive definition of "competitor" would render the distinction meaningless.

*Importance of Complementary Assets.* The second determinant of commercialization strategy is the entrant's relative investment costs of acquiring or controlling complementary assets, which have been defined as "those assets and capabilities that need to be employed to package new technology so that it is valuable to the end user" (Jorde and Teece, 1990, p. 83). Such complementary assets may be "generic" if they are not tailored to the innovation at hand. They may be "specialized" if there is unilateral dependence between the innovation and the complementary asset, or they may be "co-specialized" if there is a bilateral dependence (Teece, 1986). Presumably, the more "specific" is the asset to the particular innovation, the higher is the cost in attaining the asset due to the problem of hold-up. In addition, depending on the industry and the nature of the innovation, entrants will face different costs in acquiring and/or controlling the set of complementary assets needed to successfully commercialize their innovation.

Teece identified a set of four important complementary assets—manufacturing, distribution channels, brand development, and servicing resources—control over which may be important across industrial sectors in profiting from technological innovation.

Control over manufacturing is likely to be differentially important across industries as a result of heterogeneity in economic and sociological forces in the industries. The cost of internal development of the product, the number of competing manufacturers that could produce the product, and the expected duration of the relationship between the start-up and the manufacturer are all important factors governing internalization of the manufacturing process for the entrant (Tripsas, 1997).

A second key complementary asset for young companies is a distribution channel for their products. Again, the importance of control over distribution depends on the industry. In the medical device industry, for example, corporate relationships with hospital administrators and doctors, often accomplished through personal relations between the sales force of a company and the health care actor, are essential for selling a product to the end user (Mitchell, 1989). Because assembling a dedicated sales force is very costly for entering medical device companies, the bargaining power of established and start-up firms in this industry is affected accordingly. At the other end of the spectrum are industries in which (commodity-like) products are sold through competitive distribution networks.

A third complementary asset is developing a brand name through investing in marketing or advertising (Teece, 1986). Developing brand recognition is more important in some industries than in others for earning returns from innovation. For new entrants in the application-specific integrated circuit industry, for example, associating products with reputable companies (e.g., IBM) and advertising the association is important in earning returns.

A final complementary asset is servicing resources for the product (Mitchell, 1989; Tripsas, 1997). In some industries such as computer hardware, which requires periodic servicing, control over maintenance and computer help lines may be important in persuading customers to purchase the product, while in other industries such as biotechnology, such servicing may not be at all important in earning returns from the project.

*Interaction of Complementary Assets with Appropriability Regime*. The interaction of complementary assets with the ability of entrants from excluding others from exploiting its technology can also be important (Tripsas, 1997). For example, because source code in the software industry can effectively be encrypted and transferred to a manufacturer to burn CD-ROMs, pre-packaged software companies do not have to have direct control over this production process (through internalization). More generally, such an interaction exists because the ability of innovators to prevent imitation of its technology enables it to build or acquire complementary assets needed to successfully commercialize the technology (Teece, 1986).

C. *Characterizing Start-up Environments*

These two drivers of commercialization strategy suggest that start-ups in different industries face different environments in interacting with established firms. When innovating entrants face a weak intellectual property regime while the cost of acquiring complementary assets is relatively low, strong disclosure effects will prevent the ideas market from developing, and so entering firms will be competitors with established companies (Gans and Stern, 2000a; GHS, 2000).

On the other hand, when innovating entrants enjoy a strong IP regime but face relatively high investment costs in controlling complementary assets, entrants tend to earn its returns from innovation through accessing the ideas market and seeking a cooperative solution (GHS, 2000).

INSERT FIGURE 1

These propositions are summarized in Figure 1. Empirical work characterizing the off-diagonal boxes of the matrix in which start-ups face "mixed" environments remains as an interesting area of future research. For example, Gawer (2000) begins to address some of the issues in the upper right hand box in the case of Intel's interaction with complementary, innovative up-starts. Based on this section, we are now ready to begin our point of departure from start-up commercialization strategy in general to the effect of VC on this process.

## IV. How Do Venture Capitalists Affect Commercialization Patterns?

### A. *VC Effects on Selection of Commercialization Strategy*

Using the contingency matrix introduced in the previous section as a baseline, what effect does financial backing by venture capitalists (and its attendant transfer of some degree of corporate control to the VCs) have on the commercialization strategy of the start-up organization? This section develops two hypotheses on whether venture capitalists "skew" their portfolio firms' commercialization strategy in one direction, and if so, whether they make their portfolio companies more "sensitive" to the external business environment. The answer to these questions will shed light on the economic effects of venture capitalists on the structure of competition in high-tech markets.

Because most modern VCs are organized as limited partnerships, they typically try to exit their investments in no longer than seven to ten years after initial investment. Venture capitalists have four main ways of exiting their investments: liquidating the portfolio company (not placing additional capital into the organization), selling equity back to the entrepreneur or managers and employees of the portfolio organization, merging the company with another firm, or taking the organization to the public markets through an initial public offering (IPO).

Conventional wisdom holds that venture capitalists' most preferred exit strategy is to take a firm public. According to a Venture Economics study (1988), this strategy pays $1.95 in excess of each dollar invested (with a mean holding period of 4.2 years). The payoff from taking a firm public is far more than the $0.40 return per dollar from the next best option, having the independent firm acquired over a 3.7 year average holding period. While VCs have the incentive to select ideas that they believe have the highest likelihood of becoming the basis for stand-alone firms, this incentive may be tempered for two reasons. First, VCs face a time constraint on investment payback, which is imposed by the limited partnership form of organization. In addition, there may inherently be a limited number of technological opportunities that can form the basis of new, public companies.

In part, the ability of VCs to take their portfolio companies public depends on the strength of the IPO market, which depends more on the macroeconomic conditions of the economy than on the economic fundamentals of a start-up company (Gompers and Lerner, 1999). Regardless of the macroeconomic environment, however, researchers are beginning to recognize the importance of cooperative VC exit strategies for their start-ups (Aoki, 1998).

Aside from the direct VC control aspects of exiting their portfolio investments, VCs may also act as information intermediaries through participating on multiple boards of directors. While no direct evidence on this phenomenon has been documented for venture-backed companies, the interlocking directorates literature has emphasized the importance of this mechanism for information flows (Davis, 1991). Indeed, venture capitalists may be uniquely positioned to facilitate cooperative exit strategies as they fill nodes of an information network that contains potentially complementary technological opportunities (Burt, 1992). A venture capitalist's network of contacts, both through its own portfolio companies and through its relations with the capital and labor markets (Hellman and Puri, 1999), may thus reveal and facilitate opportunities for cooperative arrangements for the start-up. I therefore hypothesize:

*H1: Start-up organizations financed by venture capital, regardless of industrial segment, are more likely to take a "cooperator" strategy in commercializing their technologies.*

B. *VC-mediated Sensitivity to the Environment*

A stylized fact about some entrepreneurs is their penchant to retain as much ownership and control over their technology as possible, even when the founder-CEO is unable to effectively manage the enterprise (Roberts, 1991). Informal evidence suggests that venture capitalists are able to exert disciplinary control over the young venture by helping the company monitor its business environment while simultaneously participating in the firm's corporate governance (Bygrave and Timmons, 1992). Managerial control by the board of directors is not necessarily confined to replacing the chief executive of the organization. Such control can also take the form of changing the commercialization path of a technology through the choice of whether to license-out a technology or to entertain an acquisition bid, for example.

The previous section described two key elements of the business environment, the complementary asset and intellectual property regime. Because venture capitalists are active in a range of activities and functions that cut across industrial segments, they are more likely than internal directors of the company to be aware of threats and opportunities in the business environment. Indeed, because business environment differ by industry, or even by project, the external knowledge that VCs bring in guiding corporate strategy may importantly shape how the start-up firm decides to earn returns from its innovation. The mechanism by which this is accomplished is a combination of exterting control over entrepreneurial "founder effects" through corporate governance, and solid knowledge of the external business environment.

Consequently, I hypothesize that venture capitalists exert disciplinary control on their portfolio companies by making them more responsive to their business environment:

*H2: Venture capitalists "boost" the sensitivity of start-ups to their business environment, thereby reinforcing the drivers of cooperation and competition strategies proposed in Figure 1.*

## IV. Methodology and Data

### A. *Methodology*

By sampling a population of projects funded by the SBIR program and pairing this sample based on key observable characteristics—four-digit SIC code and approximate sales level—with a sample funded by venture capitalists, I create a pool of high-tech projects with varying sources of project finance. Using SBIR-backed projects as a benchmark, this matching method permits a quasi-experiment in studying the effect of financing by venture capitalists on commercialization strategy, thereby providing a powerful way to test *H1* and *H2*.[9]

Because projects funded by the SBIR program face the same underlying complementary asset and IP regime as projects funded by venture capitalists, the underlying forces that shape an entrant's commercialization strategy remain unaltered. Yet, because venture financing changes the corporate governance of project development in the organization, while SBIR funding entails no such change, I can effectively isolate the effect of venture capital on project commercialization strategy. Matching projects in this way, while an imperfect method, aims to address a gap in the strategy and venture capital literatures by using sources of exogenous variation in a natural setting to run a quasi-experiment.

### B. *Data*

Data to empirically test propositions about the relationship between financial backing of technical projects and commercialization strategies and product market outcomes was collected in a two part effort: I first collected information through a survey instrument on SBIR-backed companies. Following Lerner (1999), I subsequently assembled and surveyed a sample of VC-funded companies, matched to the SBIR sample, based on four-digit industrial code and approximate sales level.

*Assembling the SBIR Data*. In a survey of SBIR-backed companies conducted between January to March 1999, I collected detailed firm and project level data for 100 projects from 99 organizations whose technical development was funded in large part through the SBIR program.

[9] This method builds in natural controls, thereby under-sampling high-flying venture-backed firms, for example.

To be included in the sample, firms had to have a commercial product available on the marketplace. While this requirement might have been a constraint on the whole population of SBIR-backed companies, this constraint was usually not binding for the firms surveyed here since I drew from a list of the most successful SBIR recipients.[10] I imposed this condition because I am interested in relating financing mode to commercialization strategies. In the case that an organization had more than one commercial product, I asked the respondent to select the most important project from a revenue standpoint. Firms were selected from a publicly available list (posted on the SBA web site) of top SBIR winners.

On the firm level, I collected background information on the organization's employees and promotion policies; financial information about corporate ownership, expenditures and revenues; and corporate governance issues. On the project level, each company was asked to provide information on the commercialization and financing history of the technology project, including revenues through sales and licensing of the technology, the importance of the technology in achieving various goals of the firm, key personnel involved in setting the commercialization strategy of the company, and information about the commercialization strategy itself. Table 1 describes and defines the relevant variables used in the empirical analysis.

To measure the ability of the start-up organization in excluding others from exploiting its technology (the appropriability regime), I asked executives to rate—on a five point Likert scale—the importance of each of the following in deterring imitation of the firm's project: trade secrecy, patent or copyright protection, and patent or copyright litigation (or the threat of such litigation). For example, when managers rated the importance of trade secrecy as high on the Likert scale, I interpret this as suggesting a weak IP environment. The reasoning behind this interpretation is that projects that rely on secrecy to avoid expropriation of the commercial value of the underlying invention are vulnerable. As a more objective measure of the IP regime, PATENT THRESHOLD is an indicator variable which takes the value of 1 if the project has been awarded at least one patent, a condition that 65% of the projects fulfill.

[10] Selecting SBIR projects this way is also likely to diminish concerns of "quality" differentials with the VC-backed sample.

To measure the importance of complementary assets, I asked executives from our sample companies to rate, also on a five point Likert scale, the importance of control over each of the following in earning returns from their technology-based innovation: manufacturing, distribution channels, brand development, and servicing resources. I use this set of questions as a measure of whether it is feasible for entrants to acquire or control complementary assets necessary to exploit their invention, reasoning that executives would rate each complementary asset high if he or she believed the asset was attainable at reasonable cost.

In the empirical analysis, in addition to using the measure CA DISTRIBUTION LIKERT, I use CA MAX LIKERT, the maximum Likert score over a set of complementary assets necessary to commercialize a given innovation, as an indication of whether control over *any* of the assets were important for earning returns from the technology-based project.

*Assembling the Venture-backed Sample.* Following Lerner (1999), I assembled a matched set of firms receiving venture capital financing (but not SBIR funding) using four digit SIC codes and approximate sales. Companies were matched using a two-step procedure. First, I searched the *Venture Economics* database (through Security Data Corporation's Platinum Database) for candidate venture-backed companies whose primary line of business matched the four-digit SIC codes for the sample of SBIR-backed companies. I eliminated those companies that received SBIR funding (based on a database publicly available through the SBA web site). Finally, I consulted the *Corptech Directory of Technology Companies* (1998) to select only those firms within the four-digit SIC code that approximately matched the sales revenue of the SBIR sample, and surveyed the closest-matched firms. This was done in June and July of 1999. Whenever possible, I used publicly available databases to confirm information from the survey responders. For example, I verified the number of patents assigned to each organization through both the US Patent and Trademark Office's web site and the IBM patent database.

The overall response rate to the survey was approximately 50%. Firms contacted but not responding seemed to be randomly mixed between firms not having a commercial product and those too busy or not willing to respond. Within the organization, the respondent was typically one of the following individuals: the director of R&D, the director of sales or marketing, or the CEO. Most of the surveys (approximately 75%) were filled out over the telephone, with the balance either faxed or mailed back.

While the SBIR sample of companies includes representatives from nine two digit SIC codes, we eventually used 86 of these SBIR companies across five high-tech industrial segments. This results from the fact that the SBIR funds a much broader array of technological opportunities relative to venture capital. The sample includes 55 VC-backed projects and 86 SBIR-backed projects, for a total of 141 projects whose primary focus is in one of five SIC codes. Two sectors are drawn from projects at the four digit SIC level: biotechnology and pre-packaged computer software. In addition, three sectors are drawn from projects at the two digit SIC level: industrial machinery & equipment, electronic & electrical equipment, and instruments (including medical devices).[11] Because 23 observations are missing information on complementary asset ratings, the final sample consists of 118 observations.

C. *Summary Statistics*

While Table 1 defines and describes variables, Table 2 presents summary statistics of the sample, presented as a whole and divided into the VC and SBIR sub-samples. VC companies were disproportionately cooperators (44%) relative to SBIR firms (25%). Capital inflows to the projects seemed to differ by financing mode, with $2.3M for the average SBIR project and $16.7M for the average VC-backed project, though measurement error probably plagues these statistics.[12] Finally, the number of patents also seemed to differ between the two sub-samples: 8.7 awards on average for VCs and 4.9 awards for SBIRs.

Table 3 presents summary statistics for the sample based on two-digit SIC code and mode of commercialization strategy (either cooperating or competing). Notice that projects backed by VCs have (much) higher correlations with a cooperation commercialization strategy, a pattern

[11] Analysis of a similar data set of 55 SBIR-backed firms matched with 55 comparable VC-backed firms yield qualitatively the same results as those presented in this paper.

[12] Measurement error in these data are considerable, however, as we relied on SBA lists of SBIR awards and the Venture Economics database to supplement missing data on the financial history of project development from our survey. The SBA lists underestimate capital inflows into project development, as private sources of capital are not taken into account.

which holds for four of the five industrial segments. For example, for the two-digit SIC sector, electronic equipment, 67 percent of the cooperating projects were VC-backed, while only 37 percent of the competing projects were VC-backed. Similarly, for the four-digit SIC code for biotechnology, 60 percent of the cooperating projects were financed by VC, while only a quarter of the competing projects were VC-financed. While these summary statistics are suggestive, they do not reflect any statistical control, an issue I now take up.

## V. Empirical Results

### A. *Venture Capital and Commercialization Strategy*

Table 4 shows the result of basic VC probit regressions of the likelihood of taking a cooperator commercialization strategy. The positive and significant coefficient on VC is preserved in a regression that provides no controls (4-1) to a regression controlling for industry effects (4-2), in which the excluded industry is INDUSTRIAL PRODUCTS. The basic VC result persists in (4-3), which controls for industry, firm-level, and project-level effects. BASELINE EMPLOYEES and PROJECT INFLOWS are meant to capture initial project resources, while the CEO FOUNDER variable is a measure of potential "founder" effects, which may affect the commercialization path of a given technology. While the set of regressions presented in Table 4 begin to support the hypothesis that venture capitalists skew the commercialization choices of start-ups in their portfolio across industrial segments, my main results are presented in Table 5.

Table 5 shows the core effects of VC, the IP regime, and the relative cost for the entrant in controlling the necessary complementary assets to effectively compete against incumbents. How does mode of project financing (and its accompanying effects on corporate governance and accessing a network of information regarding cooperation partners) affect commercialization patterns of the start-up organization, given the Gans and Stern (2000b) framework on start-up commercialization strategy? First, note the persistent VC effect across these regressions while controlling for the dual commercialization drivers presented in Section III. Moreover, the magnitude and economic importance of the VC effect is substantial. Using equation (5-1), at the mean values of the independent variables, the predicted probability of cooperation as a commercialization strategy for venture-backed companies is 44.2 percent, while the corresponding likelihood for non-venture financed firms is only 22.9 percent, a difference of almost 100 percent difference in the likelihood of cooperation.

Table 5 also shows that the coefficient on CA MAX LIKERT is negative and significant, suggesting that as entrepreneurs face lower costs in acquiring and/or controlling necessary complementary assets to compete against incumbents, they will choose to compete against them. This result is robust to industry effects (5-2 through 5-5) and project-level effects (5-5). In addition, the result is robust to an alternate measure of the cost of controlling complementary assets, CA DISTRIBUTION LIKERT, a result demonstrated in Table 6. While more objective measures of the costs of controlling complementary assets facing entrants in different industrial segments would be preferable, establishing comparability of cost data for these assets in a range of industries is a formidable task. As far as I know, more objective complementary asset cost measures comparable across industries have not yet been developed. Therefore the Likert measures presented here represent a second-best solution of measuring executives' beliefs about the relative costs of acquiring complementary assets.

The second main driver of commercialization strategy, the intellectual property regime, is also affirmed in the data. The estimates indicate that the stronger is the IP regime that the entrant faces, the more likely is the start-up to cooperate with established companies in the course of commercializing its technology. On its face, this result seems paradoxical, but as Gans and Stern (2000b) and GHS (2000) elaborate, cooperative behavior is *facilitated* as a result of a strong IP regime because the entrant can enter into negotiations with the incumbent over technology transfer without fear of expropriation. In addition, this result is consistent with the GHS model suggesting that the relative rate at which a strong appropriability regime facilitates cooperation is increasing faster than the rate at which entrants are tempted to compete against incumbents as a result of the intellectual property protection. This result is robust to industry effects (5-2 through 5-6), project-level effects (5-2), and the particular measure of IP, as documented throughout Tables 5 and 6. While one of the IP measures is derived from Likert ratings, TRADE SECRECY LIKERT, a second measure, PATENT THRESHOLD, is more objective in that it measures whether a project has at least one patent associated with it. Table 6 demonstrates that PATENT THRESHOLD is significant and robust to both industry and firm effects.

Finally, there is empirical evidence for an interaction effect between the IP and complementary asset regime. For example, in (5-1) through (5-5), the interaction term between TRADE SECRECY LIKERT and CA MAX LIKERT is positive and significant. This suggests that for a given complementary asset cost regime, the incremental effect of loosening the IP regime is to make cooperation a more likely commercialization strategy. While this interaction effect seems to mitigate the direct IP effect on the probability of cooperation, the hypotheses developed in this paper do not make empirical predictions about this interaction effect.[13]

The industry effects in Tables 5 and 6 show that biotech firms are more likely to adopt a cooperator commercialization strategy. This result is consistent with industry-level analyses that suggest that the combination of a strong IP regime (patents are particularly effective in this sector), together with the high costs of manufacturing and distributing downstream products (drugs) makes biotech cooperation a more likely commercialization outcome (BioWorld, 1998).

B. *Venture Capital Effects on Sensitivity to the Business Environment*

The interaction term between VC and the IP regime variable TRADE SECRECY LIKERT is significant in equations (5-1) through (5-5). I interpret this result as suggesting that for venture-backed firms, the marginal effect of loosening the intellectual property regime is to make a competitive commercialization strategy more likely, a result consistent with *H2*. The magnitude of the VC * IP interaction term in Table 5 is about one-third as large as the direct IP effect, suggesting that the interaction effect is relatively important. To explore the robustness of this result, I use a more objective measure of the IP regime, PATENT THRESHOLD, in Table 6. The significance of the IP interaction effect with VC is weakened, though as industry and project-level controls are added to the analysis, the VC * IP interaction term is strengthened. Indeed, this interaction term is significant at the 20 percent level (in the anticipated direction) in equation (6-3) when the full complement of controls is included. Therefore, the proposition that venture

[13] Notice that the economic importance of this interaction effect is relatively low (with magnitudes of between 20-25 percent of the CA and IP variables). Unreported regressions reveal that controlling for this interaction effect is important, however.

capitalists make startups more sensitive to the intellectual property environment in ways that reinforce the drivers of start-up commercialization strategy is supported in this data.

In addition, the evidence for a VC interaction effect with the complementary asset regime is moderate. In Table 5, equations (5-4) and (5-5) show that the significance of the VC * CA MAX LIKERT term is weak. However, in Table 6, when the individual measure of relative complementary asset costs, CA DISTRIBUTION LIKERT, is used, the VC * CA interaction term becomes strongly significant. This result suggests that for venture-backed projects, as the cost of attaining and controlling complementary assets is lowered, the start-up is more likely to compete in the product market. Moreover, the magnitude of this interaction term is quite important, as it is approximately the same as the direct effect of the CA regime on the probability of cooperation in Table 6. What accounts for the strengthened VC * CA interaction result when the CA measure is a Likert measure of importance of distribution assets? Perhaps venture capitalists pay particular attention to the role of distribution channels in helping their portfolio companies shape their commercialization strategy. More generally, however, I interpret these Likert-based results cautiously because of the difficulty of comparing the measures across projects. As previously stated, this method, while not perfect, is a first attempt at constructing a cross-industry measure for the relative cost of acquiring complementary assets.

Taken together, the VC interaction effects with the IP and complementary asset environments of its portfolio firms are supported. This evidence in support of *H2* suggests that venture capitalists, by making the start-up organization more sensitive to the business environment, have the effect of separating out the four boxes of the commercialization matrix (Figure 1) even further relative to the entire (unconditioned) sample of technical projects.

## VI. Caveats and Conclusions

This paper has been primarily concerned with the question of how developing technology through the venture capital process changes the commercialization path of the technology through the choice of adopting a compete or cooperate strategy. Partitioning commercialization strategies into this dichotomous classification system emphasizes the competitive implications of each strategy. To study how venture capital changes commercialization patterns, I use two benchmarks. First, in order to establish a baseline by which to gauge which commercialization strategies might be expected across high-tech industries regardless of financing mechanism, I adopt the GHS (2000) framework of IP and complementary asset regime drivers of entrant commercialization strategy. A second benchmark uses SBIR-funded projects to establish a counterfactual financing mechanism that not only mitigates the capital constraint of entrepreneurs, but also differs in institutional quality from VC.

A novel data set of venture capital backed companies matched with SBIR funded firms across five high-tech industrial sectors was assembled to empirically examine how VC may alter the commercialization strategy of its start-ups. This method leaves the complementary asset and IP regime unaltered for the entire sample, while keeping the corporate governance of project development constant on a (SBIR-backed) sub-sample. The source of variation between the SBIR and VC sub-samples is then attributed to the non-financial role of venture capitalists.

Such a method relies on an assumption of a single distribution of companies from which venture capitalists and SBIR grant administrators are selecting projects to fund. While a similar method has been used by other researchers (Lerner, 1999) to study different research questions, the following section discusses potential selection biases as a result of this method. The paper concludes with two final sections: policy implications and possible extensions of this research.

A. *Issues of Selection Bias*

What factors might systematically affect the likelihood of a technical project being funded by VC versus the SBIR program? First, it is well-known that VCs concentrate most of their investments in communications, information technology, and the health sciences. In order to address the limited industrial representation of venture investments, I selected five industrial segments in which both venture capitalists and SBIR were active in investment as a crude way to control for technological opportunity.[14] Furthermore, the fact that VC- and SBIR-funded projects

[14] Over the past two years, venture capital has increasingly become concentrated in Internet concerns while the SBIR does not appear to fund pure-play “dot com” companies (nor should they, given the private capital inflows to that

in this sample were being commercialized at approximately the same time (in 1990 on average) represents a control for the strength of the IPO market, an important correlate of market opportunity (Gompers and Lerner, 1999).

A second source of systematic selection would result if SBIR applicants were more concerned with control issues relative to small businesses that pursue VC financing. Under this scenario, "empire builders" are more likely to be attracted to the SBIR program than to venture funding. If the entrepreneur elects venture financing, not only may he have to give up equity interest in his firm, he also faces the threat of being removed from the management team, thereby losing "control" of his technology. Therefore, one might predict that if SBIR recipients were systematically more concerned with control issues, they would be less likely than the VC-backed firms in seizing upon profitable cooperation opportunities. The proposition that some entrepreneurs might not be profit maximizers—and instead value a path of control over profitability—is difficult to resolve because entrepreneurs will rarely know *ex-ante* which commercialization strategy—to compete or to cooperate—will yield higher profits *ex-post*. The best measure of potential empire building tendencies in the survey instrument is CEO FOUNDER, an indicator variable that equals one when the CEO of the firm is a founder of the firm. A simple t-test of this variable from the sample does not uncover a difference between the sub-samples.[15] In addition, my qualitative interviews with SBIR recipients suggest a multitude of reasons outside corporate or technological control for seeking SBIR funds.[16]

Finally, one might wonder whether venture capitalists select projects in which to invest based on the likelihood of being able to exercise a particular commercialization strategy (cooperation). This is unlikely to be the case, however, because of the interaction effect that VCs have with the IP environment of their portfolio companies (*H2*). That is, VCs would not make portfolio companies more sensitive to the business environment if the venture capitalist had already selected a commercialization strategy, *ex-ante*, for the start-up. I interpret the VC interaction

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sector). This current asymmetry in sector of funding does not present a problem for this study as historical funding interests between the two financing mechanisms were not as divergent.

[15] In addition, in unreported regressions, when I regress COOP on CEO FOUNDER and INSIDER EQUITY, I do not detect differences in the result when I condition by SBIR and VC sub-samples.

[16] Field notes from these interviews are on file with the author.

effect as suggesting that venture capitalists choose commercialization strategies in an effort to maximize their return from developing a technology.

A “gold standard” (true) experiment would have be to randomly assign technical projects to be funded by venture capital or the SBIR program. Unobserved selection would not be an issue in this ideal world since there would be no forces of systematic selection that would bias the sub-samples of projects financed by the two mechanisms. Given the realities of social science, this true experiment is not available, of course. Instead, we adopted a methodology that made a comparison of projects with similar observed characteristics, backed by similar but differing sources of entrepreneurial finance. We then argued that prominent alternative processes that might have generated the results are unlikely.

B. *Policy Implications of this Work*

Several nations (e.g., Singapore, Israel, and Germany) have begun adopting industrial policy toward venture capital with the assumption that subsidies to this industry will help foster the competitive advantage of technology-based industries in their countries. Not only does the imitability of US-style venture capital depend on many difficult-to-replicate features such as the social network aspect of this institution, it is unclear whether encouraging the limited partnership legal form of organizing venture capital is the best course of action for all countries given the evidence presented here. If venture-backed firms are indeed more likely to commercialize their technologies via a cooperate strategy, national governments will have to weigh this alongside other factors, such as whether reinforcement of an industrial structure that favors established organizations is a desirable policy outcome.

More generally, the business policy implications of this research for established companies is a better understanding of the economic drivers of commercialization strategy for start-up organizations. Incumbents in industries in which start-ups tend to favor a cooperative commercialization strategy should encourage innovation by entrants because the established firm’s market power is not threatened. On the other hand, in industries in which the start-up’s commercialization strategy is likely to be one of competition, established firms should adopt business policies to prepare accordingly. In industries in which venture capitalists are most active, managers at the incumbent firms might adopt a bias that entrants will more likely be sources of innovative ideas that can be accessed through licensing or acquisition.

C. *Future Directions*

This study might usefully be extended in at least two ways. First, in order to better understand and directly test both the information-intermediation and disciplinary roles of venture capitalists, more detailed and micro-level data must be collected. Such data collection is costly, but perhaps fine-grained case studies, which explore the role of venture capitalists in developing commercialization strategy in start-ups through these dual mechanisms, would be a useful next direction. Another interesting study would be to more systematically investigate the mixed business environment captured by the upper right hand corner of Figure 1. Such a study would investigate entrant and incumbent commercialization strategies in a world in which the innovative entrant faces both a weak IP regime and a relatively high cost of acquiring complementary assets to enter the product market.

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## FIGURE 1
## CONTINGENCY MATRIX OF ENTRANT COMMERCIALIZATION STRATEGIES[17]

| | | **Is it Feasible (at reasonable cost) for the Entrant to Acquire or Control Complementary Assets for this Invention?** | |
|---|---|---|---|
| | | **Yes** | **No** |
| **Can the Entrant Exclude Others from Exploiting its Technology from this Invention?** | **No** | Competitive entry<br><br>Strong disclosure effects prevents ideas market from developing<br><br>** Start-ups are competitors* | Incumbents have upper hand<br><br>Incumbents may try to access start-up's innovation by profit-sharing. Incumbents may try to establish a broad network to learn about technological opportunities.<br><br>* No empirical prediction |
| | **Yes** | In practice, a rarely encountered environment<br><br>* No empirical prediction | Cooperative commercialization<br><br>Ideas market develops and entrant cooperates with the highest bidder<br><br>* *Start-ups are cooperators (licensing or M&A results)* |

[17] The underlying idea of this matrix is due to Gans and Stern (2000b) and developed more formally in GHS (2000).

## TABLE 1
## VARIABLES & DEFINITIONS

| *VARIABLE* | *DEFINITION* | *SOURCE* |
|---|---|---|
| **DEPENDENT VARIABLE: PROBABILITY OF COOPERATION** | | |
| COOPERATE | Dummy = 1 if project revenues include licensing revenues, intellectual property sales, or merger and acquisition | MIT Survey |
| **APPROPRIABILITY MECHANISM VARIABLES** | | |
| TRADE SECRECY LIKERT | 5-Point Likert scale rating of importance of trade secrecy for appropriating returns | MIT Survey |
| PATENTS | Number of project patents awarded since SBIR grant | MIT Survey, USPTO |
| PATENT THRESHOLD | Dummy = 1 if the project has been awarded at least one patent | MIT Survey, USPTO |
| PATENT LIKERT | 5-Point Likert scale rating of importance of patents for appropriating returns | MIT Survey |
| **COMPLEMENTARY ASSET VARIABLES** | | |
| CA LIKERT MAX | Maximum over the set of 5-point Likert measures for the importance of complementary assets in earning returns from this project. | MIT Survey |
| CA DISTRIBUTION LIKERT | 5-Point Likert scale rating of importance of access or control over distribution channels in earning returns from this project. | MIT Survey |
| **FIRM-LEVEL VARIABLES** | | |
| VC | Dummy = 1 if the project is funded primarily by venture capitalists | MIT Survey, Venture Economics |
| BASELINE EMPLOYEES | Number of employees at the start of the project | MIT Survey |
| CEO FOUNDER | Dummy = 1 if the current CEO is a founder of the firm | MIT Survey |
| INSIDER EQUITY | Percentage of the company held by management and employees of the firm | MIT Survey |
| **PRODUCT-LEVEL VARIABLES** | | |
| INFLOWS | Monetary inflows into the project | MIT Survey |
| TIME TO MARKET | Time in months from conception of idea to first sale | MIT Survey |
| PRODUCT INNOVATION | Dummy = 1 if the project is rated by respondent as a product innovation | MIT Survey |
| **INDUSTRY-LEVEL VARIABLES** | | |
| BIOTECH | Dummy = 1 if project is categorized in SIC 2836 | *Corptech Directory of Technology Companies* |
| INDUSTRIAL EQUIPMENT | Dummy = 1 if project is categorized in SIC 35 | *Corptech Directory of Technology Companies* |
| ELECTRONIC COMPONENTS | Dummy = 1 if project is categorized in SIC 36 | *Corptech Directory of Technology Companies* |
| INSTRUMENTS | Dummy = 1 if project is categorized in SIC 38 | *Corptech Directory of Technology Companies* |

| | | |
|---|---|---|
| SOFTWARE | Dummy = 1 if project is categorized in SIC 7372 | *Corptech Directory of Technology Companies* |

## TABLE 2
## MEANS & STANDARD DEVIATIONS

| | *FULL SAMPLE (N = 118)* | | *SBIR SAMPLE (N = 63)* | |
|---|---|---|---|---|
| | Mean | St. Dev. | Mean | St. Dev. |
| **DEPENDENT VARIABLE** | | | | |
| COOPERATE | .339 | .475 | .254 | .439 |
| **APPROPRIABILITY MECHANISM VARIABLES** | | | | |
| TRADE SECRECY LIKERT | 3.678 | 1.371 | 3.714 | 1.396 |
| PATENTS | 6.678 | 14.189 | 4.889 | 7.353 |
| PATENT THRESHOLD | .653 | .478 | .667 | .475 |
| PATENT LIKERT | 3.475 | 1.478 | 3.492 | 1.447 |
| **COMPLEMENTARY ASSET VARIABLES** | | | | |
| CA LIKERT MAX | 4.627 | .596 | 4.683 | .591 |
| DISTRIBUTION LIKERT | 3.263 | 1.330 | 3.397 | 1.302 |
| **FIRM-LEVEL VARIABLES** | | | | |
| VC | .466 | .501 | 0 | N/A |
| BASELINE EMPLOYEES | 25.481 | 43.662 | 23.691 | 34.120 |
| CEO FOUNDER | .598 | .492 | .635 | .485 |
| INSIDER EQUITY | 43.378 | 37.503 | 55.339 | 39.776 |
| **PRODUCT-LEVEL VARIABLES** | | | | |
| PROJECT INFLOWS | 9.190 | 19.445 | 2.692 | 4.253 |
| TIME TO MARKET | 44.925 | 49.068 | 52.810 | 56.952 |
| PRODUCT INNOVATION | .678 | .469 | .683 | .469 |
| **INDUSTRY-LEVEL VARIABLES** | | | | |
| BIOTECH | .136 | .344 | .127 | .336 |
| INDUSTRIAL EQUIPMENT | .102 | .304 | .063 | .246 |
| ELECTRONIC COMPONENTS | .305 | .462 | .270 | .447 |
| INSTRUMENTS | .339 | .475 | .413 | .496 |
| SOFTWARE | .119 | .325 | .127 | .336 |

**TABLE 3**
**PAIRWISE VENTURE CAPITAL CORRELATIONS**
**BY INDUSTRIAL SEGMENT**

| | | **INDUSTRY (TWO-DIGIT SIC LEVEL)** | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | **BIOTECH** | | **INDUSTRIAL PRODUCTS** | | **ELECTRONIC EQUIPMENT** | | **INSTRUMENTS** | | **SOFTWARE** | |
| | *STAT.* | *COOP* | *COMP* | *COOP* | *COMP* | *COOP* | *COMP* | *COOP* | *COMP* | *COOP* | *COMP* |
| VENTURE CAPITAL | Mean | .600 | .250 | .750 | .333 | .667 | .367 | .375 | .258 | .250 | .455 |
| | St. Dev. | .516 | .463 | .500 | .488 | .492 | .490 | .500 | .445 | .500 | .522 |
| | # Obs. | 10 | 8 | 4 | 15 | 12 | 30 | 16 | 31 | 4 | 11 |

**TABLE 4**
**BASIC VC**
**PROBIT REGRESSIONS**

| | **Dependent Variable = COOPERATE**<br>**N = 141 observations** | | |
|---|---|---|---|
| | **(4-1)**<br>Basic VC effect with no controls | **(4-2)**<br>(4-1) with industry level controls | **(4-3)**<br>(4-2) with project-level controls |
| VC | 0.496**<br>(0.224) | 0.532**<br>(0.231) | 0.524**<br>(0.267) |
| BIOTECH | | 0.980**<br>(0.450) | 0.867*<br>(0.473) |
| ELECTRONICS | | 0.238<br>(0.393) | 0.385<br>(0.408) |
| INSTRUMENTS | | 0.490<br>(0.386) | 0.448<br>(0.401) |
| SOFTWARE | | 0.232<br>(0.480) | 0.333<br>(0.501) |
| BASELINE EMPLOYEES | | | 0.004<br>(0.003) |
| CEO FOUNDER | | | -0.370<br>(0.236) |
| PROJECT INFLOWS | | | -0.004<br>(0.009) |
| PATENTS | | | 0.008<br>(0.011) |
| PRODUCT INNOVATION | | | -0.025<br>(0.257) |
| TIME TO MARKET | | | 0.002<br>(0.003) |
| CONSTANT | -0.656**<br>(0.146) | -1.068**<br>(0.354) | -1.878**<br>(0.706) |
| Log Likelihood | -86.579 | -83.442 | -78.092 |

Note: * and ** indicate coefficients are significant at the 10 and 5 percent levels, respectively.

## TABLE 5
## COMMERCIALIZATION STRATEGY
## COOPERATION PROBITS

| | **Dependent Variable = COOPERATE N = 118 observations** | | | | |
|---|---|---|---|---|---|
| | **(5-1)** Basic CA and IP effect | **(5-2)** (5-1) controlling for industry effects | **(5-3)** (5-2) with VC interacted with IP | **(5-4)** (5-3) with VC interacted with CA | **(5-5)** (5-4) with controls for product level effects |
| VC | 0.533** (0.251) | 0.618** (0.265) | 2.967*** (1.044) | 5.046** (2.416) | 4.934** (2.434) |
| CA MAX LIKERT | -1.615** (0.686) | -1.639** (0.696) | -2.156*** (0.803) | -2.081*** (0.824) | -2.021** (0.827) |
| TRADE SECRECY LIKERT | -1.428* (0.769) | -1.498* (0.793) | -1.623** (0.834) | -1.804** (0.871) | -1.753* (0.877) |
| CA MAX LIKERT * TRADE SECRECY LIKERT | 0.324** (0.167) | 0.339** (0.172) | 0.436** (0.189) | 0.469** (0.194) | 0.456** (0.195) |
| VC * CA MAX LIKERT | | | | -0.434 (0.488) | -0.434 (0.489) |
| VC * TRADE SECRECY LIKERT | | | -0.600** (0.250) | -0.612** (0.251) | -0.589** (0.253) |
| BIOTECH | | 1.031** (0.533) | 1.081** (0.549) | 0.954* (0.561) | 0.943* (0.563) |
| ELECTRONICS | | 0.097 (0.475) | 0.019 (0.484) | -0.042 (0.487) | -0.020 (0.489) |
| INSTRUMENTS | | 0.423 (0.464) | 0.524 (0.473) | 0.505 (0.480) | 0.519 (0.482) |
| SOFTWARE | | -0.024 (0.561) | -0.243 (0.577) | -0.401 (0.597) | -0.357 (0.605) |
| TIME TO MARKET | | | | | 0.003 (0.003) |
| PRODUCT INNOVATION | | | | | 0.038 (0.293) |
| CEO FOUNDER | | | | | -0.127 (0.269) |
| CONSTANT | 6.504** (3.129) | 6.245** (3.231) | 7.322** (3.495) | 6.985** (3.587) | 6.831** (3.593) |
| Log Likelihood | -69.563 | -65.951 | -62.601 | -61.685 | -61.573 |

Note: *, **, and *** indicate coefficients are significant at the 10, 5, and 1 percent levels, respectively.

## TABLE 6
## EXPLORING ROBUSTNESS TO ALTERNATE INTELLECTUAL PROPERTY AND COMPLEMENTARY ASSET MEASURES

| | **Dependent Variable = COOPERATE**<br>**N = 118 observations** | | |
|---|---|---|---|
| | **(6-1)**<br>Exploring patent-based measure of IP and individual CA measure, with VC interactions | **(6-2)**<br>(6-1) with industry controls | **(6-3)**<br>(6-2) with project-level controls |
| VC | 1.785**<br>(0.887) | 1.886**<br>(0.941) | 2.155**<br>(1.013) |
| CA DISTRIBUTION LIKERT | 0.490**<br>(0.235) | 0.584**<br>(0.251) | 0.646**<br>(0.272) |
| PATENT THRESHOLD | 1.833**<br>(0.950) | 2.030**<br>(1.013) | 2.381**<br>(1.098) |
| CA DISTRIBUTION LIKERT * PATENT THRESHOLD | -0.436*<br>(0.232) | -0.528**<br>(0.245) | -0.635**<br>(0.268) |
| VC * CA DISTRIBUTION LIKERT | -0.501**<br>(0.211) | -0.520**<br>(0.222) | -0.586***<br>(0.235) |
| VC * PATENT THRESHOLD | 0.551<br>(0.576) | 0.646<br>(0.619) | 0.844<br>(0.654) |
| BIOTECH | | 1.364**<br>(0.598) | 1.637***<br>(0.664) |
| ELECTRONICS | | 0.657<br>(0.531) | 0.864<br>(0.574) |
| INSTRUMENTS | | 0.824<br>(0.539) | 0.956<br>(0.581) |
| SOFTWARE | | 0.312<br>(0.645) | 0.428<br>(0.684) |
| INFLOWS | | | -0.014*<br>(0.008) |
| PRODUCT INNOVATION | | | 0.035<br>(0.321) |
| CEO FOUNDER | | | -0.182<br>(0.269) |
| CONSTANT | -2.590***<br>(0.943) | -3.601***<br>(1.191) | -3.862***<br>(1.311) |
| Log Likelihood | -64.305 | -60.835 | -59.194 |

Note: *, **, and *** indicate coefficients are significant at the 10, 5, and 1 percent levels, respectively.