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More Than Words: Is Startup?s Propensity to Patent and Publish Sensitive to Investor Characteristics?

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Abstract

Over the last decade, corporations became an increasingly important source of financing for innovative startups across a wide array of industries. This paper investigates the consequences of Corporate Venture Capital (CVC) investments: Do strategically-oriented CVCs affect startups' research productivity? Do CVC-backed startups overemphasize basic over applied research? We study these questions using a longitudinal sample of 591 U.S. biotechnology ventures founded from 1990 to 2003. We find that CVCs nurture the venture?s basic research more than VCs, especially when the CVC parent firm shares industry niche with the venture. And while CVCs also foster the venture?s applied research more than VCs, the effect is stronger when the CVC parent firm is in a different industry niche. In summary, our findings highlight the innovation implications of different investor types. ?

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Over the last decade, corporations became an increasingly important source of financing for innovative startups across a wide array of industries. This paper investigates the consequences of Corporate Venture Capital (CVC) investments: Do strategically-oriented CVCs affect startups' research productivity? Do CVC-backed startups overemphasize basic over applied research? We study these questions using a longitudinal sample of 591 U.S. biotechnology ventures founded from 1990 to 2003. We find that CVCs nurture the venture's basic research more than VCs, especially when the CVC parent firm shares industry niche with the venture. And while CVCs also foster the venture's applied research more than VCs, the effect is stronger when the CVC parent firm is in a different industry niche. In summary, our findings highlight the innovation implications of different investor types.

"Corporate venture funding, the investment of corporate funds into external endeavors, is expected to become a much more crucial source of funding to the industry, with 30 percent of CEOs surveyed saying they will tap corporate venture capital as a finance source in the next 12 months, versus only 10 percent who did so in the past 12 months."
PwC 2012 CEO survey of California Biomedical Industry (in collaboration with CHI and BayBio).

INTRODUCTION

Innovation is one of the cornerstones of today's economy, and as such policy makers and researchers seek to provide incentives to fund it, and to better understand the consequences of that innovation on firms and the economy. Because entrepreneurial ventures are an important source of innovative ideas and products (e.g., Acs & Audretsch, 1988), the question of how to fund innovative ventures is at the center of the larger issue (Hall, 2002).

It has been argued that venture capital (VC) stimulates the innovation of the entrepreneurial ventures they back (Kortum & Lerner, 2000; Samila & Sorenson, 2010). And yet VCs are only one source of funding. Increasingly, corporate investors, also known as corporate venture capitalists (CVC), are becoming an important alternative (Dushnitsky, 2011), which like VCs, pursue financial but also strategic objectives (Dushnitsky & Shaver, 2009; Gompers & Lerner, 1998). This study seeks to understand the implications of CVC investment on entrepreneurial innovation: Do strategically-oriented CVCs affect startups' research productivity? Do CVC-backed startups overemphasize basic or applied research?

The purpose of this paper is to study the impact on entrepreneurial ventures' innovativeness, comparing CVC-backed ventures to those funded by VCs. To that end, we study the research output (both basic and applied) of CVC-backed ventures and further explore whether such output is affected by the competitive position of the CVC-venture pair (i.e., do they target the same industry niche?). Specifically, we focus on the two main types of innovative outcomes: (1) patents, or applied research, that award

monopoly commercialization rights, and (2) scientific publications, which are the result of basic research that is far from a commercial application, and generate knowledge spillovers.

Corporate venture capital investment is on the rise. The reason is threefold. First, there is a relative decline in VC investment. The financial crisis constrains VCs' ability to raise capital from pension funds, endowments and other traditional financiers. This, in turn, leads to lesser availability of venture capital, and therefore increases the relative attractiveness of CVCs. Second, entrepreneurial ventures recognize that established corporations offer not only financial capital but also access to valuable complementary assets (e.g., corporate manufacturing facilitates, distributions channels, etc.). There are some industries, such as the pharmaceutical industry, where corporate complementary assets are highly valued, and thus CVC-backing is particularly attractive. Third, more and more corporations understand the value of having 'eyes and ears' in the world of innovative entrepreneurial ventures. Indeed, the number of CVCs has more than doubled in the past decade (Dushnitsky, 2011).

Because CVCs are affiliated with a large corporation, they are driven by a balance of VC-like financial objectives and corporate-oriented strategic goals. As a result, corporate venture capitals pose unique opportunities and threats to the much smaller entrepreneurial venture. The advantages include the aforementioned access to complementary assets: the corporation can be instrumental in speeding the time-to-market and reducing the commercialization costs of an entrepreneurial invention, as well as substantial endorsement effect and industry know-how (Stuart *et al.*, 1999). The disadvantages have to do with the fact that a large corporation is well-positioned to expropriate an entrepreneurial idea and commercialize it as its own (Dushnitsky & Shaver, 2009; Katila *et al.*, 2008).

In a nutshell, our analysis pivots on three elements. We explore whether (a) the research output of entrepreneurial ventures (i.e., basic or applied) is sensitive to (b) investor identity (i.e., VC or CVC), and (c) the relative market positioning of the venture-investor pair (i.e., whether or not the venture operates in the same industry niche as the CVC). Our findings present evidence of a division of labor. Specifically,

CVC-backed ventures exhibit greater basic and applied research compared to VC-backed ones. Interestingly, the impact of same-industry-niche CVC investor diverges: it is associated with the highest increase in a venture's basic research, yet the lowest impact on applied research.

We investigate these issues by studying 591 biotechnology ventures founded between 1990 and 2003, of which 214 ventures are backed by a corporate venture capital and the remainder are VC-backed. The biotechnology industry is an ideal setting to test our hypotheses: (a) it is capital intensive and requires VC or CVC-backing, (b) it is a field where basic and applied research are highly intertwined, leading firms to invest in both (Rosenberg, 1990), and (c) it provides well-accepted measures of basic-research outcomes (i.e., scientific publications) and commercial applied- research outcomes (i.e., patents). The results suggest that inventor type affects the ventures' innovation trajectory. CVC-backing promotes ventures' publications more than VC-backing does; the effect is even greater when the CVC parent firm is in the same industry niche as the venture. We also find that CVCs foster patenting more than VCs, especially when the CVC and the startup compete in different industry segments, suggesting that CVCs nurture the patenting but also internalize part of the innovation outcomes of the startup.

This study makes several contributions. First, it adds to a growing literature that documents innovation implications of different investor types. We focus on the biotechnology industry, where VCs and CVCs are commonplace. Second, it is the first paper, to the best of our knowledge, to investigate the consequences of different investors along different innovative outcomes. Whereas prior work focuses on commercialize-able innovation (i.e., patents), we also consider the impact of ventures' basic research (i.e., scientific publications). We therefore shed light on the way in which investor characteristics contribute to knowledge spillovers.

TYPES OF INNOVATIVE OUTCOMES

It is commonplace to distinguish between two archetypes of innovation activity: basic and applied research. The National Science Foundation defines basic research as "systematic study directed toward

fuller knowledge or understanding of the fundamental aspects of phenomena and of observable facts without specific applications towards processes or products in mind", and applied research as "systematic study to gain knowledge or understanding necessary to determine the means by which a recognized and specific need may be met."[1] Economists and management scholars use similar definitions. For instance, Stern (2004: 837) defines "participation in science to be distinguishable from commercially motivated knowledge production, involve the formulation and testing of theories (which may, but need not, result in commercial spillovers), and result in public disclosure in academic journals."

In the biotechnology industry, patents are particularly instrumental in appropriating commercial value (Cohen *et al.*, 2002; Levin *et al.*, 1987; Shan *et al.*, 1994). The technology that results from the applied research efforts is typically protected through patents, which are externally validated through the patent examination process (Griliches, 1990), and are indicators of commercialize-able new products (Basberg, 1987; Hagedoorn & Cloodt, 2003). Entrepreneurial ventures tend to patent their innovations so as to secure the commercial monopoly rights associated with them. In contrast, basic research has no direct commercial application and is typically disseminated through scientific publications and academic conferences. It is a public good and plays an instrumental role in applied research and technology (Cohen *et al.*, 2002; Gambardella, 1995; Gittelman & Kogut, 2003; Powell *et al.*, 1996; Zucker *et al.*, 2002). Public institutions invest in this public good, but interestingly, firms do as well, as a means to improve their productivity in their applied research activities, and as an incentive for their scientists (Stern, 2004).

With the passing of the Bayh-Dole act in 1980, patenting in the universities became prevalent, raising the question of whether academic publications were diminished in turn. One stream of literature has sought to analyze the extent to which science and technology in the universities act as substitutes (Agrawal & Henderson, 2002; Azoulay *et al.*, 2009; Goldfarb, 2008; Larsen, 2011; Mowery & Ziedonis, 2002), and the role of institutions in shaping this interaction (Furman & Stern, 2011).

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[1] As defined by the National Science Foundation (http://www.nsf.gov/statistics/randdef/fedgov.cfm, accessed on 1/1/2012)

While universities have a central role in science, firms also engage in basic research and share their results through academic publications. The rationale for such investment is that basic research partly leads to applied research, because it increases the absorptive capacity of the firm (Cohen & Levinthal, 1989, 1990; Rosenberg, 1990), but also because it provides an incentive for scientists (Dasgupta & David, 1994; Stern, 2004). Lim (2004) shows that this close industry relationship between science and technology is stronger in pharmaceuticals than in other fields, such as semiconductors. Indeed, much of the work on the science-technology relationship focuses on the life sciences fields (e.g., Azoulay *et al.*, 2009; Murray & Stern, 2007; Stern, 2004).

It follows that patenting and publications are distinct, but they are highly intertwined, underscoring the need to study both types of research if we are to anlyze the dynamics of entrepreneurial venture's innovation. And while extant work has focused on the basic-applied research output from universities, there has been little work on the basic-applied balance in the private sectors, and specifically on that of entrepreneurial ventures. There is no work that we are aware of on the impact of different investors on this balance.

CORPORATE VENTURE CAPITAL AND STARTUP INNOVATIVENESS

In recent years, an incipient stream of literature has begun to analyze the role of investors on the venture's innovative outcomes. In addition to some work on the role of government investment (Svensson, 2007), the main focus is on venture capitalists. Kortum and Lerner (2000) show that VCs have spurred patenting across industries in the U.S. Furthermore, the presence of venture capitalists increase the effect of knowledge spillovers from research centres and univeristies on the rates of patenting of firms (Samila & Sorenson, 2010).

Yet, to the best of our knowledge, past work has focused on one type of investor –VCs- on one type of innovative outcome –patents. This paper takes two steps further, studying the effect of corporate venture capitals as compared to venture capitalists, on the two types of research – basic and applied. The

key insight is that as financial investors, the VCs benefit when the ventures they back are successful at creating and commercializing innovation. As strategic investors with existing products and services of their own, corporations may have a different approach. In what follows, we expand and hypothesize on these issues.

CVCs and Ventures' Basic Research Activity

As the investment arm of a corporation, corporate venture capitalists may provide additional resources and knowhow to the entrepreneurial ventures, but may also have interests in them beyond mere financial success. Hence, to understand how CVCs impact innovation differently from VCs we need to first understand the interest that the former has on the innovation outcomes of the venture, and then the means by which they can affect the innovation processes.

There are two broad motives for firms to engage in basic research. As a "ticket of admission," basic research increases the absorptive capacity of the firm and, in turn, its research productivity (Arora & Gambardella, 1994; Cohen & Levinthal, 1989, 1990; Rosenberg, 1990). Besides, basic research is valued by scientists and provides them with an incentive to engage in the R&D activities that will lead to the discovery of a technology (Dasgupta & David, 1994; Stern, 2004). For these reasons, both large corporations and entrepreneurial ventures engage in basic science in addition to applied science.

Extant work indicates that entrepreneurial ventures are specifically a source of highly valuable and innovative ideas (Kortum & Lerner, 2000; Shane, 2001; Zingales, 2000). According to this line of reasoning, star scientists/innovators will opt away from fixed salary (i.e., as an employee in a corporate R&D lab) and towards profit sharing (i.e., founding their own new venture) when they have an idea that is highly lucrative (Anton & Yao, 1995; Gans & Stern, 2003). Thus, we expect to observe the formation of new ventures primarily when entrepreneurs have highly innovative ideas (Aghion & Tirole, 1994).

Accordingly, large corporations engage in corporate venture capital activities as a vehicle to gain a window into cutting edge and high potential research developed by high-technology entrepreneurial

ventures (Dushnitsky & Lenox, 2005a; Wadhwa & Kotha, 2006). Strategic investors are, therefore, interested in promoting the basic research at the venture, because it drives the future commercial success of the ventures innovation (Rosenberg, 1990), but also because it keeps scientists engaged and motivated (Stern, 2004), and this is particularly relevant in a small and young organization that can offer fewer extrinsic rewards.

The question that follows is whether the CVC can offer resources and capabilities that could be valuable for the venture's R&D activities. One of the mechanisms is the provision of financial resources. Financing is a typical constraint that researchers in high technology industries face. Another mechanism has to do with access to management talent. Professionalizing the venture (Hellmann & Puri, 2002) may also prove relevant to the R&D processes, because lower-quality management may detract attention from the R&D processes to focus on day-to-day problem solving activities. In addition to these mechanisms (Block & MacMillan, 1993; Dushnitsky & Lenox, 2005a), a CVC may also take advantage of the resources and knowledge from its parent corporation: providing unique services that build on corporate resources, including access to corporate laboratories, knowledge of navigating regulatory demands and FDA processes, as well as access to their suppliers and distribution networks, or access to their patent lawyers (Acs *et al.*, 1997; Zucker *et al.*, 1998). These resources can be used to help develop and test promising new inventions (Scotchmer, 2004).

It follows that CVC parent firms have both the incentive and the resources to support and stimulate basic research conducted by the entrepreneurial venture. In comparison, VC-backed ventures are privy to business advice, yet do not experience the same level of scientific conversations. Consequently, we expect CVC-backed ventures to create more scientific knowledge of the type published in academic journals.

> *Hypothesis 1. All else being equal, the publication outcomes of CVC-backed ventures increase more than those of VC-backed ventures.*

The implications of CVC-backing may be sensitive to the degree to which the corporation and the venture compete in the same industry niche. The topic of knowledge-sharing, including the effect of resource complementarities and complexities inherent to knowledge transfer (e.g., Dyer & Singh, 1998; Hamel, 1991; Sampson, 2007), has been examined in the framework of strategic alliances and may be exacerbated in the context of corporate venture capital where the entrepreneur's main asset is knowledge based.

In high technology fields, innovation is a lengthy process and firms often specialize in different stages of the innovation chain. There is, then, certain division of labor, with startups often focused on the early stages of the process and incumbents farther down the chain. The biotechnology and pharmaceuticals are the archetypical examples in the literature (Galambos & Sturchio, 1998; Pisano, 1991, 2006). It follows that CVC parent firms in the same industry niche as the startup have additional incentives to foster this basic research, because the knowledge outcomes of such research are of great value to their R&D projects. In essence, CVC parent firms explore by investing in the venture's basic research (Cohen & Levinthal, 1990; Dushnitsky & Lenox, 2005a; Wadhwa *et al.*, 2009).

An industry niche overlap will also enhance the parent's ability to accurately evaluate and potentially commercialize an innovation. The degree to which a firm learns from a venture depends in part on its absorptive capacity (Cohen & Levinthal, 1990; Pisano, 1991; Veugelers, 1997). Recent work highlights the 'relative' nature of absorptive capacity, that is, a firm's ability to learn from another firm is contingent on domain similarities (Ahuja & Katila, 2001; Lane & Lubatkin, 1998). Overlap in knowledge domains allows a firm to better gauge the value of its prospective partner's invention. Essentially, CVC parent firms in the same industry niche possess resources and knowledge that are more complementary to the ventures' than those of CVCs in a different industry niche, and as a result the former are better equipped to aid the venture.

Consistent with the prediction in hypothesis 1, we argue that both CVCs in the same and in a different industry niche will nurture basic-research more than VCs (hypotheses 2.a and 2.b, respectively). When compared, though, CVCs in the same industry segment should have a greater impact on basic research than those in a different segment (hypothesis 2.c).

> *Hypothesis 2. (a) All else being equal, the publication outcomes of ventures backed by same-industry-niche CVCs increase more than those of VC-backed ventures.*
>
> *(b) All else being equal, the publication outcomes of ventures backed by different-industry-niche CVCs increase more than those of VC-backed ventures.*
>
> *(c) All else being equal, the publication outcomes of ventures backed by same-industry-niche CVCs increase more than those backed by different-industry-niche CVCs.*

CVCs and Venture's Applied Research Activity

Investors, be that a CVC or an independent VC, also affect a venture's applied research activities. A key observation is that investors' objectives shape the value they assign to applied research. One might argue that VCs, as financial investors, view applied research as a means-to-an-end (i.e., it allows a venture to access more capital, either through further fundraising, licensing or eventually, IPO or trade sale), whereas for strategic CVCs the output of the applied research is a goal in and by itself. Specifically, corporate venture capitalists invest in entrepreneurial ventures because they provide a "window" into different technologies, hence allowing them to learn and explore (Dushnitsky & Lenox, 2006; Wadhwa *et al.*, 2009). For VCs, however, applied research leads to patents, which as a quality signal for high-technology ventures increase the value of their investment, especially when the venture is young and the information asymmetries are greater (Hsu & Ziedonis, 2011). Also, both CVCs and VCs can aid the venture in their R&D processes, but as in the case of basic research, CVCs have a greater array of resources and knowledge that complement those of the venture, and as a result they are better positioned than VCs to nurture applied science.

The picture is, however, more complex, because CVC parent firms have the infrastructure, and possibly the incentives, to internalize the venture's technology. It is therefore necessary to analyze the dynamics of technology appropriation between the established corporation and the venture.

Both VCs and CVCs have an incentive to foster the venture's patenting outcomes, which as a signal of quality lower the information asymmetries (Hsu & Ziedonis, 2011), making the entrepreneurial venture more attractive to later stage investors and also to the stock market investors or corporations, facilitating further rounds of investment, and IPO or a trade-sale. Furthermore, patents can be licensed or sold, and this is for the most part the main source of profits for early stage ventures that still lack a commercial product. In essence, by nurturing applied research and the resulting patents, corporate and independent VCs enable the financial success of the entrepreneurial venture in their portfolio.

But the resources and knowledge-base of the CVC parent firm provide the entrepreneur with an alternative to the costly and time-consuming patenting process. Through the corporation, the venture has access to distribution channels and so it may be possible to avoid (or at least postpone until the commercialization is plausible) the patent application and subsequent licensing agreements. Moreover, many ventures reach licensing and/or commercial agreements with the CVC parent corporation in a way that allows the venture to capture part of the rents associated with the innovation, while leaving the costly commercialization phase to the corporation. Finally, it is also possible that the corporation takes advantage of their privileged position, to expropriate the technology of the startup. In this case the effect of CVC-backing would not necessarily translate into more patents for the venture, even though it may translate into more patents for the CVC if they want to fully expropriate the technology.

Overall, we argue that CVCs possess resources and knowhow that complement those of the venture, and hence may enhance its applied research outcomes more than VCs . However, CVCs may also reduce the patenting outcomes of the venture by providing an alternative avenue to the venture or by

expropriating its technology. Because it is an empirical question whether CVCs foster patents more than VCs or not, we propose the two effects on hypothesis 3 (a) and (b).

Hypothesis 3. (a) All else being equal, the patenting outcomes of CVC-backed ventures increase more than those of VC-backed ventures.

(b) All else being equal, the patenting outcomes of CVC-backed ventures increase less than those of VC-backed ventures.

These positive and negative effects of CVC-backing are exacerbated when the CVC parent firm competes in the same industry niche as the entrepreneurial venture. Research in life sciences is a lengthy and complex process and as a result biotechnology ventures tend to focus more on the earlier stages of the process, while incumbents focus on the later stages (Pisano, 1991). When the CVC parent firm and the venture are in the same industry segment, there is a greater degree of complementarity between the resources and knowledge-bases of both. This greater complementarity of resources facilitates the commercialization of the technology through avenues different from the patent, also increasing the incentives of the corporation to expropriate and internalize the technology. In essence, even though there is a greater potential to nurture the applied research efforts, the CVC also offers a better alternative to patenting, either voluntarily by the entrepreneur or forced by the CVC parent firm. Therefore, we expect that the negative effect on patenting outcomes will be predominant when the CVC parent firm's and the venture's industry niches overlap (hypothesis 4.a).

In contrast, when the CVC goal is to expand the parent's product categories, and hence invests in a startup in a new (different) industry niche, they are less likely to internalize the innovation directly. In this case, the parent does not have the organizational structure in this business segment in order to directly exploit this technology, and it is more valuable to keep it in the startup. For instance, this is the case of the Novartis Option Fund, which seeks to "enabl[e] the development of novel programs and technologies that may be complementary to Novartis' research endeavors" and "is coupled with an option to [license] a

specific therapeutic program giving early validation for the startup company's technology or programs by a large Pharma."[2] In this case Novartis funds ventures in complementary (but different) areas and negotiates the licensing of the technology *ex ante*. Even though both the VCs and the CVCs have an interest in fostering patents, those CVC parent firms in different industry niches are still in better position than the VCs to aid the venture. Therefore, we expect that the positive effect predicted in hypothesis 3.a will be stronger in this case (hypothesis 4.b).

> *Hypothesis 4. (a) All else being equal, the patenting outcomes of ventures backed by same-industry-niche CVC increase less than those of VC-backed ventures.*
>
> *(b) All else being equal, the patenting outcomes of ventures backed by different-industry-niche CVC increase more than those of VC-backed ventures.*

METHODOLOGY

Empirical setting and sample description

We test our hypotheses using a sample of 591 U.S. biotechnology ventures founded during the period 1990 to 2003, and observed until 2005. Our sample brings together financial performance of these ventures as well as the investment they received, and a full history of their publications and patents. Venture Economics collects the data using a variety of sources, including the investment banking community, industry associations, or surveys of general partners and their portfolio companies. This database is widely used in previous research (Dushnitsky & Lenox, 2005a, 2005b; Gompers, 1995; Guler & Guillen, 2010; Sorenson & Stuart, 2001).

Biotechnology is an ideal setting to test our hypotheses. Being high-technology, innovation is valuable and ventures have a general desire to increase their innovative outcomes; as a result, patents and publications are good measures of innovation in this industry (Rothaermel & Thursby, 2007; Stuart *et al.*, 1999; Zucker *et al.*, 2002), Moreover, critical developments in the industry are strongly rooted in

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[2] Source: Novartis website, http://www.novartisventurefunds.com/index.php?id=234 (accessed Jan 17, 2012).

advancement of basic research, yet also require additional progress through applied research (e.g., Gittelman & Kogut, 2003; Huang & Murray, 2009; Lim, 2004). Finally, since innovation is costly, they rely heavily on external funding from corporate and independent VCs.

The main goal of this paper is to assess the effects on the innovation strategies of CVCs relative to VCs. To establish a baseline for comparison, we restrict the sample to those ventures that receive funding from either investor during the window of observation. Each venture is observed since founding and until 2005, and they drop from the sample only in case of bankruptcy or acquisition. The rationale to close the window in 2005 stems from the time lag between filing and publication of patents. Collected in 2011, a six year lag is roughly the mean lag (4 years) plus one standard deviation (2 years), increasing our confidence that we observe most of the patents published by the ventures in our sample.[3] Table 1 shows the distribution of founding years over the period of observation, generally increasing until the peak of the financial bubble in 2000, and drastically decreasing right afterwards.

[Table 1 around here]

Variable definitions

Dependent variables

$Patents_{i,t}$ is a count of patents[4] for venture i and year t (flow variable). The flow of patents per year is a common measure of innovative outcomes (e.g., Ahuja & Katila, 2001; Cockburn *et al.*, 2002). With the help of several research assistants, we hand-collected patent information from the United States Patent and Trademark Office (U.S.P.T.O.), matching the biotechnology startup in the sample to the assignee of the patent. The matching took into consideration the location of the startup as established in the patent, checking whether the venture had research labs in other locations when necessary, and

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[3] Note that we should only be concerned with the right tail of the distribution. Just as a reference, if the distribution were normal, this lag of mean+sd would cover roughly 85% of the patents.

[4] We chose to estimate the count of patents rather than the citations because our arguments are not related to the quality of the patent, but to the level of outcome in itself. The number of citations varies with the patent examiner additions, and with the traction of a particular field of research at a given point in time (e.g. monoclonal antibodies vs. stem cells). Since our theory does not speak to these choices we prefer to use a more conservative measure.

comparing the inventors across different patents to ensure the accuracy of the matching. We only included

published patents, but used the date of application, as it is customary in the literature.

$Publications_{i,t}$ is a count of scientific publications for venture i and year t (flow variable), which

is a typical measure of basic science on past research (e.g., Agrawal & Henderson, 2002; Azoulay *et al.*,

2009).We used the Web of Knowledge (formerly ISI) Database, from Thomson, hand-collecting those

publications such that the focal venture is listed as the affiliation of one of the authors, and following the

same matching criteria we used for patents. This database is widely used in prior work (Azoulay *et al.*,

2009; Cockburn & Henderson, 1998; Gittelman & Kogut, 2003; Goldfarb, 2008), and it has two features

that suit our research question: it imposes quality filters to the journals included in their list, and unlike

more specialized databases, it covers a wide array of disciplines. Less depth in the number of journals

included allows us to have more comparable publications in terms of quality. Greater scope in the number

of journals included is an attractive feature for biotechnology research, which is a highly interdisciplinary

area which draws from biology to computer science.

Independent variables and controls

$CVC_{i,t-1}$ is an indicator of whether venture i was CVC-backed in *t-1*. The variable is 0 until a

CVC invests in the venture, and 1 thereafter. This is the main variable of interest in hypotheses 1 and 3.

$CVC\ Industry\ Overlap_{i,t-1}$ and $CVC\ No\ Overlap_{i,t-1}$ breaks the information from $CVC_{i,t-1}$

into two indicator variables. The former measure takes the value of 1 when there is a CVC investor, and

that CVC parent firm operates in the same industry niche as the venture (as measured by a four-digit SIC

code). The latter measure takes the value of 1 when there is a CVC investor, and the CVC –venture pair

exhibit no industry niche overlap. Industry overlap is defined following Dushnitsky and Shaver (2009);

for ventures, we followed the Venture Economics Industry Classification (VEIC) and matched to the SIC

classification using Dushnitsky's VEIC_SIC concordance. We compare the industry that defines the

primary operations of the investor with the industry of venture as defined by this concordance. These are

the two main independent variables used to test hypotheses 2 and 4.

$VC_{i,t-1}$ is an indicator of the presence of an independent venture-capital firm in the syndicate.

While by the definition of the sample most of the startups are VC-backed at some point in time during the

period of observation, the timing differs, and so this variable controls for the year in which a VC initially

invested in the focal venture.[5]

$VentureAge_{i,t-1}$ measures the number of years since the venture was founded. This variable

proxies for the growth of the startup, that enables it to increase the patent and publication output.

Econometric approach

The main econometric challenge of the paper is that CVCs choose the startups they fund. We

design our empirical strategy to address this identification issue in a variety of ways. First, we present a

univariate analysis of VC and CVC investment and the degree of patenting and publishing of the

entrepreneurial ventures. We compare the investments of VCs and CVCs and whether they lie above or

below the median patenting or publishing for the comparable cohort of ventures. By looking at two

moments in time –the time of investment by either the VC or the CVC, and four years after this

investment – we are able to differentiate the selection from the nurturing effects. We focus on the flow of

patents and publications, rather than the stock, so that we can better assess the change in trends over time.

The main set of multivariate-models, at the venture-year level, analyzes how changes in investors

for a particular venture affect the yearly patenting and publishing outcomes. We specify fixed-effects

Poisson models, estimated through quasi-maximum-likelihood, which is robust to overdispersion and to

introducing the fixed-effects (Wooldridge, 1997). Robust standard errors were calculated using the

xtpqml Stata command (Simcoe, 2007). We estimate four models, to test the four hypotheses:

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[5] On the two-stage specifications the data is cross-sectional; hence this variable is 1 for most of the observations and is not included in the specification.

$$E[Publications_{i,t}]$$
$$= exp\big(\beta^1_{CVC}CVC_{i,t-1} + \delta^1_{ivc}VC_{i,t-1} + \delta^1_{pat}Patents_{i,t-1} + \delta^1_{age}Venture\_Age_{i,t-1} + \tau^1_t$$
$$+ \theta^1_i\big)[H1]$$

$$E[Publications_{i,t}]$$
$$= exp\big(\beta^2_{Overlap}CVC\ Industry\ Overlap_{i,t-1} + \beta^2_{Non}CVC\ No\ Overlap_{i,t-1}$$
$$+ \delta^2_{ivc}VC_{i,t-1} + \delta^2_{pat}Patents_{i,t-1} + \delta^2_{age}Venture\_Age_{i,t-1} + \tau^2_t + \theta^2_i\big)[H2]$$

$$E[Patents_{i,t}] = exp(\beta^3_{CVC}CVC_{i,t-1} + \delta^3_{ivc}VC_{i,t-1} + \delta^3_{pub}Publications_{i,t-1} + \delta^3_{age}Venture\_Age_{i,t-1}$$
$$+ \tau^3_t + \theta^3_i)\ [H3]$$

$$E[Patents_{i,t}] = exp(\beta^4_{Overlap}CVC\ Industry\ Overlap_{i,t-1} + \beta^4_{Non}CVC\ No\ Overlap_{i,t-1} + \delta^4_{ivc}VC_{i,t-1}$$
$$+ \delta^4_{pub}Publications_{i,t-1} + \delta^4_{age}Venture\_Age_{i,t-1} + \tau^4_t + \theta^4_i)\ [H4]$$

The dependent variables are defined as the number of *Publications* or the number of *Patents* of venture *i* on year *t*. We define the variable as a flow to capture the change after the CVC or VC enter the syndicate. Because the independent variables are 0 before the CVC or VC enter, respectively, and 1 thereafter, they capture the change in the yearly patenting or publishing outcomes. By using a flow rather than a stock measure of output (namely, focusing on annual patent output rather than aggregate stock of patents), we are able to better identify the post-investment nurturing effect.

Finally, we complement the fixed-effects panel data models with structural models that explicitly address the matching between ventures and investors. Following the specification by Dushnitsky and Shaver (2009), we estimate in a first stage the probability that the venture is CVC-backed, and in a second stage we estimate the number of patents and publications. These models are cross-sectional, and analyze the last year of observation for each of the ventures, which is when the information is more complete. We estimate two different specifications: a treatment-effects model and a structural Poisson model. The former jointly estimates by maximum-likelihood a probit regression on the first stage, and an OLS regression on the second stage. The latter estimates the same first stage regression, and then includes the residuals of this first stage on the second stage, using bootstrap techniques to calculate correct standard errors. In the second stage we used a Poisson, that better fits the nature of the data; since we

include the residuals from the first regression, the model is robust to over-dispersion (Cameron & Trivedi, 2009: 592). While each econometric approach has unique advantages, we further emphasize that our results are mainly consistent across the two approaches.

RESULTS

Tables 2 and 3 present the descriptive statistics, with the unit of analysis being the venture-year and the venture respectively. The sample consists of 591 ventures, with 4,225 venture-year observations. On average, ventures obtain 2.54 patents and 3.36 publications on a given year, with a positive and significant correlation of 0.44 (table 2).

[Tables 2 and 3 around here]

Table 4 presents the univariate analysis of VC- and CVC-backed ventures and their distribution in terms of patents and publications. For all the VC-backed ventures, the table indicates the percentage below or above the median number of patents or publications of firms in their age cohort; and likewise for CVC-backed ventures. We present this analysis in two points in time: a) at the time of investment by the VC or CVC, respectively (panel A); and b) four years after the investment by the VC or CVC (panel B). Jointly, panels A and B identify the selection and nurturing effects. In panel A we observe how VC and CVC select more or less innovative firms along the two innovative dimensions. In panel B, changes in the level of innovativeness inform us of whether the venture lowers, maintains, or increases the year patenting (publishing) outcomes. Measuring the innovative outcomes as flows, rather than stocks, allows us to assess yearly changes and disentangle the time of selection from the time post-selection.

Panel A shows that at the time of investment 53% of VC-backed ventures are low in publications and low in patents, and 24% are low in publications and high in patents. In contrast, more than 50% of CVC investments are high in publications. The nurturing effect four years after the investment can be gauged from the changes in these percentages between panel B and panel A, hence comparing the yearly patent or publishing outcomes in two moments in time. For VCs it is still the case that most of the

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ventures fall in the low patent/low publication category. Yet, there is a noticeable change, with a change from 12% to 19% in the high/high category that may indicate a nurturing effect by VCs. For CVC trends we observe the general pattern, but more acute changes. There are a greater percentage of CVC-backed startups that fall into the high patents/high publication category (from 29% at the time of investment to 44% four years after). Overall, the data seem to support the hypotheses that CVC-backing improves both patents and publications even after accounting for selection.

[Table 4 around here]

Multivariate analyses are presented on tables 5 and 6. Table 5 presents the fixed-effects Poisson regressions, estimated by quasi-maximum-likelihood.[6] All these models include venture and year fixed effects, and control for *Venture_Age*. Model 5.1 tests the effect of CVC_{t-1} investment on *Publications* (hypothesis 1). *Patents* do not have a significant effect on *Publications*. The main effect of *CVC* on publications is positive, statistically significant, and economically relevant. In the years after the *CVC* joins the syndicate, the yearly publication output increases by 53%. This effect is far greater to the effect of *VC* (28% increase), which is marginally significant, in support of hypothesis 1. These results provide evidence that CVCs have a much greater impact on basic research than VCs.

Model 5.2 separates the effect of CVC into *CVC_Industry_Overlap* and *CVC_No_Overlap*, to analyze the effect of being in the same industry niche as the venture. We find support for hypotheses 2.a and 2.b, with positive and significant coefficients for both CVC variables, being both of them greater than the coefficient for VC investment. More importantly, we find support for hypothesis 2.c, with coefficient estimates of 0.78 and 0.50 for *CVC_Industry_Overlap* and *CVC_No_Overlap*, respectively. This

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[6] Fixed-effects models estimate the within-venture variation, and as a result all ventures with only one observation or with no change in the dependent variable drop. Hence, the number of observations is lower than in tables 2 and 3. In unreported analyses we compared the sub-samples used in the patents and publications regressions finding that: a) the sub-samples used in the patents and publications regressions have significantly more patents and more publications on average, which is explained by the fact that ventures with zero patents and zero publications throughout the period of analysis dropped in these regressions; and b) there are no significant differences between sub-sample used in the Patent models and the one used in the Publication models.

difference is statistically significant and also economically relevant, with a 28% greater effect on publications when the CVC overlaps with the startup than when it doesn't.

Model 5.3 tests the effect of CVC_{t-1} investment on *Patents* (hypotheses 3a and 3b), controlling for the investment by a VC_{t-1} firm, and also for the level of *Publications$_{t-1}$*. Consistent with the innovation literature, publications lead to an increase in patents, though the effect is small in magnitude (10 additional publications translate in a 3% increase in the patent outcome). The effect of *CVC* on *Patents* is positive and significant. Furthermore, the effect is economically relevant: the yearly patent output increases by 43% in the years after the CVC joins the investment syndicate. Compared to the 38% increase in the patent yearly output after a VC, CVCs have a greater effect on patents. Hence, we find support for hypothesis 3a, and not for hypothesis 3b.

Model 5.4 estimates the effect on patents of CVC backing when there is industry niche overlap with the venture and when there is not. Hypothesis 4.a predicted that the effect of *CVC_Industry_Overlap* was smaller than the effect of *VC* investment. Contrary to our predictions, we find that the effect is greater (45% increase in patents, compared to the 41% from VC-backing), though only marginally significant. The coefficient for *CVC_No_Overlap* is positive and significant. CVC-backing when there is a different business segment increases the patents by 44%, which is significantly greater than the 41% increase of VC-backing. Economically a 3% difference is only moderate, but it should be noted that this is a yearly effect, and so it accumulates in the years after the CVC enters. Also, since CVCs tend to fund firms which are already VC-backed, these effects are generally added to the effects of VCs.

[Table 5 around here]

These results are consistent with the univariate analyses on table 3, which showed a remarkably higher percentage of CVC-backed ventures that ranked high in both patents and publications compared to their peers. Importantly, the fixed-effect specifications control for latent venture characteristics (e.g.,

inherent innovation capabilities) and therefore further suggest the role of CVC-backing in stimulating ventures' innovativeness.

Table 6 presents the results of the two-step structural models, using a cross-sectional sample of ventures' innovation outcome during the last year of observation for each firm. The analysis complements the previous table by explicitly addressing the selection process. The first stage estimates, using a probit model, the probability of the venture being CVC-backed. The results are broadly consistent with those in Dushnitsky and Shaver's (2009). The second stage regressions estimate the *Publications* and *Patents* correcting for the selection in the first stage. The first two models estimate the two stages jointly by maximum-likelihood, and assume the count of *Publications* and the count of *Patents* behave approximately as a linear variable. The last two columns estimate the first stage and include the residuals in second-stage Poisson model, using bootstrap techniques to calculate the standard errors. The results are robust with the fixed-effect Poisson models: the presence of a CVC fosters the *Publications* and *Patents* yearly counts. The magnitude of the effects is greater in size than in table 5, but it should be interpreted "between ventures" as opposed to "within ventures." According to the models 6.3 and 6.4, CVC-backed ventures have 100% more publications and 124% more patents than non-CVC-backed ventures, even after adjusting for selection effects.

[Table 6 around here]

DISCUSSION AND CONCLUSION

This paper analyzes the effect of CVC investment, compared to VC investment, on two types of innovative outcomes of startups: scientific publications, as the outcome of basic research, and patents, as the outcome of applied research. We found that CVC-backing greatly increases the basic research outcomes of the venture, with effects that more than double the effect of a VC joining the syndicate. We argue that with greater incentives to foster basic research, as a ticket of admission to applied research (Rosenberg, 1990), and with a greater pool of resources and knowledge (Acs *et al.*, 1997), CVC parent

firms help the firms greatly increase their scientific discoveries. These effects are even stronger when the parent of the CVC and the venture operate in the same industry niche, because there are greater complementarities in the knowledge-base of the two firms.

The dynamics are very different when we analyze the effect of CVC on patents. While the effect is positive and greater than that of VCs, this is the outcome of two opposite effects. On one hand, CVC parent firms have resources and knowhow above and beyond those of VCs, and are therefore capable of nurturing the venture's applied research. And yet, these same resources and infrastructure provide an alternative avenue to the venture to profit from the innovation, avoiding the costly patenting process. Notwithstanding, the corporation may also have incentives to expropriate the technology to commercialize it on its own. By distinguishing between CVCs in the same industry niche as the venture – where there are more incentives to internalize the innovation – and CVCs in a different industry niche, we conclude that both processes are operating simultaneously.

The paper seeks to contribute to the CVC literature by showing that CVCs are not just an alternative source of financing. They provide entrepreneurial ventures with valuable resources that allow them to increase the rate of innovation by an economically significant amount. Our results further suggest that when the venture and CVC pair operate in the same industry niche, the resources of the latter provide the venture with an alternative way to profit from their innovation. Yet, the corporation is also in a position to expropriate the technology developed by the venture. The effects of CVC on the innovation processes are, therefore, not neutral to the competition between the two, showing that this is a case where the knowledge sharing dynamics pointed out by the strategic alliance literature are aggravated.

We have also sought to contribute to the literature on basic vs. applied research, by analyzing the drivers of these two different types of innovation. Our results are consistent with previous findings, which show that basic research leads to applied research, but not necessarily (Stern, 2004). Importantly, we find that not only do ventures have an incentive to do both applied and basic science (Rosenberg, 1990), but

corporations also have an incentive to foster the basic research of the startups they fund. This suggests that they benefit in some way from this knowledge spillovers, and is consistent with the idea of corporate investing as a window into other technologies (Dushnitsky & Lenox, 2005b).

Our research has implications for ventures, CVCs and their parents, and for public policy. When seeking additional funding, entrepreneurial ventures should better understand the implications of being financed by an established corporation. In particular, they should evaluate the resources that the corporation may share with them, and the extent to which these resources are valuable for their innovation processes. Moreover, whether the venture is a competitor or whether they have a focus on basic vs. applied science are also important issues to consider.

Finally, given the innovation contribution of CVC-backing, policy makers should reward CVC investment in a similar manner to their support of venture capital funds. At this time of crises, when reactivating the innovation and the damaged entrepreneurial net is needed the most, and when individual investors are more risk averse than ever before, strengthening the investment of corporations may be one important step for the future of the economy.

TABLES

Table 1. Sample distribution by year of founding

Year of founding	No. of Ventures
1990	19
1991	24
1992	47
1993	35
1994	40
1995	41
1996	43
1997	61
1998	53
1999	44
2000	63
2001	54
2002	35
2003	32
All sample	591

Table 2. Descriptive Statistics, panel data analyses.

		Mean	s.e.	Min	Max	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
(1)	$Patents_t$	2.54	7.96	0	245								
(2)	$Publications_t$	3.36	9.13	0	209	0.44							
(3)	CVC_{t-1}	0.21	0.41	0	1	0.11	0.19						
(4)	$CVC\_Industry\_Overlap_{t-1}$	0.04	0.19	0	1	0.00	0.04	0.40					
(5)	$CVC\_No\_Overlap_{t-1}$	0.17	0.37	0	1	0.12	0.19	0.88	-0.09				
(6)	VC_{t-1}	0.72	0.45	0	1	0.09	0.15	0.19	0.05	0.18			
(7)	$Publications_{t-1}$	2.85	8.59	0	209	0.40	0.90	0.19	0.04	0.19	0.15		
(8)	$Patents_{t-1}$	2.38	7.87	0	245	0.80	0.49	0.12	0.00	0.13	0.10	0.46	
(9)	$Venture\_Age_{t-1}$	3.90	3.19	0	14	0.10	0.26	0.24	0.09	0.21	0.35	0.30	0.15

No. venture-years = 4,225 (no. ventures 591)

Table 3. Descriptive Statistics, cross-section analyses (at the time of the last observation)

		Mean	s.e.	Min	Max	(1)	(2)	(3)	(4)	(5)	(6)	(7)
(1)	Patents	1.65	3.87	0	41							
(2)	Publications	3.76	8.80	0	141	0.47						
(3)	CVC	0.36	0.48	0	1	0.16	0.17					
(4)	Investor_Biotech_Experience	0.44	0.30	0	1	0.09	0.11	0.39				
(5)	Proximity	6.27	5.34	0	16	-0.02	0.01	0.02	0.11			
(6)	CVC_Size	185.74	416.74	0	1552	0.20	0.17	0.54	0.21	0.02		
(7)	Venture_Quality	0.20	0.40	0	1	0.34	0.41	0.14	0.12	0.01	0.18	
(8)	Venture_Age	7.15	3.44	0	15	0.10	0.23	0.04	-0.03	-0.11	0.01	0.40

No. ventures = 591

Table 4. Distribution of VC- and CVC-backed ventures by their relative patenting and publication levels.

Panel A. At time of investment by VC or CVC
(VC-backed; CVC-backed)

	Publication Flow ≤ median value	Publication Flow > median value
Patent Flow ≤ median value	(53%, 34%)	(11%, 25%)
Patent Flow > median value	(24%; 12%)	(12%, 29%)

No. of Ventures: 377 VC-backed, 214 CVC-backed.
At time of investment by VC: Age median=1, Patent Flow median=0, Publication Flow Median=0.
At time of investment by CVC: Age median=3, Patent Flow median=1, Publication Flow Median=0.

Panel B. Four years post investment by VC or CVC.
(VC-backed; CVC-backed)

	Publication Flow ≤ median value	Publication Flow > median value
Patent Flow ≤ median value	(48%, 26%)	(19%, 19%)
Patent Flow > median value	(13%, 11%)	(20%, 44%)

No. of Ventures: 230 VC-backed, 111 CVC-backed.
4 years post-VC investment: Age median=5, Patent Flow median=1, Publication Flow Median=1.
4 years post-CVC investment: Age median=6, Patent Flow median=1, Publication Flow Median=1.

Table 4 classifies ventures into CVC-backed (if they are funded by a CVC during the window of observation) or by VC-backed (if they are not funded by a CVC). Note that CVC-backed ventures are often VC-backed, issue which will be analyzed in further analyses.
For all ventures that are VC-backed, we calculate the median number of patents and publications at the time of VC investment (generally at year 1). Likewise, we calculate the median for CVC-backed ventures, which are typically funded around year 3. Then, we calculate the proportion of VC-backed ventures that fall into each of the four cells, and the corresponding proportions for the CVC-backed ventures.
On Panel B there are about half the observations than on panel A. This attrition is driven by the right-censoring in the data; ventures that are observed less than five or six years do not show on Panel B.

Table 5. Poisson Panel Fixed-Effects regression on Patents and on Publications, estimated by quasi-maximum-likelihood

Model	5.1	5.2	5.3	5.4
Dependent Variable	Publications	Publications	Patents	Patents
CVC_{t-1} [H1, H3]	0.53***		0.43***	
	(0.11)		(0.12)	
$CVC\_Industry\_Overlap_{t-1}$ [H2a,H4a]		0.78**		0.45+
		(0.25)		(0.26)
$CVC\_No\_Overlap_{t-1}$ [H2b,H4b]		0.50***		0.44***
		(0.11)		(0.13)
VC_{t-1}	0.28+	0.25	0.38**	0.41***
	(0.16)	(0.16)	(0.12)	(0.12)
$Patents_{t-1}$ [a]	0.05	0.05		
	(0.04)	(0.04)		
$Publications_{t-1}$ [a]			0.03*	0.03*
			(0.01)	(0.01)
$Venture\_Age_{t-1}$ [b]	0.32*	0.32*	0.41	0.41
	(0.16)	(0.16)	(0.32)	(0.32)
Venture fixed-effects	Yes	Yes	Yes	Yes
Year fixed-effects	Yes	Yes	Yes	Yes
No.venture-years	3,484	3,381	3,572	3,481
No.ventures	456	440	458	446

Robust standard errors in parentheses

*** p<0.001, ** p<0.01, * p<0.05, + p<0.10

Attrition in the fixed-effects models is due to: a) ventures with only one venture-year, or b) ventures with no change in Publications (Patents) drop from Publications (Patents) regressions. There are missing data in the CVC_SIC_Overlap and CVC_No_Overlap variables.

[a] Linearly transformed for ease of interpretation. Unit: 10 publications or 10 patents, respectively.

[b] Winsorized (for convergence). $Venture\_Age_t \geq 13$ is assigned a value of 13.

Table 6. Two-Stage Structural Models on Patents Flow and Publications Flow, at time of last observation of the data

Model (estimation technique)	6.1 Treatment-Effects (Maximum Likelihood)	6.2 Treatment-Effects (Maximum Likelihood)	6.3 Two-step structural model (bootstrap)	6.4 Two-step structural model (bootstrap)
First Stage, DV	CVC	CVC	CVC	CVC
Investor_Biotech_Experience	0.88***	0.77***	0.89***	0.89***
	(0.19)	(0.19)	(0.19)	(0.19)
Proximity	-0.05***	-0.04***	-0.05***	-0.05***
	(0.01)	(0.01)	(0.01)	(0.01)
CVC_Size[a]	0.22***	0.22***	0.22***	0.22***
	(0.05)	(0.05)	(0.05)	(0.05)
Venture_Quality	0.40*	0.42*	0.28	0.28
	(0.19)	(0.18)	(0.18)	(0.18)
Age[b]	-0.11***	-0.10***	-0.10***	-0.10***
	(0.01)	(0.01)	(0.01)	(0.01)
Second Stage, DV	Publications	Patents	Publications	Patents
CVC [H1, H2]	3.73***	2.29**	1.00***	1.24**
	(1.10)	(0.77)	(0.29)	(0.40)
Patents[a]	9.66*		0.71***	
	(3.95)		(0.19)	
Publications[a]		1.89***		0.21
		(0.21)		(0.15)
Age[b]	0.54***	0.06	0.15***	0.05+
	(0.11)	(0.04)	(0.02)	(0.03)
Constant	-3.14**	-0.40	-0.56*	-0.63*
	(1.11)	(0.51)	(0.28)	(0.31)
Residuals First Stage			-0.26*	-0.40**
			(0.12)	(0.14)
No.Venture-Years	591	591	591	591
LR test of independence	5.98*	12.45***		

Robust standard errors in parentheses

*** $p<0.001$, ** $p<0.01$, * $p<0.05$, + $p<0.10$

[a] Linearly transformed for ease of interpretation. Unit: 10 patents, 10 publications; CVC_Size was divided by 100.

[b] Winsorized (for convergence). $Venture\_Age_t \geq 13$ is assigned a value of 13.

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