

**Entrepreneurial Spawning:
Public Corporations and the Genesis of New Ventures, 1986-1999**

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This paper examines the factors that lead to the creation of venture capital-backed entrepreneurs, a process we term “entrepreneurial spawning.” We contrast two alternative views of the spawning process. In one view, employees of established firms are trained and conditioned to be entrepreneurs by being exposed to the entrepreneurial process and by working in a network of entrepreneurs and venture capitalists. Alternatively, individuals become entrepreneurs because the large bureaucratic companies for which they work are reluctant to fund their entrepreneurial ideas. After controlling for a variety of firm characteristics including its patent portfolio and industry, we find that the most prolific spawning firms were public companies located in Silicon Valley and Massachusetts that were themselves once VC-backed. Less diversified firms are also more likely to spawn new firms. Spawning levels for these firms rise as their sales growth declines. Overall, these findings appear to be more consistent with the view that entrepreneurial learning and networks are important factors in the creation of venture-capital backed firms.

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Introduction

There is now a large and growing literature analyzing the factors that determine whether entrepreneurs raise venture capital (VC) funding (Hellmann and Puri [2000]; Burton, Sørensen, and Beckman [2002]) and the factors that affect the terms of this financing (Gompers [1997], Kaplan and Stromberg [2002]). There is much less understanding of how these VC-backed entrepreneurs come to be entrepreneurs in the first place. In this paper, we try to fill this gap by examining the factors that lead to the creation of VC-backed entrepreneurs, a process we term “entrepreneurial spawning.”

We contrast two alternative views of the spawning process. In one view, employees of established firms are trained and conditioned to be entrepreneurs by being exposed to the entrepreneurial process and by working in a network of entrepreneurs and venture capitalists. The prolific spawning of entrepreneurial firms by Fairchild Semiconductors and its descendents is a prominent example of “how entrepreneurial learning and networks may function,” as Saxenian [1994] writes. Fairchild was founded by eight engineers who left Shockley Semiconductor with \$1.5 million in venture capital funding from Arthur Rock, one of the early (and later most successful) venture capitalists. While the “Traacherous Eight” succeeded as inventors of the first integrated circuit in 1959, the founders and other engineers soon began to leave Fairchild to begin firms of their own. Saxenian notes that between 1957 and 1976, at least 23 out of 67 entrants to the semiconductor industry had at least one founder who worked for Fairchild (Braun and Macdonald [1982]), including Advanced Micro Devices, Intel, and National Semiconductor, almost all of which were based in Silicon Valley.

In this view, individuals already working for entrepreneurial firms, particularly those already backed by venture capitalists and located in hotbeds of venture capital activity—notably Silicon Valley and Massachusetts—may find launching their own venture less daunting than others might. This may be the case for a number of reasons. First, working in such firms exposes would-be entrepreneurs to a network of suppliers of labor, goods, and capital, as well as a network of customers (Saxenian [1994]). Because starting a new venture requires suppliers and customers to make relationship-specific investments before it is guaranteed that the venture will get off the ground, networks can be particularly useful in alleviating this chicken-and-egg problem (Hellmann [2002]). Second, would-be entrepreneurs learn how to found companies by participating in the entrepreneurial process alongside other, more experienced entrepreneurs. Finally, individuals with a higher taste for risky activities may have already found their way to entrepreneurial firms, consistent with the sorting processes hypothesized by Jovanovic [1979], Holmes and Schmidt [1990] and Gromb and Scharfstein [2002]. We refer to this depiction of entrepreneurial spawning as the “Fairchild view.”

An alternative view of the entrepreneurial spawning process is that individuals become entrepreneurs because the large bureaucratic companies for which they work are reluctant to fund their entrepreneurial ideas. The most prominent example of this is Xerox, which developed many of the key technologies underlying the growth of the personal computer, but which failed to commercialize these technologies (summarized in Hunt and Lerner [1995]). In 1969, Xerox chief executive Peter McCollough commissioned the firm’s head of research to build a new laboratory to provide the company with the technology to move the firm from being the leading office copier

company to being the dominant supplier of information-intensive products (Chesbrough [2002]). The Palo Alto Research Center (PARC) was formed to house this group in 1970. The firm hired outstanding researchers for this new technical initiative, including physicists, mathematicians, materials scientists, computer system architects, and software engineers. PARC proved to be enormously fertile, inventing such technologies as laser printing, the Ethernet, the graphical user interface, and personal distributed computing. Despite appeals by PARC leaders to invest in commercializing these innovations, the firm's Rochester, New York-based executives resisted such expenditures. Instead, the vast bulk of the value from these inventions was captured by employees who left Xerox to found companies such as Adobe Systems and 3Com (as well as licensees such as Apple Computer).

There are at least three reasons that large, established firms might be more prone to spawn entrepreneurial ventures. (We will refer to this as the “Xerox view” of entrepreneurial spawning.) First, it may be that firms are incapable of responding to radical technological changes that upset the established ways of organizing their businesses. Christensen [1997], perhaps the most visible proponent of this view, has written about the failure of companies to capitalize on “disruptive technologies”:

Why was it that firms that could be esteemed as aggressive, innovative, customer-sensitive organizations could ignore or attend belatedly to technological innovations with enormous strategic importance? ... Finding new applications and markets for new products seems to be a capability that each of these firms exhibited once, upon entry, and then apparently lost. It was as if the leading firms were held captive by their customers, enabling attacking entrant firms to topple the incumbent industry leaders each time a disruptive technology emerged (Christensen [1997], p. 24).

Henderson [1993] presents evidence of the organizational incapacity of firms to respond to technological change. Using data from the semiconductor photolithography industry, she shows that incumbents were consistently slower than entrants in developing and introducing new technologies.

A second, related reason why large, established companies may spawn more is that high-level managers at these firms are incapable of evaluating these entrepreneurial opportunities because they fall outside the company's core line of business. Assessing these opportunities may also require the analysis of "soft information," which hierarchical organizations may have a hard time doing (Stein [2002]; Berger, *et al.* [2002]). Moreover, the internal capital market tends to favor established lines of business over less established, but perhaps more promising businesses (Scharfstein [1998]; Scharfstein and Stein [2000]). These arguments suggest that a considerable amount of entrepreneurial spawning should come from large established firms, where these problems are presumably most severe.

Finally, it is also possible that the level of entrepreneurial spawning would be high among these firms not because of any sort of inefficiency at these firms, but rather because these firms wisely choose to focus on their core business or "core competence." The wisdom of focusing on one's "core competence," has been a mainstay of management consulting since the 1980s. It is also supported by the findings that: diversified firms tend to trade at a discount to a portfolio of comparable focused firms (Berger and Ofek [1995]); firms that diversified excessively during the 1960s and 1970s were more likely to be acquired and broken up in the subsequent two decades; and when firms diversified into unrelated businesses, the productivity of their existing businesses

declined (Schoar [2002]). Thus, in this view, even though good entrepreneurial ideas might be germinated at these firms, management wisely chooses not to develop them because it would do more harm than good to their core businesses.

This paper is an empirical exploration of the Fairchild and Xerox views of the entrepreneurial spawning process. To analyze these perspectives on spawning, we assemble a database of employees who leave public companies to start venture capital-backed firms during the period 1986-1999. From these data, we are able to calculate the spawning levels of public companies. We then relate these spawning levels to firm characteristics in a cross-sectional analysis and examine how these spawning levels change over time for particular firms.

Controlling for firm size, the patent portfolio, and industry, we find that the most prolific spawning firms from 1986-1999 were public companies located in Silicon Valley and Massachusetts that were once VC-backed themselves.. These effects are substantial: being located in Silicon Valley increases the spawning level by almost 38%; public companies in Massachusetts have a 23% higher spawning level; and companies that were once VC-backed have a 23% higher spawning level.

Diversified firms appear to spawn less, not more. Firms focused in one segment have spawning levels 19% higher than those operating in multiple segments. Moreover, after controlling for the quantity, quality, and originality of patents that firms have in the areas of principal interest to venture capitalists (computers and communication as well as drugs and medical), the existence of other types of patents in the portfolio (e.g., mechanical patents) tends to reduce a company's spawning level. This result is inconsistent with the notion that more diversified firms will spawn more. Our findings

appear to be more consistent with the notion that diversified firms are less entrepreneurial and thus less prone to have the sorts of people who would have the inclination, ability, or skills to start new VC-backed firms.

One competing interpretation of our findings is that VC-backed firms in Silicon Valley and Massachusetts have high spawning levels not because of entrepreneurial learning, networks or attributes, but simply because they have technologies and operate in businesses that are of more interest to venture capitalists in the first place (as, for instance, the tabulations in Kortum and Lerner [2000] suggest). While this remains a possible explanation, it is worth noting that we have controlled extensively for patent characteristics (quantity, class, quality, and originality) and industry. Thus, if high spawners simply function in fields of greater relevance to venture capitalists, they must do so in a way that is neither observable to us nor captured by our patent and industry controls. One could also argue that our finding of high spawning levels among focused firms arises because more of the company's businesses are in areas of interest to venture capitalists. Here, too, one would have to argue that this is true after controlling for industry and patent composition. Of course, the ideal approach would be to use instruments for the variables of interest, but it is hard to find exogenous determinants of location, prior financing, and focus.

The final empirical section of the paper examines how spawning levels change over time for firms. Thus, we construct a panel of annual spawning levels for firms with patents in areas of interest to venture capitalists. When we use firm fixed effects in our regression analysis, we find that firm spawning levels are lower when a firm's past sales growth is high relative to the firm's mean level of growth. We interpret this finding as

indicating that when firms are growing rapidly, employees choose to stay at their firms (and perhaps develop their entrepreneurial ideas internally) because they perceive the rents from doing so to be high. When growth slows, however, employees are more prone to seek entrepreneurial opportunities outside the firm.

The rest of the paper is organized as follows. Section I describes the construction of the data set and summarizes the data. The analysis is presented in Section II. Section III concludes the paper, discusses some implications of our findings, and highlights other research opportunities in this area.

I. Constructing the Data Set

The core data for the analysis come from VentureOne. VentureOne, established in 1987, collects data on firms that have obtained venture capital financing. Firms that have received early-stage financing exclusively from individual investors, federally chartered Small Business Investment Companies, and corporate development groups are not included in the database.

The companies are initially identified from a wide variety of sources, including trade publications, company Web pages, and telephone contacts with venture investors. VentureOne then collects information about the businesses through interviews with venture capitalists and entrepreneurs. The data collected include the identity of the key founders (the crucial information used here) and the industry, strategy, employment, financial history and revenues of the firm. Data on the firms are updated and validated through monthly contacts with investors and firms.

For the purposes of this analysis, we examine the founders and initial executive officers (henceforth referred to as “entrepreneurs”) that joined firms listed in the VentureOne database during the period from 1986 and 1999.¹ Typically, the database reported the previous affiliation and title of these entrepreneurs, as well as the date they joined the firm. In some cases, however, VentureOne did not collect this information. In these cases, we attempt to ascertain the information, examining contemporaneous news stories in LEXIS-NEXIS, securities filings, and web sites of surviving firms.² We believe this data-collection procedure may introduce a bias in favor of having more information on successful firms, but it is not apparent to us that it affects our analysis.

Table I summarizes the population of entrepreneurs and their venture capital-backed start-up firms. First, the table presents the number of entrepreneurs that joined new venture capital-backed companies in the VentureOne database by the year that they joined those venture-backed firms, as well the number of new venture capital-backed firms that these entrepreneurs joined in each year. We also list the number of venture-capital backed technology companies. We then present the number of entrepreneurs who held at least one of three key titles in the new company—CEO, president, and chief technical officer (CTO)—as well as the count of entrepreneurs who left firms that were publicly traded.

¹We did not include events in earlier periods because of concerns about selection biases. VentureOne has “back-filled” data on entrepreneurial firms through the early 1980s, but firms that did not survive until 1987 were not added to the database. Due to lags in identifying and surveying firms, at the time this study was initiated, the 2000 and 2001 data were substantially less complete than in other years.

²When we were unable to ascertain the year in which the individual joined the firm, we used the year in which the firm was formed, which was the modal answer in cases where we had complete data. This does introduce some empirical difficulties, as we discuss below.

Finally, we report the share of entrepreneurs that were from entities that were publicly traded at the time of their departure.

Two observations should be highlighted from the summary statistics. First, the level of activity has risen over the period, reflecting the more general growth of the venture capital industry over these years.³ The number of entrepreneurs joining venture capital-backed start-ups increases from 483 in 1986 to 1717 in 1999. Similarly, the number of distinct venture capital-backed firms represented in the sample increases from 218 in 1986 to 799 in 1999. Second, the share of entrepreneurs that emerge from publicly traded firms is significant. The first measure we report calculates the share as a percentage of all entrepreneurs. This measure suggests that there has been an increase of about 40% over this period in the share of entrepreneurs coming from public companies (from 30% to 42% of the entire sample of entrepreneurs). There are many entrepreneurs, however, for which the database reports no prior work history. If one excludes these entrepreneurs from the calculation, the share of entrepreneurs coming from public companies appears more stable, averaging approximately 45% per year. The difference in these findings is probably attributable to the more complete reporting of prior work histories in later years.

The data on entrepreneurs are linked to information on the companies that spawned them. In particular, we determine whether the entrepreneur had previously been employed at a publicly traded firm in the United States, and, if so, we link it to the appropriate firm in

³The reader may be puzzled by the fact that the volume of spawned venture capital-backed start-ups falls in 1999, which was a record year for venture capital activity. This decline reflects the fact that the years reported are those where the entrepreneurs joined the new firms, not the year of first venture capital financing. Because the financing of early-stage firms dropped sharply after the April 2000 plunge in the NASDAQ, the volume of entrepreneurs joining ultimately funded venture capital-backed start-ups may have been lower.

the Compustat and Center for Research into Securities Prices (CRSP) databases. We also identify the spawning firm's patents (and their characteristics) using the National Bureau of Economic Research's (NBER) Patent Citation Data File (summarized in Hall, Jaffe, and Trajtenberg [2001]). This database links patent data from the U.S. Patent Office to Compustat through 1989. We update the link for companies listed in Compustat after 1989.⁴

Table II lists the firms and industries that were most active in spawning new firms. Panel A lists the 48 publicly traded corporations that spawned ten or more entrepreneurial teams during the sample period. (Multiple individuals departing to establish a firm are regarded as a single team). Panel B describes the top three-digit Standard Industrial Classification (SIC) codes in which the most spawners operated. (Each firm is assigned to one three-digit SIC code, based on the primary industry assigned in Compustat.) The dominant importance of firms in the software, computer and office equipment, and drug industries is apparent. The concentration of entrepreneurs spawned from public firms in these industries closely mirrors the overall investment pattern of the venture capital industry. It is not surprising that the venture capitalists would look to finance entrepreneurs with relevant technology experience.

Table III compares spawning firms to non-spawning firms. We take averages for each company that ever spawned a VC-backed start-up in the VentureOne database during these years: *i.e.*, those that spawned at least one entrepreneur over the time period. We

⁴ Because there are a very large number of companies listed in the patent database, it was not feasible to scan the entire database for possible links to Compustat. Thus, we listed all companies in the patent database with at least two patents in the computers and communication and medical and drugs patent categories and narrowed our search of public companies to this subset of patent holders.

contrast these firms to those that spawned no VC-backed firms. For the purposes of interpreting our later results, we report summary data only on those firms that end up in our basic regression analysis.

The tabulation reveals that spawning firms tend to be significantly larger than non-spawners. For instance, the median spawning firm has 60% higher sales, 90% greater assets, and 170% more employees. Tobin's Q is calculated as the ratio of the market value of the firm to the book value of its assets, following the procedure delineated in Kaplan and Zingales [1997]. Because the distribution of Tobin's Q has a dramatic rightward skew, we report winsorized versions of this measure, cutting off the distribution at a Q of 10, roughly corresponding to the 99th percentile. The mean Q of spawning companies (2.75) is somewhat higher than the mean Q of non-spawning firms (2.54). The difference in the medians is much larger: 2.18 versus 1.71. The average EBITDA to assets ratio is not appreciably different across the two sub-samples but sales growth is considerably higher among the spawning firms.⁵

In addition to looking at differences in the financial performance of spawning and non-spawning firms, we also tabulate whether the headquarters of these firms are in Silicon Valley or Massachusetts and whether the firm itself was VC-backed. Prior VC backing is determined by linking our companies to the Venture Economics database of all venture capital financings up until 1996 (discussed in Gompers and Lerner [1999]), and then supplemented with the annual listing of venture capital backed IPOs in *Venture Capital*

⁵These measures are also winsorized. In the case of EBITDA to assets we cut off any ratios below -0.5 and above 0.5 and in the case of sales growth we cut off any rates above 10.

Journal. Following Saxenian [1994], we define Silicon Valley as California's Alameda, San Mateo, and Santa Clara counties. Although the hub of start-up activity in Massachusetts is around Route 128 (Middlesex County), the state is small enough that it is not meaningful to make distinctions among the counties of Massachusetts.⁶ We determine the headquarters' location from Compustat. Spawning firms are much more likely to have been VC-backed themselves (35.5% vs. 12.2%) and to be located in the hubs of venture capital activity, Silicon Valley and Massachusetts.

The table also lists information on the degree of focus of the spawning and non-spawning firms. We consider a firm focused if it reports just one industry segment in its filings with the Securities and Exchange Commission.⁷ Spawning firms tend to be more focused even though they are substantially larger.

Not surprisingly, spawning firms have considerably more patents over the period from 1980 to 1999, particularly in patent classes that are most relevant to venture capital, *i.e.*, patents with a primary assignment to category 2, "Computers and Communications," or category 3, "Drugs and Medical," using the classification scheme in the NBER data file.

⁶ We code the entrepreneur as being spawned from the most recent company for which he worked even though he may have a wealth of experience working at other types of companies.

⁷ There are a number of limitations of this focus measure. One is that firms have discretion in what businesses they choose to lump together into a business segment. Thus, some single-segment firms that pool a number of businesses into one segment may be no more focused than a multi-segment firm that breaks them out. Another limitation is that some of the multiple segment firms may have quite related businesses across different segments. Our measure takes no account of those relationships. In either case, we believe that on average the firms we categorize as focused will indeed be more focused than the other firms in the sample.

Finally, the table reports information on the average quality and originality of patents in categories 2 and 3 for these companies. The standard measure of patent quality (see the extended discussion in Jaffe and Trajtenberg [2002]) is the number of citations the patent receives. We use this citation measure of quality, adjusting for the year in which the patent was granted and the sub-category of the patent.⁸ Thus, our quality measure is the firm fixed effect in a regression of a patent's citations on a set of dummy variables for the year in which the patent was granted and the patent sub-category. The table indicates that the average patent quality of spawning firms is higher than that of non-spawning firms.

Recent research (summarized in Jaffe and Trajtenberg [2002]) has highlighted the importance of the measure of patent originality. A patent is considered more original if it cites patents across more patent categories, as it is more likely to synthesize knowledge across a variety of disciplines. We use this measure reported in the NBER patent database, again adjusting for the granting year of the patent and the patent's sub-category. The table shows that the average originality of patents held by spawning firms is lower than that of non-spawning firms.

II. Analysis

We present the results here in four sub-sections. We start in sub-section II.A by analyzing the factors that affect the total number of venture capital-backed start-ups that public companies spawn over the entire sample period, 1986-1999. In the next two sub-

⁸ The NBER database includes four subcategories for Computers and Communications: "Communications," "Computer Hardware and Software," "Computer Peripherals," and "Information Storage." There are four sub-categories for Drugs and Medical: "Drugs," "Surgery and Medical Instruments," "Biotechnology," and "Miscellaneous."

sections, II.B and II.C, we examine the extensive and intensive margins of spawning--*i.e.*, the factors that determine whether a firm spawns at all and the factors that determine how much spawning a firm undertakes conditional on spawning at least one firm. We then examine in sub-section II.D whether the factors that explain overall spawning levels explain spawning levels on a yearly basis. In this sub-section we also look at the annual spawning levels in a model with firm fixed effects. Thus, we are able in this part of the paper to examine the time-varying characteristics that affect whether a firm's spawning level is above or below its own mean.

A. The Determinants of Total Spawning

In this section, we analyze the factors that affect the total number of venture capital backed companies spawned by public companies during the sample period 1986-1999. One issue that we face from the outset is that some firms will have very little spawning activity simply because they specialize in areas that are of little interest to venture capitalists. Indeed, historically, more than 80% of venture capital disbursements have gone to firms in the information technology and health-related fields. Thus, for the bulk of the analysis, we will restrict our analysis to firms who were awarded at least one patent between 1981 and 1999 in NBER patent categories 2 (computer and communications) or 3 (drugs and medicine), which correspond to areas of greatest interest to venture capitalists.

As the dependent variable, we use the logarithm of the number of venture capital-backed start-ups that the firm spawns over the sample period (plus the number one to avoid dropping non-spawning firms). When more than one person leaves a given

company in a given year to form a particular firm, we still count it as one firm that was spawned. In some of the analyses we look only at spawning of start-ups in technology intensive businesses for which the patents in categories 2 and 3 are most relevant. As shown in Table 1, these spawned firms account for roughly two-thirds of the companies spawned in a given year.

We start by looking at overall spawning because of our inability to identify the spawning date with certainty for every venture capital-backed company. In many cases, VentureOne does not report the date on which the entrepreneur joined the start-up. In these cases, we tried to fill in this information from publicly available information, but in many of them, we were unsuccessful. When we could not find the information from other sources we used the founding date of the start-up. There are, however, a number of cases in which the founding date of the company precedes the founding date of the public company, indicating that the entrepreneur most likely joined at a later time. These observations are dropped from the analysis when annual spawning levels are analyzed. This tends to disproportionately reduce the measured spawning levels of young public companies. Of course, looking at overall spawning levels has its own limitations, the most important of which is that it does not allow us to examine the time dynamics of spawning. Since there is no perfect solution to this problem, we analyze the determinants of total spawning levels here and annual spawning levels in sub-section II.D below.

The first column of Table IV reports the results of a cross-sectional regression in which the dependent variable is the log of a firm's total spawning. The mean of this variable is 0.482, indicating that the average firm spawns 0.619 firms between 1986 and 1999. The regressors in this analysis are: (1) the log of the total number of patents the

firm was granted between 1981 and 1999 in each of the six NBER patent categories (as described in Hall, Jaffe, and Trajtenberg [2001]); (2) the mean of logarithm of the firm's assets over the sample period expressed in 1996 dollars; (3) the mean ratio of EBITDA to assets; (4) the mean annual growth of real sales; (5) the mean of annual Q; (6) a dummy variable that equals one if the firm was venture capital-backed; (7) separate Silicon Valley and Massachusetts dummies; (8) the mean of the firm's focus dummy; (9) the quality of patents in categories 2 and 3; and (10) the originality of the patents in categories 2 and 3. Because the firms are in the sample for different numbers of years, we also include a set of dummy variables for each year the firm is in the sample. The t-statistics are based on heteroskedasticity-adjusted standard errors that allow for non-independence of observation across firms within the same 2-digit SIC code.

Not surprisingly, the coefficients of the patent quantities in categories 2 and 3 are positive and highly statistically significant. The coefficient indicates that the elasticity of spawning with respect to patenting in category 2 is 0.235 and that the elasticity in category 3 is 0.141. It is noteworthy also that this elasticity is less than one; doubling a company's patents generates significantly less than twice as many spawned entities. There may be several explanation of this. First, not all businesses are based on patents and technological know how; patents may be irrelevant for these spawned entities. Second, many patents may have no immediate practical business value. If larger firms with more patents are more likely to have such patents (perhaps because they have internal patent departments that reduce the cost of applying for patent awards, and thus make it worthwhile to apply for more marginal awards), the incremental impact of a patent on spawning activity could be lower. A third possibility is that some patenting

may be an attempt to limit the extent to which employees take their ideas and start new ventures. Finally, to the extent that we have included other measures of size, such as the logarithm of real assets, these variables may be picking up some of the effect of an increase in patenting.

Interestingly, the coefficients on the other four patent categories are all negative and, in the case of mechanical patents (category 5) and other patents (category 6), they are statistically significant. This finding suggests that having research activities outside of the main venture-capital-related areas reduces the level of spawning. This is not consistent with the Xerox view that spawning is a consequence of corporate bureaucracy. It is, however, consistent with the Fairchild view to the extent that firms operating in multiple areas of research tend to be less entrepreneurial in style and attract a less entrepreneurial type of employee. We discuss this and related findings later in this section.

The table also indicates that firms with more assets spawn more firms, which is not surprising given that the dependent variable is not size adjusted. There is no statistically significant link between spawning and EBITDA over assets, nor with one-year real sales growth. High Q firms do, however, spawn more. There are many potential explanations for this finding. One plausible explanation is that firms have high Q because they are expected to develop new businesses. The ideas for these new businesses are generated by the firm's employees and some of them may choose to develop the ideas on the outside, backed by venture capital.

The coefficient of the venture capital dummy is positive, large and highly statistically significant. The estimate of 0.264 indicates that, all else equal, public

companies that were once venture capital backed spawn 26.4% more firms than those that were not venture capital backed. The coefficient of the Silicon Valley dummy indicates that public companies based in Silicon Valley spawn 37.7% more firms than those based outside the two hubs of VC activity. The coefficient estimate on the Massachusetts dummy is also large and statistically significant; while smaller than the effect of being in Silicon Valley, the effect is comparable in size to that of being VC-backed.

The result that venture capital-backed firms spawn more is consistent with the Fairchild view of spawning. In this view, employees of VC-backed firms learn how to be entrepreneurs through the experience of working in an entrepreneurial environment. They may also have greater exposure to the network of suppliers of goods, capital, and labor, as well as customers. And, employees that select into venture capital backed firms may be less risk averse, and thus more willing to accept the risks associated with starting a new company. While it is difficult to determine the precise mechanism through which employment at a venture capital backed firm affects the amount of spawning, the effect is quite strong in the data. The finding does not appear to be consistent with the alternative Xerox view of spawning.

The positive effect of being located in Silicon Valley and Massachusetts is also consistent with the Fairchild view. In both regions, employees have a closer connection to a network of suppliers of goods, capital and labor that is critical to the creation of a new enterprise. Saxenian [1994] argues that being located in a region with other small entrepreneurial firms makes it easier to find companies that are willing to supply critical inputs. She argues that this effect is stronger in Silicon Valley than in Massachusetts because the latter region tends to have larger, more vertically integrated firms. Although

we estimate a larger effect in Silicon Valley than in Massachusetts, it would be a stretch to say that we have confirmation of Saxenian's claim.

We also find that a firm's average level of focus is positively related to the extent of its spawning. The estimated effect is also quite large. A firm that is focused throughout the sample period spawns 20% more than a company that is diversified throughout. This finding appears at odds with the view that spawning is a response to bureaucratic rigidities in large, technology-intensive firms. The result appears more consistent with the Fairchild view.

The regression results also indicate that older public companies spawn fewer venture capital backed start-ups. The estimated elasticity of 5.8% is small. Given the imprecision with which we measure firm age, we would not put much stock in the magnitude of this coefficient.

Finally, the regression includes measures of patent quality and originality. Firms with higher quality patents in categories 2 and 3 appear to spawn more, while those with lower average originality appear to spawn less. The coefficient of patent quality is statistically significant, while the coefficient of patent originality is not. An increase from the 25th percentile of quality to the 75th percentile, --- an increase of 6.3 adjusted citations --- leads to an increase of 2.8% in the level of spawning, a small effect. Like the age effect, it is hard to put too much weight on the estimated quality effect.

The second set of regressions in Table IV uses spawning in technology industries as the dependent variable. We find the same basic patterns of results here as we did in the regression with overall spawning. The last two columns repeat the first two but add industry dummies for two-digit SIC codes. The key findings are unaffected: the

coefficients of the venture capital, Silicon Valley, and Massachusetts dummies and the coefficient of average focus all remain positive and statistically significant. The magnitudes of the coefficients also change very little. Mean Q, age, and patent quality are no longer statistically significant, though their magnitudes change very little.

B. The Characteristics of Firms that Spawn

In the sample of 1370 companies that patent in categories 2 and 3, 515 companies spawn at least one venture capital-backed firm and 855 spawn none. What are the factors that determine whether a firm spawns at least one firm? To address this question, we report the results of regressing a dummy variable that takes the value one if the firm spawns at all on the same set of regressors as those reported in Table IV. Although we report the ordinary least squares estimates in Table V, the logit results are substantively similar.

Not surprisingly, firms with more patents in categories 2 and 3 are more likely to spawn a VC-backed start-up. A firm with only one patent in category 2 (the 25th percentile of patent quantity) has a 33.5% chance of spawning a VC-backed start-up, whereas a firm with 9 patents in category 2 (the 75th percentile) has a 54.6% chance of spawning a VC-backed start-up. The estimated effect for patents in category 3 is similar in magnitude. Patenting in the other patent categories—particularly in categories 5 and 6—tends to reduce the probability of spawning.

The estimated effects of the critical variables of interest—prior VC backing, location, and focus—are all large and statistically significant. The predicted probability of spawning any start-up is 20.2% higher for VC-backed public companies than for firms

that were not venture capital-backed. The empirical model predicts that non-VC-backed public firms have a 33.0% probability of spawning at least one company, while a VC-backed public company has a 53.1% chance of spawning such a firm. The estimated effects are similar in magnitude for firms located in Silicon Valley and Massachusetts. Firms located outside of either have a 34.7% chance of spawning at least one start-up, while a public company located in Silicon Valley has a 51.2% chance of spawning a start-up and one located in Massachusetts has a 48.4% chance of spawning a start-up. The estimated effect of the focus variable is somewhat smaller than those of location and prior VC backing.

A firm that is focused throughout the sample period has a 51.8% chance of spawning at least one start-up, while a firm that was diversified throughout the sample has a 43.4% chance of spawning a start-up. In interpreting the magnitude of the focus coefficient, however, one has to keep in mind that the regression also includes the number of patents outside of categories 2 and 3, which also measures the degree of focus. Indeed, if one excludes the quantity of patents outside of categories 2 and 3, the estimated coefficient of average focus doubles in magnitude and is highly statistically significant in all specifications.

With respect to patent characteristics, patent quality appears to be significantly and positively related to spawning at least one company, while the effect of originality is negative albeit statistically insignificant.

The second column of Table V repeats this specification for spawning of technology intensive businesses. The results are essentially unchanged. The last two

columns add 2-digit SIC code industry dummies. The estimated effects change little across specifications, though patent quality is no longer statistically significant.⁹

C. The Intensity of Spawning

In this section, we examine the intensity of spawning, conditional on the firm spawning at least one venture capital-financed firm. Table 6 re-estimates the specifications in Table 4 for the 515 companies that spawn at least one start-up. The main difference between the coefficients estimated in Table 4 and those estimated in Table 6 is that, although the estimated coefficient of the VC dummy is positive, its magnitude is small and statistically insignificant. Thus, one might conclude that prior VC backing affects whether a company spawns, but not how much it spawns conditional on spawning.

The estimated effects of location continue to be large, though the coefficient estimate of the Massachusetts dummy is now estimated imprecisely, perhaps because the sample size is so much smaller now. The coefficient of focus is also positive and borderline statistically significant at the 5% confidence level. The estimated effect of quality is also positive and statistically significant. None of these effects change substantially when we restrict the dependent variable to the spawning of high-tech firms (column 2) and add industry dummies (columns 3 and 4).

⁹Patent quality in categories 2 and 3 appears to be higher if the company patents little outside those categories. Thus, the negative coefficients of patenting outside categories 2 and 3 may proxy in part for poor patent quality in categories 2 and 3. Excluding the patent quantities in categories other than 2 and 3 increases the coefficient of patent quality, which becomes highly statistically significant.

D. The Determinants of Annual Spawning Levels

In this sub-section we analyze the determinants of spawning on an annual basis. As discussed above, measuring annual spawning is imprecise given the data we have because in some cases we do not know when the entrepreneur joined the start-up. When we do not have this information, we assumed that it occurred at the founding of the start-up. If the start-up is founded before the spawning company goes public, then the observation is dropped from the sample. This means that we tend underestimate to a greater extent the number of spawned entities from companies that have gone public more recently. With this caveat in mind, we present the results of pooled cross-section/time series analysis in Table 7 and a firm fixed effect analysis in Table 8.

We observe the same basic pattern of results in the first column of Table 7. Prior VC backing, a Silicon Valley or Massachusetts headquarters, and focus are all positively related to the annual spawning levels. The effects are somewhat attenuated by including industry dummies and by limiting the spawning to those in technology-intensive industries as shown in columns 2 and 3 of Table 7.

The last column of Table 7 reports the result of the between estimator: regressing firm average annual spawning levels on firm averages of the regressors. This approach is similar to the approach taken in Table 4, but relies on the more imprecise measure of annual spawning as opposed to cumulative spawning. Although the results are all consistent with those observed in Table 4, the coefficients are generally more imprecisely estimated in Table 7.

Table 8 reports estimates of a regression equation with firm fixed effects. We cannot, of course, estimate the effects of the time-invariant factors such as prior VC backing and location. Thus, we include only those variables that change over time. The main question that we can address with this approach is whether firms tend to spawn more when their performance and growth are relatively good or when they diminish. There are two alternative views. On the one hand, spawning may be higher during relatively good times as employees are exposed to more entrepreneurial opportunities. On the other hand, when growth slows or performance weakens one might expect employees to be more aggressive in pursuing outside entrepreneurial opportunities as the value of remaining at the company falls.

Table 8 shows that spawning is unrelated to Q and the EBITDA measure, but it is negatively and significantly related to lagged 3-year sales growth. The estimated coefficient, however, is small. The model implies that an increase in sales growth from the 25th percentile to the 75th percentile, reduces the log quantity of spawning from 0.089 to 0.085, a change of just 4.6%. It is difficult to determine whether the effect is genuinely small or is small because of the significant measurement error in calculating annual spawning levels. In either case, however, the results appear to be consistent with the view that employees leave firms not at the peak of their growth rates, but instead when growth rates have fallen. This is consistent with the view that employees pursue entrepreneurial opportunities outside their firms when the rents from staying at the firm are diminished.

The regression also includes the logarithm of age and the firm focus measure. Spawning appears to decline as a firm ages; the coefficient is significant at the 10%

confidence level. The coefficient of focus is positive, consistent with our earlier cross-sectional findings, but the estimated effect is statistically insignificant. In this analysis with firm fixed effects, we can only identify the effect of focus through changes in this variable. To the extent that focus changes little over time, the empirical test does not have much statistical power.

The remaining columns of the table examine slightly different specifications. The second column looks at spawning in high-tech industries. We continue to observe a negative relationship between spawning and sales growth. The third column includes two alternative measures of sales growth: mean industry sales growth over the prior three years and firm-specific deviations from mean sales growth. The results indicate that it is the firm-specific component of sales growth that drives the relationship to spawning.

One might be concerned that what is driving the sales growth results is that firms with large reductions in sales or those that go bankrupt are laying off workers, some of whom find new jobs and some of whom start new companies. If this were true we would expect to see all of the results coming from an increase in spawning when sales drop and not from a decrease in spawning when sales rise. To examine this possibility, we replace the continuous measure of sales growth with dummy variables for two regions of sales growth: sales growth greater than the 75th percentile of sales growth; and sales growth less than the 25th percentile of sales growth. The inter-quartile range is excluded so the estimated coefficients are measured relative to this region of sales growth. The results indicate that high sales growth is associated with less spawning than moderate sales growth and that low sales growth is associated with the more spawning. Though the

magnitude of these coefficients are roughly the same, only the coefficient on the high sales growth dummy is statistically significant.

III. Conclusions and Suggestions for Future Research

This paper examines the determinants of entrepreneurial spawning, *i.e.*, the propensity of publicly-traded corporations to spawn new venture capital-backed firms. While entrepreneurial activity has received a tremendous amount of attention from academic researchers and the popular press, the source of new entrepreneurial firms has received relatively little systematic attention. We show that existing public companies are an important source of entrepreneurs for venture capital-backed start-ups, particularly public corporations with patents in areas of interest to venture capital. Younger firms, that were backed by venture capitalists themselves and that are located in the main hubs of venture capital activity (Silicon Valley and Massachusetts) are more likely to spawn new firms. Moreover, firms focused in one main line of business are more likely to be the source of entrepreneurial ventures.

These findings appear to be inconsistent with the view that entrepreneurs start new firms in response to their frustration with large, bureaucratic companies. Instead, they suggest that the breeding grounds for entrepreneurial firms are other entrepreneurial firms. It is in these environments that employees learn from their co-workers about what it takes to start a new firm and are exposed to a network of suppliers and customers who are used to dealing with startup companies. These spawning entrepreneurial firms may also implicitly select for less risk averse individuals who are willing to bear the greater risks of starting a new firm.

Our findings have a couple of implications. In particular, they suggest that entrepreneurial activity in a given region has increasing returns (Saxenian [1994]). Stimulating entrepreneurship in a region with few existing entrepreneurial firms is difficult; there may be many individuals with the technological know-how to start a new VC-backed firm, but many fewer who know how to start new companies. In addition, the network of suppliers and customers may not be strong enough to support a new venture.¹⁰ Policies that have sought to foster entrepreneurial and venture capital-activity by providing capital or investment incentives may not be enough. Instead, regions may need to attract firms with existing pools of workers who have the “training and conditioning” to become entrepreneurs.

At the same time, the results suggest that the ultimate success (in terms of scale) of individual VC-backed firms may be bounded. The analysis shows that when growth slows, employees are likely to leave their firms to start new ones. Thus, there may be limits to how big a VC-backed firm can get while maintaining their most entrepreneurial employees.

There are a number of related research questions we plan to pursue. We list four of them here. First, we hope to supplement this analysis with a survey of spawned entrepreneurs. What reasons do they give for leaving their firm and starting a new one? How do the responses vary depending on the type of company from which the entrepreneur was spawned? Second, what is the relationship between the spawned startup and the spawning parent? Do they tend to be in similar businesses? And, what

¹⁰Lerner [1999] discusses the powerful political pressures that can lead to the scattering of venture capital funding across regions, as well as presenting consistent evidence from one government program to finance small high-technology businesses.

determines whether the spawned entity is related or unrelated to the spawning firm? Third, how does spawning affect the parent? In particular does it have a negative effect on growth and performance of the spawning firm as its most creative employees leave to start new ventures? Finally, how do the characteristics of the spawning firms affect the success of the new ventures? For example, are entrepreneurs from more successful spawning firms more or less likely to be successful themselves? And, how do the characteristics of the spawning firm's patents affect the likelihood of success of the new venture?

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Table 1
Summary of Entrepreneurs

The sample is based on Venture One's database of 15,297 founders of 5,112 venture capital-backed startups who received venture capital financings from 1986-1999. The previous employment history of the founders is tabulated. Public companies are those identified from Compustat. The third column lists the number of founders who are the CEO, President, or Chief Technology Officer of the startup. The fourth column lists the number of founders whose most recent employer was a public company.

<i>Year</i>	<i>Number of Entrepreneurs</i>	<i>Number of Startups</i>	<i>Number of Technology Startups</i>	<i>CEO/Pres/ CTO</i>	<i>Number of Entrepreneurs from Public Companies</i>	<i>Fraction from Public Cos.</i>	<i>Fraction from Public Cos. When We Have Previous Company Identified</i>
1986	483	221	144	268	145	30.0%	45.9%
1987	628	260	171	325	196	31.2%	43.6%
1988	694	267	172	359	229	33.0%	44.2%
1989	721	292	176	392	246	34.1%	43.6%
1990	843	333	214	463	295	35.0%	44.3%
1991	840	345	222	484	307	36.5%	45.1%
1992	1065	408	237	567	342	32.1%	41.4%
1993	1016	384	221	606	380	37.4%	46.3%
1994	1172	446	253	747	368	31.4%	41.3%
1995	1290	527	257	906	417	32.3%	41.4%
1996	1623	680	372	1236	599	36.9%	44.6%
1997	1448	669	361	1109	535	36.9%	42.6%
1998	1747	809	365	1376	692	39.6%	45.0%
1999	1717	804	232	1396	717	41.8%	46.5%

Table 2
Summary of Information on Previous Employer of Founders

The sample is derived from public companies listed in Compustat during the period 1986-1999. A spawned entrepreneur is an employee who leaves a public company to start a venture capital-backed firm. Data on founders come from the VentureOne database of 15,297 founders of 5,112 venture capital-backed start-ups during the period 1986-1999. Panel A lists all public companies that spawn at least ten entrepreneurial teams during the sample period, 1986-1999 and the number of entrepreneurial teams they spawn during the sample period. (Multiple individuals departing to a single firm are regarded as a single entrepreneurial team.) Panel B lists all industries in which public companies spawn at least 20 entrepreneurs in total and the number of entrepreneurs they spawn.

Panel A: Top Public Spawning Companies

<i>Company</i>	<i>Number of Spawned Entrepreneurial Teams</i>	<i>Company</i>	<i>Number of Spawned Entrepreneurial Teams</i>
IBM	70	Nortel Networks	17
AT&T	60	Unisys	17
Sun Microsystems	55	National Semiconductor	17
Apple Computer	48	Advanced Micro Devices	16
Hewlett-Packard	46	Mentor Graphics	15
Oracle	41	Cirrus Logic	14
General Electric	37	Genentech	14
Microsoft	30	Bristol Myers Squibb	14
Xerox	29	Raychem	14
Baxter	29	Dun & Bradstreet	14
Intel	28	SmithKline Beecham	13
Disney	28	MCI	13
Silicon Graphics	27	Pfizer	13
Lotus Development Corp.	26	Texas Instruments	13
Motorola	25	Legent	12
DEC	24	Tandem Computer	12
Cadence Design Systems	21	Bank of America	11
Johnson & Johnson	21	Peoplesoft	11
Verizon	19	Morgan Stanley	11
Novell	18	Adaptec	11

Table 2 (Continued)

Panel B: Top Three Digit Industries for Spawners

<i>Industry</i>	<i>Number of Spawned Entrepreneurial Teams</i>
Computer Programming and Data Processing	1009
Computer and Office Equipment	588
Drugs	348
Communication Equipment	212
Surgical, Medical, and Dental Instruments	204
Electronic Components and Accessories	185
Telephone Communications	178
Laboratory, Analytical, and Optical Equipment	83
Security Brokers, Dealers, And Flotation	61
Radio And Television Broadcasting Stations	52
Commercial Banks	50
Non-Store Retailers	30
Special Industry Machinery, Except Metalworking	24

Table 3
Characteristics of Public Spawners vs. Non-spawners

The sample is derived from public companies listed in Compustat during the period 1986-1999. Spawners are identified as those public companies in which at least one employee left to start a venture capital-backed firm. Data on founders come from the VentureOne database of 15,297 founders of 5,112 venture capital-backed start-ups during the period 1986-1999. The table compares the characteristics of public companies that spawn at least one entrepreneur during the sample period 1986-1999 (the first three columns) to the characteristics of public companies that never spawn during the sample period (the second three columns). All dollar figures are in millions of 1999 dollars. Patent category 2 refers to computer and communication patents as classified in the NBER Patent Citation Data File and category 3 refers to medical and drug patents. The differences in the means are all statistically significant based on heteroskedasticity-consistent t-statistics that adjust for non-independence of observations of the same firm over time.

	<i>Spawners</i>			<i>Non-spawners</i>		
	<i>Median</i>	<i>Mean</i>	<i>Observations</i>	<i>Median</i>	<i>Mean</i>	<i>Observations</i>
Sales (\$MMs)	\$185.2	\$3,428.6	515	\$116.1	\$1,343.3	855
Assets (\$MMs)	\$191.7	\$4,949.1	515	\$100.5	\$1,732.6	855
Employees (000s)	23.1	44.2	515	0.85	8.01	855
Winsorized Sales Growth*	19.3%	52.6%	515	11.2%	37.6%	855
Winsorized Tobin's Q*	2.18	2.75	515	1.71	2.54	855
EBITDA/Assets	0.111	0.058	515	0.107	0.054	855
Venture Capital-Backed		35.5%	515		12.2%	855
Silicon Valley		19.8%	515		5.9%	855
Massachusetts		9.9%	515		5.9%	855
Number of Spawned Entrepreneurs	2	4.07	515			
Any patents		28.4%	515		28.4%	855
Number of Patents in Category 2	4	137.5	515	2	15.9	855
Number of Patents in Category 3	0	51.2	515	0	10.8	855
Patent Quality	0.618	1.336	515	-0.922	-0.606	855
Patent Originality	0.019	0.019	515	0.062	0.059	855

* Observations with greater than the 99th percentile are coded as being at this level.

Table 4
Regression Analyses of Spawning Levels

The table presents regression results for the cumulative number of spawned entrepreneurs for each firm in our sample. The sample is derived from public companies listed in Compustat during the period 1986-1999 with patents in either Computer and Communications or Drugs and Medical based on the NBER Patent Database classification scheme. The dependent variable in the regressions is the natural logarithm of the cumulative number of venture capital-backed entrepreneurs spawned over the whole sample period. The information on entrepreneurs comes from a sample of 15,297 founders of 5,112 venture capital-backed start-ups in the VentureOne database of venture capital financing who received venture capital financing before June 2000. Independent variables include the natural logarithm of inflation-adjusted firm size; the firm's sales growth over the previous three years Winsorized at the 99th percentile, Tobin's Q for the firm Winsorized at the 99th percentile; the natural logarithm of patents in six patent categories, dummy variables indicating whether the firm was backed by venture capitalists, dummy variables indicating if the firm was located in Silicon Valley or Massachusetts, measures for the firm's patent originality the natural logarithm of firm age, and a dummy variable that equals one if the firm reports only one industry segment in Compustat. All regressions include year dummies for every year that the firm is in the sample, though the coefficients are not shown; some include industry fixed effects. Heteroskedasticity-consistent t-statistics in parentheses adjust for non-independence of observations of the same firm over time.

Independent Variables	<i>Dependent Variable: Log of Number of Entrepreneurs Spawned</i>			
	Total Spawning	Technology Spawning	Total Spawning	Technology Spawning
	(1)	(2)	(3)	(4)
Log of Chemical Patents	-0.0191 [-1.18]	-0.0146 [-1.08]	-0.0093 [-0.51]	-0.0067 [-0.39]
Log of Computer and Communications Patents	0.2203 [6.75]	0.1958 [6.34]	0.1864 [8.60]	0.1707 [8.35]
Log of Drugs and Medical Patents	0.1443 [8.99]	0.1449 [9.99]	0.1384 [6.74]	0.1431 [7.27]
Log of Electrical and Electronic Patents	-0.0259 [-0.82]	0.0012 [0.05]	0.0008 [0.04]	0.0221 [1.17]
Log of Mechanical Patents	-0.0376 [-2.45]	-0.0457 [-2.81]	-0.0673 [-3.12]	-0.0752 [-3.66]
Log of Other Patents	-0.0614 [-4.19]	-0.0616 [-5.23]	-0.0556 [-2.50]	-0.0579 [-2.81]
Log of Real Assets	0.1250 [7.77]	0.0897 [7.40]	0.1504 [9.11]	0.1143 [7.26]
Mean EBITDA/Assets	-0.1380 [-1.42]	-0.0891 [-1.23]	-0.3679 [-2.89]	-0.2788 [-2.27]
Mean Winsorized Sales Growth Over Previous Year*	0.0122 [0.88]	0.0062 [0.42]	0.0131 [0.73]	0.0082 [0.42]
Mean Winsorized Tobin's Q*	0.0219 [3.70]	0.0157 [3.70]	0.0149 [1.45]	0.0115 [1.18]
Venture Capital-Backed	0.2335 [6.11]	0.2135 [9.61]	0.1895 [3.89]	0.1728 [3.56]
Silicon Valley-Based	0.3772 [6.93]	0.3875 [7.08]	0.3461 [5.17]	0.3606 [5.43]
Massachusetts-Based	0.2355 [3.62]	0.2066 [2.96]	0.2013 [3.26]	0.1793 [2.91]
Focused Firm	0.1952 [2.69]	0.1484 [2.64]	0.1893 [3.42]	0.1438 [2.76]
Log of Firm Age	-0.0575 [-2.36]	-0.0603 [-2.60]	-0.0488 [-1.96]	-0.0552 [-2.38]
Patent Quality	0.0061 [4.74]	0.0066 [4.23]	0.0043 [1.73]	0.0049 [2.08]
Patent Originality	-0.0841 [-1.05]	0.0257 [0.49]	-0.1473 [-1.81]	-0.0279 [-0.37]
Constant	-0.8499 [-6.21]	-0.7153 [-6.25]	-0.9714 [-9.48]	-0.8285 [-8.35]
Number of Observations	1,370	1,370	1,370	1,370
Adjusted R-squared	0.418	0.403	0.433	0.400
Industry Fixed Effects	No	No	Yes	Yes

* Observations with greater than the 99th percentile are coded as equal to the 99th percentile.

Table 5
Regression Analyses of Likelihood of Doing Any Spawning

The table presents regressions of the probability of a sample firm having any spawning activity. The sample is derived from public companies listed in Compustat during the period 1986-1999 with patents in either Computer and Communications or Drugs and Medical based on the NBER Patent Database classification scheme. The dependent variable in the regressions is a dummy variable that equals one if the firm ever spawns at least one venture capital-backed entrepreneurs. The information on entrepreneurs comes from a sample of 15,297 founders of 5,112 venture capital-backed start-ups in the VentureOne database of venture capital financing who received venture capital financing before June 2000. Independent variables include the natural logarithm of inflation-adjusted firm size; the firm's sales growth over the previous three years Winsorized at the 99th percentile, Tobin's Q for the firm Winsorized at the 99th percentile; the natural logarithm of patents in six patent categories, dummy variables indicating whether the firm was backed by venture capitalists, dummy variables indicating if the firm was located in Silicon Valley or Massachusetts, measures for the firm's patent originality the natural logarithm of firm age, and a dummy variable that equals one if the firm reports only one industry segment in Compustat. All regressions include year dummies for each year that the firm is in our sample, though the coefficients are not shown; some include industry fixed effects. Heteroskedasticity-consistent t-statistics in parentheses adjust for non-independence of observations of the same firm over time.

Independent Variables	<i>Dependent Variable: Dummy Variable Indicating Any Spawning</i>			
	Total Spawning	Technology Spawning	Total Spawning	Technology Spawning
	(1)	(2)	(3)	(4)
Log of Chemical Patents	-0.0035 [-0.35]	-0.0062 [-0.99]	0.0059 [0.44]	0.0009 [0.08]
Log of Computer and Communications Patents	0.0921 [7.14]	0.0902 [7.26]	0.0746 [5.71]	0.0729 [6.11]
Log of Drugs and Medical Patents	0.0755 [7.66]	0.0842 [11.71]	0.0669 [5.32]	0.0811 [6.97]
Log of Electrical and Electronic Patents	-0.0015 [-0.09]	0.0107 [0.79]	0.0105 [0.73]	0.0211 [1.56]
Log of Mechanical Patents	-0.0276 [-1.95]	-0.0367 [-3.31]	-0.0496 [-3.03]	-0.0592 [-4.11]
Log of Other Patents	-0.0446 [-2.85]	-0.0478 [-4.50]	-0.0438 [-2.75]	-0.0449 [-3.11]
Log of Real Assets	0.0654 [8.40]	0.0544 [7.32]	0.0830 [8.72]	0.0707 [7.82]
Mean EBITDA/Assets	-0.1451 [-2.56]	-0.1290 [-2.25]	-0.2911 [-2.99]	-0.2570 [-2.78]
Mean Winsorized Sales Growth Over Previous Year*	0.0263 [1.59]	0.0094 [0.58]	0.0259 [1.61]	0.0098 [0.61]
Mean Winsorized Tobin's Q*	0.0024 [0.49]	0.0010 [0.34]	-0.0002 [-0.03]	-0.0002 [-0.03]
Venture Capital-Backed	0.2024 [8.56]	0.1865 [9.54]	0.1780 [4.89]	0.1688 [4.71]
Silicon Valley-Based	0.1644 [4.39]	0.1947 [4.93]	0.1431 [3.34]	0.1766 [4.10]
Massachusetts-Based	0.1363 [3.43]	0.1405 [3.56]	0.1146 [2.53]	0.1247 [2.79]
Focused Firm	0.0838 [2.22]	0.0592 [2.13]	0.0756 [1.92]	0.0571 [1.58]
Log of Firm Age	-0.0271 [-1.23]	-0.0389 [-1.97]	-0.0205 [-1.19]	-0.0327 [-2.05]
Patent Quality	0.0032 [3.30]	0.0039 [3.11]	0.0021 [1.10]	0.0029 [1.57]
Patent Originality	-0.0816 [-1.19]	0.0047 [0.11]	-0.1202 [-1.75]	-0.0255 [-0.40]
Constant	-0.2417 [-3.34]	-0.2460 [-4.95]	-0.3253 [-4.69]	-0.3321 [-5.00]
Number of Observations	1,370	1,370	1,370	1,370
Adjusted R-squared	0.275	0.300	0.277	0.292
Industry Fixed Effects	No	No	Yes	Yes

* Observations with greater than the 99th percentile are coded as equal to the 99th percentile.

Table 6
Regression Analyses of Cumulative Spawning Levels Conditional on Any Spawning

The table presents regressions of the cumulative spawning rates for firms, conditional on the firms doing any spawning during our sample period. The sample is derived from public companies listed in Compustat during the period 1986-1999 with patents in either Computer and Communications or Drugs and Medical based on the NBER Patent Database classification scheme. The dependent variable in the regressions is the natural logarithm of the cumulative number of venture capital-backed entrepreneurs spawned over the entire sample period from these public companies. The information on entrepreneurs comes from a sample of 15,297 founders of 5,112 venture capital-backed start-ups in the VentureOne database of venture capital financing who received venture capital financing before June 2000. Independent variables include the natural logarithm of inflation-adjusted firm size; the firm's sales growth over the previous three years Winsorized at the 99th percentile, Tobin's Q for the firm Winsorized at the 99th percentile; the natural logarithm of patents in six patent categories, dummy variables indicating whether the firm was backed by venture capitalists, dummy variables indicating if the firm was located in Silicon Valley or Massachusetts, measures for the firm's patent originality the natural logarithm of firm age, and a dummy variable that equals one if the firm reports only one industry segment in Compustat. All regressions include year dummies for each year that the firm is in our sample, though the coefficients are not shown; some include industry fixed effects. Heteroskedasticity-consistent t-statistics in parentheses adjust for non-independence of observations of the same firm over time.

Independent Variables	<i>Dependent Variable: Conditional Spawning Level</i>			
	Total Spawning	Technology Spawning	Total Spawning	Technology Spawning
	(1)	(2)	(3)	(4)
Log of Chemical Patents	-0.0135 [-0.77]	-0.0014 [-0.06]	-0.0016 [-0.05]	0.0182 [0.52]
Log of Computer and Communications Patents	0.1963 [4.60]	0.2056 [4.62]	0.1333 [4.24]	0.1447 [3.89]
Log of Drugs and Medical Patents	0.1047 [9.14]	0.1111 [8.10]	0.1064 [3.55]	0.1015 [2.96]
Log of Electrical and Electronic Patents	-0.0439 [-1.03]	-0.0346 [-0.80]	-0.0169 [-0.60]	-0.0206 [-0.64]
Log of Mechanical Patents	-0.0306 [-0.59]	-0.0326 [-0.77]	-0.0595 [-1.67]	-0.0535 [-1.20]
Log of Other Patents	-0.0263 [-0.51]	-0.0236 [-0.40]	0.0120 [0.29]	0.0235 [0.46]
Log of Real Assets	0.1433 [7.82]	0.0844 [3.18]	0.1870 [6.36]	0.1321 [4.04]
Mean EBITDA/Assets	-0.1071 [-0.76]	0.0090 [0.06]	-0.5791 [-2.86]	-0.4348 [-1.86]
Mean Winsorized Sales Growth Over Previous Year*	-0.0141 [-0.91]	0.0171 [0.74]	-0.0086 [-0.43]	0.0279 [1.00]
Mean Winsorized Tobin's Q*	0.0390 [5.31]	0.0351 [4.14]	0.0418 [2.50]	0.0305 [1.70]
Venture Capital-Backed	0.0261 [0.56]	0.0267 [0.54]	0.0229 [0.37]	0.0068 [0.10]
Silicon Valley-Based	0.3091 [4.81]	0.2790 [3.81]	0.2774 [3.94]	0.2528 [3.52]
Massachusetts-Based	0.1773 [1.58]	0.1356 [1.10]	0.1565 [1.88]	0.0972 [1.00]
Focused Firm	0.1987 [1.98]	0.1124 [1.27]	0.1469 [1.58]	0.0844 [0.83]
Log of Firm Age	-0.0933 [-1.31]	-0.0837 [-1.74]	-0.0980 [-1.78]	-0.1059 [-1.76]
Patent Quality	0.0081 [2.11]	0.0103 [1.74]	0.0070 [1.73]	0.0089 [2.16]
Patent Originality	-0.0352 [-0.30]	0.0462 [0.46]	-0.1135 [-0.79]	-0.0387 [-0.24]
Constant	-0.2614 [-1.36]	-0.1001 [-0.51]	-0.5022 [-3.29]	-0.3132 [-1.84]
Number of Observations	515	428	515	428
Adjusted R-squared	0.440	0.406	0.443	0.401
Industry Fixed Effects	No	No	Yes	Yes

* Observations with greater than the 99th percentile are coded as equal to the 99th percentile.

Table 7
Cross Sectional Regression Analyses of Annual Spawning Levels

The regression are pooled cross-sectional regressions or the between estimators from fixed effects regressions of annual spawning levels for publicly traded firms. The sample is derived from public companies listed in Compustat during the period 1986-1999 with patents in either Computer and Communications or Drugs and Medical based on the NBER Patent Database classification scheme. The dependent variable in the regressions is the natural logarithm of the number of venture capital-backed entrepreneurs spawned in a given year from these public companies. The information on entrepreneurs comes from a sample of 15,297 founders of 5,112 venture capital-backed start-ups in the VentureOne database of venture capital financing who received venture capital financing before June 2000. Independent variables include the natural logarithm of inflation-adjusted firm size; the firm's sales growth over the previous three years Winsorized at the 99th percentile, Tobin's Q for the firm Winsorized at the 99th percentile; the natural logarithm of patents in six patent categories, dummy variables indicating whether the firm was backed by venture capitalists, dummy variables indicating if the firm was located in Silicon Valley or Massachusetts, measures for the firm's patent originality the natural logarithm of firm age, and a dummy variable that equals one if the firm reports only one industry segment in Compustat. All regressions include year dummies, though the coefficients are not shown; some include industry fixed effects. All regressions include year dummies, though the coefficients are not shown; some include industry or firm fixed effects. t Heteroskedasticity-consistent t-statistics in parentheses adjust for non-independence of observations of the same firm over time.

Independent Variables	<i>Dependent Variable: Annual Spawning Level</i>			
	Total Spawning	Total Spawning	Technology Spawning	Between Estimates from Firm Fixed Effects Regressions of Annual Total Spawning Levels
	(1)	(2)	(3)	(4)
Log of Chemical Patents	-0.0045 [-0.61]	-0.0029 [-0.37]	-0.0005 [-0.08]	-0.0022 [-0.22]
Log of Computer and Communications Patents	0.1047 [7.34]	0.0935 [7.03]	0.0756 [6.90]	0.1429 [13.79]
Log of Drugs and Medical Patents	0.0366 [3.45]	0.0354 [3.15]	0.0345 [3.39]	0.0331 [3.68]
Log of Electrical and Electronic Patents	-0.0161 [-1.94]	-0.0069 [-0.86]	0.0025 [0.36]	-0.0540 [-4.69]
Log of Mechanical Patents	-0.0119 [-1.53]	-0.0191 [-2.17]	-0.0158 [-2.06]	-0.0054 [-0.43]
Log of Other Patents	-0.0232 [-3.14]	-0.0198 [-2.52]	-0.0226 [-3.24]	-0.0248 [-1.83]
Log of Real Assets	0.0281 [7.73]	0.0325 [6.68]	0.0244 [6.20]	0.0277 [8.04]
Mean Winsorized Sales Growth Over Previous Three Year*	-0.0004 [-0.19]	-0.0012 [-0.54]	-0.0005 [-0.24]	0.0039 [1.27]
Mean EBITDA/Assets	0.0183 [0.65]	-0.0343 [-1.09]	-0.0191 [-0.73]	-0.0366 [-0.95]
Mean Winsorized Tobin's Q*	0.0089 [2.63]	0.0071 [2.19]	0.0037 [1.38]	0.0073 [2.08]
Log of Firm Age	-0.0112 [-2.10]	-0.0074 [-1.34]	-0.0053 [-1.05]	-0.0090 [-1.07]
Venture Capital-Backed	0.0370 [2.41]	0.0193 [1.27]	0.0187 [1.35]	0.0134 [0.95]
Silicon Valley-Based	0.1289 [4.78]	0.1274 [4.74]	0.1217 [5.01]	0.1028 [6.22]
Massachusetts-Based	0.0245 [1.80]	0.0182 [1.35]	0.0106 [0.87]	0.0225 [1.23]
Focused Firm	0.0308 [3.12]	0.0315 [3.13]	0.0295 [3.22]	0.0386 [2.38]
Patent Quality	0.0012 [2.04]	0.0007 [1.11]	0.0008 [1.56]	0.0006 [0.70]
Patent Originality	-0.0163 [-0.87]	-0.0252 [-1.25]	-0.0084 [-0.48]	-0.0207 [-0.67]
Constant	-0.1392 [-4.87]	-0.1665 [-5.68]	-0.1239 [-5.08]	-0.1738 [-1.45]
Number of Observations	10,914	10,875	10,875	10,914
Adjusted R-squared	0.227	0.249	0.217	0.342
Industry Fixed Effects	No	Yes	Yes	NA

* Observations with greater than the 99th percentile are coded as equal to the 99th percentile.

Table 8
Firm Fixed-Effects Regression Analyses of Annual Spawning Levels

The table presents the firm fixed-effects regressions for the sample of publicly-traded spawning firms. The sample is derived from public companies listed in Compustat during the period 1986-1999 with patents in either Computer and Communications or Drugs and Medical based on the NBER Patent Database classification scheme. The dependent variable in the regressions is the natural logarithm of the number of venture capital-backed entrepreneurs spawned in a given year from these public companies. The information on entrepreneurs comes from a sample of 15,297 founders of 5,112 venture capital-backed start-ups in the VentureOne database of venture capital financing who received venture capital financing before June 2000. Independent variables include the natural logarithm of inflation-adjusted firm size; the firm's sales growth over the previous three years Winsorized at the 99th percentile, the firm's industry sales growth over the previous three years Winsorized at the 99th percentile and deviations from that industry sales growth over the previous three years Winsorized at the 99th percentile, Tobin's Q for the firm Winsorized at the 99th percentile; the natural logarithm of patents in six patent categories, the natural logarithm of firm age, and a dummy variable that equals one if the firm reports only one industry segment in Compustat. All regressions include year dummies, though the coefficients are not shown; some include industry or firm fixed effects. Heteroskedasticity-consistent t-statistics in parentheses adjust for non-independence of observations of the same firm over time.

Independent Variables	<i>Dependent Variable: Annual Spawning Level</i>			
	Total Spawning	Technology Spawning	Total Spawning	Total Spawning
	(1)	(2)	(3)	(4)
Log of Chemical Patents	-0.0018 [-0.25]	0.0090 [1.43]	-0.0018 [-0.25]	-0.0020 [-0.28]
Log of Computer and Communications Patents	0.0506 [6.94]	0.0319 [4.96]	0.0504 [6.94]	0.0501 [6.85]
Log of Drugs and Medical Patents	0.0092 [1.35]	0.0062 [0.95]	0.0093 [1.36]	0.0092 [1.35]
Log of Electrical and Electronic Patents	0.0002 [0.04]	0.0055 [0.97]	0.0002 [0.04]	-0.0001 [-0.02]
Log of Mechanical Patents	-0.0076 [-1.20]	-0.0068 [-1.28]	-0.0074 [-1.18]	-0.0077 [-1.21]
Log of Other Patents	-0.0001 [-0.01]	-0.0036 [-0.65]	0.0000 [0.00]	-0.0001 [-0.02]
Log of Real Assets	0.0375 [6.29]	0.0291 [5.56]	0.0373 [6.27]	0.0392 [6.47]
Winsorized Sales Growth Over Previous Three Year*	-0.0059 [-3.04]	-0.0037 [-2.08]		
Winsorized Deviation from Industry Sales Growth Over Previous Three Year*			-0.0060 [-3.08]	
Winsorized Industry Sales Growth Over Previous Three Year*			0.0048 [0.37]	
Sales Growth of Firm in the Highest Quartile of Sales Growth				-0.0121 [-2.09]
Sales Growth of Firm in the Lowest Quartile of Sales Growth				0.0101 [1.49]
Mean EBITDA/Assets	-0.0173 [-0.74]	-0.0125 [-0.57]	-0.0185 [-0.78]	-0.0099 [-0.41]
Mean Winsorized Tobin's Q*	0.0006 [0.22]	-0.0015 [-0.64]	0.0005 [0.22]	0.0007 [0.00]
Log of Firm Age	-0.0246 [-1.83]	-0.0004 [-0.03]	-0.0245 [-1.82]	-0.0247 [-1.82]
Focused Firm	0.0023 [0.27]	0.0091 [1.25]	0.0023 [0.27]	0.0023 [0.27]
Constant	-0.0768 [-1.35]	-0.1478 [-2.92]	-0.0789 [-1.39]	-0.0912 [-1.59]
Number of Observations	10,929	10,929	10,929	10,929
Adjusted R-squared	0.476	0.438	0.476	0.476

* Observations with greater than the 99th percentile are coded as equal to the 99th percentile.