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Despite widespread interest in the key role that venture capital plays in financing young, high-tech firms, little is known about the relative performance of venture-backed firms over the long-run. Using data from the U.S. high-tech sector, this paper examines the performance and financing of venture- and non-venture-backed firms during the decade following their IPO. Venture-backed firms survive longer, grow faster, are more R&D intensive, have generally superior operating performance, raise more external equity, and have a greater cumulative impact on the U.S. high-tech sector. These findings suggest that the true legacy of venture capital finance extends well beyond the IPO.

Introduction

Firms that relied on venture capital for their early-stage, private financing have had an unmistakable impact on economic activity and now dominate many of the most innovative and dynamic industries in the U.S. economy. Between 1975 and 2003 more than 2,400 venture-backed firms undertook an initial public offering, and approximately 60% of these firms were located in seven key high-tech industries.[1] At the end of 2003 venture-backed firms accounted for over 20% of the publicly traded firms in the U.S., represented over 25% of the market value of publicly traded firms, and were responsible for more than 12% of sales. In the high-tech sector venture-backed firms have had an even more dramatic effect—in 2003 venture-backed

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[1] Source: Venture Economics. The industries (by three-digit SIC code) are 283, 357, 366, 367, 382, 384, and 737. Overall, there are more than 250 three-digit SIC industries.

firms accounted for 70% of the market value of publicly traded computer software firms, for example, and were responsible for over 50% of sales and over 60% of R&D in the computer hardware industry.[2]

This activity has attracted widespread attention. An impressive literature has emerged documenting the key role that venture capitalists play in financing and monitoring private, start-up firms, and ultimately helping them undertake an initial public offering (IPO) (e.g., Gompers and Lerner (1999 and 2001)). Recent studies using U.S. data suggest that venture capitalist financing and involvement has a positive impact on the early development of the firm. Hellmann and Puri (2000, 2002), for example, find that venture-backed start-ups bring products to market faster and have a more fully developed internal organization than non-venture-backed start-ups. There is also evidence that venture-backed firms perform better than their non-venture-backed counterparts in the period of time immediately surrounding the IPO (Jain and Kini (1995)). Much less is known, however, about the growth and performance of venture-backed firms over longer periods following the IPO.

The objective of this paper is to examine the magnitude and duration of any performance differences that exist between venture- and non-venture-backed firms in the decade following the IPO. Specifically, the analysis focuses on survival, growth, R&D intensity, operating performance, use of external financing, and cumulative impact on the U.S. high-tech sector. The study is based on U.S. firms that went public between 1980 and 1989 in seven key high-tech industries. In addition to results for the full sample of high-tech IPOs, separate findings are presented for a small sample of venture- and non-venture-backed firms carefully matched based on three-digit industry and firm size prior to the IPO. The matched sample methodology, also employed by Megginson and Weiss (1991) and Jain and Kini (1995), provides a check on the full sample results and helps ensure that the venture-backed firms are evaluated against a set of non-venture-backed firms that are otherwise as similar as possible.

Whether or not venture-backed firms will outperform in the years following their IPO is an interesting empirical question. Addressing this issue provides a more complete assessment of the true legacy of venture capital financing, and contributes to the emerging literature on the impact that venture backing has on the post-IPO firm. In addition, the venture capital industry is cyclical and both regionally and internationally concentrated.[3] As a result, many firms do not have access to venture capital finance, even in economies where venture financing is relatively abundant. Knowledge about the performance of venture-backed firms over time is important for evaluating whether or not non-venture-backed firms face serious competitive disadvantages, and for understanding why some countries may have difficulty specializing in the production of high-tech goods. Finally, there are many public policy efforts, both in the U.S. and abroad, designed to increase access to private venture capital, or even to supply some form of public venture financing.[4] A better understanding of the long-run relative performance of venture-backed firms

[2] These statistics were computed using data from Compustat and Venture Economics. Gompers and Lerner (2001) report similar figures for 2000.

[3] For information on the cyclical nature of the venture capital industry see chapter six in Gompers and Lerner (2001), and for information on regional concentration see chapter one in Gompers and Lerner (1999). For differences in venture capital financing across countries see Jeng and Wells (2000).

[4] Lerner (2002) and Gompers and Lerner (2001, Chapter 9) discuss efforts in the U.S. See Bottazzi and Da Rin (2002 and 2003) for a discussion of efforts in Europe.

will help evaluate the merits of these programs, and may even inform their design and implementation.

The paper begins with a discussion of the factors that may cause venture- and non-venture-backed firms to perform differently over the long-run. Section two discusses data sources and the sample of IPOs examined, as well as differences between venture- and non-venture-backed firms the year prior to the IPO. The IPO itself and the impact it has on the issuing firm is examined in section three. Section four considers firm survival in the decade following the IPO, while section five evaluates firm performance and financing in the post-IPO period. Section six provides a brief look at the cumulative impact that venture- and non-venture-backed IPOs from the 1980s have had on the U.S. high-tech sector, and section seven concludes the paper.

Overall, this study documents large and persistent differences in the performance and financing of venture- and non-venture-backed firms. Most notably, venture-backed firms survive longer, have significantly faster rates of growth for almost a decade following the IPO, and have much higher R&D and capital spending to sales ratios in the post-IPO period. In addition, venture-backed firms generally exhibit superior operating performance after the IPO (though not dramatically so), and they appear to have greater access to external sources of finance after the IPO, particularly external equity. Because of their superior performance, by 2003 the share of high-tech sales, R&D and market value accounted for by venture-backed IPOs from the 1980s was many times larger than the share accounted for by firms that received no venture capital. These findings, which suggest that the true legacy of venture capital finance extends well beyond the IPO, raise interesting questions about the factors responsible for such large and persistent performance differences, and should be of keen interest to any country or region interested in the production of high-tech goods.

I. Should Venture-Backed Firms Outperform Over the Long-Run?

Evidence on the long-run relative performance of venture-backed firms is limited, especially with respect to the real side of the firm in the years after the IPO. Jain and Kini (1995) found that venture-backed firms in the U.S. had a significantly less severe decline in operating performance as they moved through the IPO, and significantly faster sales growth in the three years immediately following the IPO. Gompers and Lerner (2001) compared the buy-and-hold returns of venture- and non-venture-backed IPOs between 1976 and 1999 and found that venture-backed IPOs had significantly higher returns, especially during the mid- to late-90s. Brav and Gompers (1997) found that the superior stock price performance of venture-backed IPOs during the 1972-1992 period disappeared when the returns were weighted by the size of the offering. In the U.S. the general perception appears to be that venture-backed firms are superior, but this remains an open empirical question.[5]

A. Why Venture-Backed Firms Might Outperform

There are a number of reasons to believe that venture-backed firms will outperform non-venture-backed firms in the years following the IPO. In particular, venture capital directly relaxes the financing constraints that many young, high-tech firms face. With this financing,

[5] Bottazzi and Da Rin (2002 and 2003) note that this is a common perception in Europe as well. The evidence they present, however, indicates that venture-backed firms raise more funds from the IPO but do not exhibit significantly faster growth immediately thereafter.

venture-backed firms are in a position to fund growth options when they arise, and it enables them to make the necessary investments in equipment, personnel and R&D that will drive the long-run performance of the firm. Because non-venture-backed firms must assemble financing from other sources, key investments may be delayed, under-funded, or even abandoned. Gompers and Lerner (2001, p. 62) note that venture-backed firms "can grow more quickly and uniformly because the assurance of future financing if they reach their milestones releases them from having to track down new money." Additionally, as Brav and Gompers (1997) discuss, venture capitalists might continue to relax financing constraints well after the firm goes public. There is some evidence that venture-backed firms are able to issue public equity at a lower total cost than non-venture-backed firms (e.g., Megginson and Weiss (1991)), and venture backing might also make other forms of external finance more accessible.

Venture capital financing is especially important to firms in the high-tech sector because these firms have the most difficulty obtaining more traditional sources of external finance, such as debt or public equity. External finance is often unavailable or prohibitively expensive for high-tech firms because they are very risky, they have few tangible assets, and there is a great deal of asymmetric information between the owners of the firm and outsiders about the firm's prospects.[6] Venture capitalists have developed several techniques to overcome these information asymmetries, such as carefully screening the firms they invest in, staging the investments they make over time, and tying the entrepreneur's compensation to the performance of the firm.[7] Venture capitalists also regularly visit and closely monitor the firms they finance (Gorman and Shalman (1989)), allowing them to finance high-growth firms that would otherwise be capital constrained.

Such active monitoring and close involvement appear to be the characteristics that separate venture capitalists from other suppliers of finance, such as private "angel" investors. The nature and extent of venture capitalist involvement varies, but, as Kortum and Lerner (2000, p. 676) note, the venture capitalist "is typically active as a director, an advisor, or even a manager of the firm."[8] Gompers and Lerner (1999) discuss how venture capitalists are able to use the positions they occupy on the board of directors to exert considerable influence over the firms they finance, even replacing the original CEO (who is often the founder).[9] Hellmann (2000) refers to venture capitalists as "coaches" that provide assistance on everything from strategy and recruitment to marketing and basic bookkeeping. Gompers and Lerner (2001, p. 64) claim that the venture capitalist provides "guidance, monitoring, shaping of management teams and boards, networking, and credibility" to the early development of the firm. They also discuss (p. 43) the "essential competitive advantage" that venture backing provides, enabling a company to "stand a much better chance of succeeding in the marketplace."[10]

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[6] See Carpenter and Petersen (2002a) for a discussion of the importance of equity finance, and more discussion of the reasons that high-tech firms have difficulty obtaining external finance.

[7] For a more thorough discussion of the mechanisms venture capitalists employ to overcome these information asymmetries, see Gompers and Lerner (1999, pp. 130-132). See Gompers (1995) for evidence on how venture capitalists use staging to monitor and gather information from portfolio firms.

[8] For evidence on venture capitalist representation on the board of directors see Lerner (1995) and Mikkelson et al. (1997).

[9] Hellmann and Puri (2000) present evidence indicating that the founder of a venture-backed firm is, in fact, more likely to be replaced than the founder of a non-venture-backed firm.

[10] Hsu (2004, p. 1805) presents evidence suggesting that "VCs "extra-financial" value may be more distinctive than their functionally equivalent financial capital."

Recent studies suggest that venture backing does have a positive impact on the early development of the firm. Hellmann and Puri (2000) find that venture backing reduces the time it takes for innovative companies to take a product to market; and, in a separate study, Hellmann and Puri (2002) find that venture-backed start-ups have a more fully developed internal organization than non-venture-backed start-ups. There is also evidence that venture capitalists remain actively involved with the firms they finance, even in the years following the IPO. For example, in 89% of the cases examined by Barry et al. (1990) the lead venture capitalist remained on the firm's board of directors one year after the IPO. Additionally, a recent study by Hochberg (2005) found that venture backing had a positive impact on corporate governance after the firm had gone public. It is not clear whether venture backing will have a positive impact on firm performance over the long-run as well, but the general perception appears to be, as Gompers and Lerner (2001, p. 64) suggest, that "the early participation of venture firms…helps innovators sustain their success long after their company issues an IPO."

B. Why Venture-Backed Firms Might Not Outperform

There are, however, reasons to believe that venture involvement might actually be detrimental to the long-run performance of the firm. In order to obtain venture capital the entrepreneur is forced to give up not only a share of ownership in the firm, but also a considerable amount of control over the future direction of the firm. Because the entrepreneur's incentives are no longer as closely aligned with the success of the firm, the performance of the firm may suffer, especially if the entrepreneur, and the entrepreneur's human capital, were to leave the firm.[11] Conflicts between the venture capitalist and entrepreneur might also develop, which, as Bygrave and Timmons (1992) have discussed, can certainly harm the progress of the firm.[12] Hellmann and Puri (2000) also note that there are substantial costs involved when the entrepreneur is forced to spend a great deal of time meeting with and appeasing the ever-present venture capitalist.[13]

Venture capitalists might also have a negative impact on long-run performance if they are overly focused on maximizing their returns over the short-run. Though venture capitalists do not liquidate their ownership stake at the time of the IPO, they do typically sell (or distribute) most of their holdings in the first few years thereafter. As Gompers and Lerner (1998) discuss, venture funds are organized with a predefined lifetime, so venture capitalists must liquidate their holdings, either by selling shares in the open market or distributing shares directly to the investors.[14] In the sample of share distributions they examine, the average time between the IPO and the first share distribution is 1.69 years. They also find that venture capitalists distribute almost all of their holdings at this time. In an effort to maximize the value of the firm in the first or second year after the IPO, venture capitalists might encourage the firms they finance to delay or abandon important investment projects, for example. While this may improve the market's

[11] As Gompers and Lerner (2001) discuss, venture capitalists take great strides to keep this from happening, such as ensuring that the entrepreneur retains a large equity stake in the firm.

[12] They cite one CEO who claims that "When negotiating with a venture capital firm I disregard what they say about added value. My strategy is to minimize their value subtracted!"

[13] Gompers and Lerner (2001, p. 5) note that "entrepreneurs have often felt that the terms demanded by venture capitalists are far too onerous for the amount of capital they provide." They add, however, that "these claims have little basis in reality."

[14] They note that most funds have a ten year lifetime, with an option to extend for three additional years. For a number of reasons, including insider selling rules and tax concerns, venture capitalists typically liquidate their holdings by distributing shares directly to investors in the fund.

perception of the company's balance sheet, and thereby increase the current stock price, it could be detrimental to the long-run performance of the firm.[15]

A related concern is that venture capitalists may be inclined to take a firm public earlier than would be optimal for the firm. Not only do venture capitalists make most of their money on the firms in their portfolio that ultimately go public, but having a firm they financed reach the IPO stage can be especially valuable when the venture capitalist attempts to raise additional funds.[16] So, venture capitalists (particularly younger ones) might engage in "grandstanding" by rushing a firm public. But a premature IPO could be very costly for the firm, resulting in greater underpricing and ultimately diminishing the future growth rate of the firm. Gompers (1996) finds that firms taken public by young venture capitalists are significantly younger, exhibit more underpricing, and raise much less from the IPO than firms taken public by older, more experienced, venture capitalists.[17]

C. Selection and Performance

Finally, performance differences might also arise because venture capitalists select which firms they will finance, and some non-venture-backed firms may have explicitly chosen not to seek venture funding. Venture capitalists finance a small fraction of the entrepreneurs that approach them for financing, and they have developed careful screening methods to determine which firms they will back (Gompers and Lerner (2001)). It is plausible to expect that venture capitalists will identify and fund a high proportion of the most promising new opportunities; and, if so, selection may be an important reason why venture-backed firms outperform non-venture-backed firms over time. It is also likely that some of the most promising firms will eschew venture capital because of its very high cost (in terms of lost ownership and control).[18] If the best firms are able to finance their activities either internally or from other external sources and are able to go public on their own, firms that received venture financing might exhibit underperformance over time.

D. An Empirical Question

Ultimately, whether venture-backed firms will outperform the firms that received no venture financing is an empirical question. The objective in the remainder of this paper is to document the magnitude and persistence of any performance differences that exist between venture- and non-venture-backed firms. As such, there is no attempt in the analysis that follows to explain why the performance differences exist, or to evaluate the various factors that may be

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[15] Gompers and Lerner (1998) find that there is a significant decline in share price just after a distribution.

[16] Jeng and Wells (2000) cite an early study by Venture Economics which found that after an average holding period of 4.2 years venture capitalists earned, on average, 195% on the firms in their portfolios that reached the IPO stage. The firms that were acquired, by comparison, were held on average 3.7 years and had an average return of only 40%.

[17] It is important to note, however, that because venture capitalists take multiple firms public they have a reputation to protect, and acquiring a reputation for window-dressing and/or rushing firms public could be quite damaging to the venture capitalist over time. See Jain and Kini (1995) for a more thorough discussion, and for evidence that venture-backed firms are less likely to engage in window-dressing just before IPO.

[18] Megginson and Weiss (1991) report that "venture capitalists expect to earn a compound annual return of 25 to over 50 percent (depending on the stage of the investment) on their investments in private companies." In addition, "venture capitalists invariably structure their investments in such a way that most of the business and financial risk is shifted to the entrepreneur."

responsible. The findings presented here lay the groundwork for a careful analysis of these questions in the future.

II. Sample Description and Initial Firm Characteristics

A. Data Sources

The primary data sources used in the study are Thompson Financial's SDC database, Venture Economics' VentureXpert database, and Compustat. The SDC database identifies the firms undertaking an initial public offering and provides some basic characteristics about the offer. The data from Venture Economics identifies which firms were financed with venture capital, and (generally) reports the total amount of venture funding that was received. The Compustat database is used to follow these firms in the years following the IPO. Coverage in Compustat is therefore a necessary condition for being included in the sample.[19] In order to track post-IPO performance for at least a decade, the analysis focuses on firms that went public between 1980 and 1989. Spinoffs and firms incorporated outside of the U.S are not included in the sample.[20]

B. IPOs in the High-Tech Sector

As other researchers have noted, venture capitalists specialize in financing high-tech firms (e.g., Gompers and Lerner (1999, Table 1.2)). In the U.S. during the 1980s, seven high-tech industries accounted for over 55% of the venture-backed IPOs that took place, but only around 19% of the offers that were not venture-backed. These industries are pharmaceuticals (SIC 283), computers and office machines (SIC 357), communications equipment (SIC 366), electronic components (SIC 367), measuring and controlling instruments (SIC 382), surgical and medical instruments (SIC 384), and software and computer related services (SIC 737). Because this is where venture capital activity is focused, and because of the worldwide interest in the relationship between access to risk capital and high-tech production, the analysis is limited to these seven industries in the high-tech sector. Overall, in this 'full' sample of high-tech IPOs from the 1980s, 422 firms were financed with venture capital and 388 were not. The largest number of IPOs occurred in SIC 357 (computers and office machines) and in SIC 737 (software and computer related services), while SIC 367 (electronic components) and SIC 382 (measuring and controlling instruments) had the fewest. The share of venture- and non-venture-backed IPOs was generally similar across the industries with the exception of computers and office machines which had almost twice as many venture-backed offers.[21]

C. The Matched Sample of High-Tech IPOs

The first two columns of Table I contain information on key firm characteristics in the year prior to the IPO for the full sample of high-tech IPOs. On average, the venture-backed firms are much larger prior to the IPO (in terms of sales and assets) and raise much more from

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[19] A small fraction of the IPOs identified by the SDC database never show up in Compustat, or, if they do, coverage begins more than one fiscal year after the IPO. These firms are immediately dropped. In constructing the matched sample firms without Compustat coverage a year prior to the IPO are also dropped.

[20] The SDC database (with some corrections) is used to identify spinoffs and the Compustat database to identify firms incorporated outside of the U.S.

[21] In the full sample the breakdown of venture- and non-venture-backed IPOs by industry is: 55 VC, 43 NVC in SIC 283; 113 VC, 60 NVC in SIC 357; 35 VC, 42 NVC in SIC 366; 40 VC, 30 NVC in SIC 367; 31 VC, 39 NVC in SIC 382; 45 VC, 64 NVC in SIC 384; and 103 VC, 110 NVC in SIC 737.

the IPO than the non-venture-backed firms. In addition, venture-backed firms are much more R&D intensive, have a higher operating return on assets, and have a lower total debt to assets ratio. While the primary interest is on the long-run performance and economic impact exhibited by the full sample of firms, it is also interesting to consider how venture-backed firms perform over time relative to a sample of non-venture-backed firms that are initially very similar. Toward this end, a matched sample of venture- and non-venture-backed firms based on industry and firm size is also constructed (similar to Megginson and Weiss (1991) and Jain and Kini (1995)). Specifically, within each three-digit industry, a venture-backed firm is matched with the non-venture-backed firm that has the closest level of total assets in the fiscal year prior to the IPO, as long as the non-venture-backed firm has assets between 60% and 140% of the venture-backed firm's and has not already been used as a match. So as to impose the same data requirements on all firms in the matched sample, there is no re-matching if a firm exits or is dropped from coverage in Compustat. As discussed later, to the extent that this rule introduces a bias it should work against the venture-backed firms.

While the matching algorithm is similar in spirit to Barber and Lyon (1996) and Loughran and Ritter (1997), it is more restrictive. Matching is based only on firm size within a narrow three-digit industry because the following analysis concerns post-IPO performance along a number of different margins (e.g., survival, growth, operating performance, investment, and economic impact.). Though matching is based on total assets, the firms in the matched sample are also very similar in terms of sales, employees and physical capital. In addition, matching greatly reduces the initial differences in IPO proceeds and operating performance.[22] In fact, the median initial difference in return on assets between a venture-backed firm and its match is just 10%.

The strict matching criterion reduces the size of the sample considerably, to 183 of each type of firm, because many venture-backed firms simply have no good non-venture-backed match. Sample size is clearly being sacrificed for closeness of match – while the sample size declines by almost 55%, the median percent difference between the initial size of the venture-backed firm and its match is less than four percent. In SIC 357 it is particularly difficult to find matches for the venture-backed firms because they are so much larger than the non-venture-backed firms across the board. The venture- and non-venture-backed firms in SIC 737, on the other hand, match up fairly well, and this industry accounts for over a third of the firms in the matched sample.[23]

D. Firm Characteristic prior to the IPO

Table I contains a comprehensive set of the characteristics the firms in the two samples exhibit the fiscal year prior to the IPO.[24] As previously discussed, venture- and non-venture-

[22] The venture-backed firms raised more funds than the non-venture-backed firms at both the mean ($21.06 vs. $14.83) and median ($13.62 vs. $8.23), but these differences are very similar to those reported by Megginson and Weiss (1991) and Jain and Kini (1995), even though they each matched by offer size when creating their samples. Specifically, Megginson and Weiss report a median offer of $15.0 million for the venture-backed and $9.2 million for the non-venture-backed firms in their sample, while Jain and Kini report a median offer of $14.80 million for the venture-backed firms in their sample and $11.60 million for the non-venture-backed firms.

[23] In the matched sample the number of venture- and non-venture-backed firms by industry is: 25 in SIC 283, 29 in SIC 357, 13 in SIC 366, 14 in SIC 367, 18 in SIC 382, 20 in SIC 384, and 64 in SIC 737.

[24] For the matched sample, if data is missing for a firm its match was also dropped from the values reported in the table. Including all available data has very little impact on the values reported, and has no impact on the significance tests.

backed firms in the matched sample are generally very similar in terms of initial size. In fact, none of the differences in initial size, at the mean or median, are statistically significant. There are, however, some significant differences in investment spending for the venture- and non-venture-backed firms in the matched sample. The absolute level of spending on physical capital is somewhat higher for the venture-backed firms at both the mean ($1.94 million vs. $1.38 million) and the median ($0.60 million vs. $0.46 million), though these differences are not statistically significant. The ratio of capital expenditures to sales is slightly higher for the venture-backed firms at the mean (0.46 vs. 0.32) and is significantly greater at the median (0.07 vs. 0.05). Differences in R&D spending are much more pronounced. The median level of spending on R&D is around twice as large for the venture-backed firms ($1.00 million vs. $0.49 million), as is the median ratio of R&D to sales (0.11 vs. 0.06). These differences are statistically (and economically) significant, as are the mean differences.

A key measure of operating performance is operating return on assets, which is computed by dividing gross operating income before depreciation and amortization by the book value of assets.[25] In the matched sample, the venture-backed firms have a lower return on assets at both the mean and median, though the difference is not statistically significant. Other measures of operating performance (not reported), such as net profit margin and return on equity, are also very similar for the venture- and non-venture-backed firms.[26] There are significant differences between the venture- and non-venture-backed firms in terms of capital structure prior to the IPO. Namely, at the median, venture-backed firms have a significantly smaller level of *total* debt per dollar of assets, where total debt is computed by adding long-term debt and debt in current liabilities. *Long-term* debt per dollar of assets (not reported) is actually very similar across firm type, suggesting that non-venture-backed firms are more reliant on short-term debt financing.

Finally, the last rows in Table I report firm age at the time of the IPO.[27] Venture-backed firms are younger at both the mean and the median in both samples, which is consistent with several other studies of venture financing (e.g., Megginson and Weiss (1991)). On the one hand this indicates that venture-backing might enable firms to access public equity earlier than would otherwise be possible (or feasible), but could also be a sign of grandstanding by the venture capitalist. In either case, age at the IPO is likely to impact the results that follow, since age has been found to be a key determinate of firm growth and survival (e.g., Evans (1987) and Hall (1987)).

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[25] Since R&D is treated as an expense instead of an investment, it is not included in operating income. So, R&D is added to operating income before depreciation and amortization to compute gross operating income. Similarly, Carpenter and Petersen (2002b) create a 'gross cash flow' measure by adding R&D to cash flow. See also Himmelberg and Petersen (1994) and Hall (1992).

[26] Another way to measure operating performance is to scale operating cash flow (operating income minus capital expenditures) by total assets. This measure is very similar to operating return on assets, so it is not reported. For studies that employ one or both of these measures see, for example, Kaplan (1989), Jain and Kini (1994 and 1995) and Mikkelson et al. (1997).

[27] Most of the age data was graciously provided by Laura Field and Jay Ritter (see Field and Karpoff (2002) and Loughran and Ritter (2004)), the rest was hand collected from various issues of Moody's. In the full sample, age data is missing for 60 venture-backed and 129 non-venture-backed firms. In the matched sample age data is missing 45 venture-backed firms and 39 non-venture-backed firms. In the remainder of the paper age for the firms with missing data is set to the median of all IPO firms in their industry.

E. Venture Financing and Initial Firm Characteristics

In the years leading up to the IPO, the median venture-backed firm in the full sample received $9.30 million from venture capitalists and the average venture investment was over $21 million. In the matched sample, the median investment was $6.78 million and the average investment $13.13 million. While this funding was received over several years, the venture investments are very large relative to the size of the firm, and are much larger than the amount of total debt carried by either type of firm into the IPO, at both the mean and median.

Given that venture-backed firms have received equity financing from the venture capitalist, and have access to similar quantities of long-term debt, it is perhaps not surprising that they are in a better position than the non-venture-backed firms to make investments (in both R&D and physical capital) prior to the IPO. The equity financing that venture-backed firms have received may be particularly important for financing R&D; and, in fact, for the venture-backed firms in the matched sample there is a strong, positive relationship between the total amount of venture capital received and R&D investment in the fiscal year prior to the IPO. Regressions (not reported) that control for industry and IPO-year fixed effects, indicate that an additional $1 million in cumulative venture funding is associated with a $70,000 increase in R&D spending in the year before the IPO. The non-venture-backed firms, on the other hand, rely more heavily on short-term debt financing, which is not well suited to finance high-tech investment, particularly R&D (see, e.g., Carpenter and Petersen (2002b), Hall (1992) and Brown and Petersen (2005)). So, while the venture- and non-venture-backed firms have similar stocks of physical capital just before the IPO, the venture-backed firms have likely accumulated a considerably larger stock of knowledge capital.[28]

III. The Initial Public Offering

The impact that an initial public offering has on the characteristics of the firm is noteworthy. As Table I indicates, venture-backed firms, on average, have larger IPOs than firms that received no venture capital. In the matched sample, the venture-backed firms also raise more funds relative to their size in the year before the IPO, a difference that is significant at the median (1.95 vs. 1.52) but not at the mean (2.89 vs. 2.44).[29] In the full sample, venture-backed firms actually raise significantly less per dollar of assets than the non-venture-backed firms at both the mean (2.29 vs. 4.11) and the median (1.34 vs. 1.92). The price of the issue is very similar for the venture- and non-venture-backed firms in the matched sample, but significantly larger for the venture-backed firms in the full sample.

Since cash is a component of total assets, there is a dramatic increase in firm asset size that occurs at the time of the IPO. In fact, going public dramatically impacts almost every aspect of the issuing firm. Table II reports mean and median percent changes in several key variables from the year before ($t = -1$) to two years after ($t = 2$) the IPO. A Wilcoxon two-sample signed-rank test is used to examine whether the median percent change is significantly different for the venture- and non-venture-backed firms.

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[28] Monitoring by venture capitalists that keeps firms from "window-dressing" their balance sheet just before the IPO might also lead to more investment by venture-backed firms prior to the IPO. This is suggested by Jain and Kini (1995).

[29] In matched sample regressions (not reported) that control for industry, IPO-year, age, return on assets, and leverage; at the sample mean, venture-backing is associated with a 19% increase in amount raised per dollar of total assets. Bottazzi and Da Rin (2002 and 2003) present similar results for European IPOs.

Not surprisingly, the size variable impacted most by the IPO, at least at the median, is total assets. For the matched sample, the median increase in total assets from the year before the IPO to two years after is around 225% for the venture-backed firms and 175% for the non-venture-backed firms. Sales, as well as employees (not reported) and the stock of physical capital (not reported), also increased substantially. For all size measures the venture-backed firms exhibited greater growth through the IPO, though only for sales was the difference in growth statistically significant at conventional levels. Results from the full sample were very similar.

The IPO also has a significant impact on capital expenditures and R&D for both venture- and non-venture-backed firms. In the matched sample, the median venture-backed firm increases capital expenditures by over 100%, and increases spending on R&D by over 140%. The non-venture-backed firms increase both capital expenditures (80%) and R&D (120%) by a slightly smaller amount, but the difference is not statistically significant. The average change in both capital expenditures and R&D, however, is much larger for the non-venture-backed firms (though again the differences are not statistically significant).

Relative to sales, the non-venture backed firms have significantly larger increases in both capital expenditures and R&D. While the median venture-backed firm has a 16% *decline* in the capital spending to sales ratio, the median non-venture-backed firm *increases* capital expenditures to sales by 5%. Similarly, R&D to sales increases by just 2% for the median venture-backed firm but 29% for the median non-venture-backed firm. Findings for the full sample are similar, though there is a great deal of variation and the differences are not statistically significant.

Overall, the results suggest that, in terms of financing physical investment and R&D, the IPO is particularly important to the non-venture-backed firms. The median non-venture-backed firm significantly increases their R&D and capital spending *intensity*, and the mean change in the *level* of investment in both physical capital and R&D is dramatic (well over 500% in each case). It is noteworthy that the changes around the IPO are much more subdued for the venture-backed firms; though recall from Table I that the venture-backed firms have much higher investment levels before the IPO, especially with regard to R&D. As this highlights, venture financing may be particularly valuable because the early access to external equity finance means that venture-backed firms do not have to wait for the IPO to invest in R&D. The ability to make key investments in the pre-IPO period will undoubtedly impact firm performance over time, and may give the venture-backed firms a significant advantage over their non-venture-backed counterparts.

IV. Survival

A. Cumulative Exit Rates

Remaining in business as an independent economic agent (i.e., surviving) is probably the most basic way to gauge firm performance over time. As Klepper (2002, p. 37) notes, "[length of survival] appears to be closely related to other measures of performance such as profitability, size, and growth, and arguably it is the most comprehensive of the group." In Panel A of Table III, cumulative exit rates, together with the share of exits caused by a merger or acquisition, are reported at five and ten years after the IPO. In the matched sample, exit rates are generally very similar for the venture- and non-venture-backed firms, though a slightly larger share of the non-venture-backed firms exit in the first ten years following the IPO (by $t = 10$). Five years after the IPO 24.6% of the venture-backed firms, and 23.5% of the non-venture-backed firms, have

exited. By t = 10 almost half of the original sample is gone (48.8% of the venture-backed firms and 51.2% of the non-venture-backed firms). In the full sample, non-venture-backed firms have a much higher exit rate, which is perhaps not surprising given their much smaller size initially.

Differences between the venture- and non-venture-backed firms with regard to the type of exit are pronounced in each sample. While the most common reason for exit is a merger or acquisition for each type of firm, by t = 10 a larger share of the venture-backed firms (62%) in the matched sample exit in this manner than do the non-venture-backed firms (54%). In the full sample, a much larger share of the venture-backed firms exit due to a merger or acquisition.

B. Proportional Hazard Estimates

To more systematically examine survival after the IPO, consider a proportional hazard model of the form

$$h(t) = h_0(t)\, exp\{\beta' X\}. \quad (1)$$

The Cox proportional hazard model is a popular way to model duration because it imposes no structure on the baseline hazard $h_0(t)$, it easily handles censored observations, and the interpretation is straightforward. The ability to deal with censored observations is important, because many firms have not exited by the end of the sample period. In addition, a merger is an ambiguous type of exit, so it makes sense to treat mergers as censored observations instead of outright failures. In each case the model accounts for the fact that the firm survived until the end of the sample, or until the merger.[30]

Panel B of Table III contains the results from Cox regressions using both the full and matched samples. In each case the dependent variable is the number of years the firm survived after the IPO (Time-To-Exit). The independent variables are the log of total assets the year before the IPO, the log of firm age at the IPO, and a dummy variable (VC) equaling one if the firm was venture financed and zero otherwise. Several studies have found size and age to be important determinates of firm survival, most concluding that, all else equal, firms that are larger and older survive longer (Sutton (1997)). Industry and IPO-year dummies are also included in the regressions, but not reported with the results.

For each sample the coefficient on the VC dummy is negative and statistically significant. The negative coefficient indicates that after controlling for initial size and age venture-backed firms have a lower hazard rate than non-venture-backed firms, and hence a longer expected duration. The risk ratio says that, relative to non-venture-backed firms, venture-backed firms in the full sample are just 0.56 times as likely to exit in any given period (0.61 times as likely in the matched sample).[31] Not surprisingly, the results also suggest firms that are larger and older at the time of the IPO tend to survive longer.

C. Implications of the Exit Statistics

Recall that firms are not replaced in the matched sample once they exit Compustat coverage. Thus, the exit statistics have some important implications for the results that follow.

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[30] See Kiefer (1988) for more information on hazard models in general, and the Cox proportional model in particular.

[31] It is important to note that the inferences one draws from these coefficient estimates will be misleading if the model is misspecified and/or important explanatory variables are omitted. See Kiefer (1988, pp. 671-676), Kiefer and Skoog (1984), Lancaster (1990), and Ridder and Verbakel (1984).

The fact that overall exit rates are so similar in the matched sample greatly mitigates any bias that exit introduces as performance is examined over time. Observed growth rates, for example, will be overstated because of exit, but should be similarly overstated for both venture- and non-venture-backed firms. In fact, because the sample of non-venture-backed firms sheds a slightly larger share of underperformers by the end of the sample period (this is especially true in the full sample), any bias that is introduced should actually work against the venture-backed firms. Additionally, if firms that are merged or acquired have a greater sustained impact on economic output than firms that went bankrupt or were liquidated, the true performance of venture-backed firms relative to non-venture-backed firms will be understated.

V. Performance and Financing after the IPO

This section considers whether persistent empirical differences in the performance and financing of venture- and non-venture-backed firms exist in the decade following the IPO. This is done using a battery of descriptive regressions, reported in Tables IV – VI. Since the interest is on the post-IPO period, the first observation taken for each firm occurs at t = 2, and the last observation is taken at t = 10. Starting with t = 2 allows the first growth rates to be computed from t = 1, the first fiscal year following the IPO. All of the firms are included until they exit or are no longer covered by Compustat, and the bias this introduces, as just discussed, should work against the venture-backed firms. Once again, separate results are reported for the full and matched samples.

A. Firm Growth after the IPO

Sales and total assets are used to evaluate the relative growth of venture-backed firms after the IPO, though the results for employment growth are very similar. Sales growth is also commonly used to gauge the operating performance of the firm (e.g., Gompers et al. (2003)). The growth regressions take the following form:

$$G_{i,t} = \alpha_0 + \alpha_1 VC_i + \alpha_2 t + \alpha_3 VC_i * t + \alpha_4 ln(BM_{i,t-1}) + \alpha_5 ln(Age_{i,t=0}) + \alpha_6 Industry_i + \alpha_7 IPO\text{-}Year_i + \varepsilon_{i,t}. \quad (2)$$

Since t is the number of years since the IPO, $G_{i,t}$ is the growth rate of firm i at time t, and is equal to the log change over the previous year. A dummy variable, *VC*, is equal to one if the firm was venture-backed and zero otherwise, and an interaction between the VC dummy and the number of years since the IPO is included to examine whether the relative growth rates across venture- and non-venture-backed firms change over time. The only additional controls, which include the book-to-market ratio at the end of the prior fiscal year and the age of the firm at the IPO, are similar to those used by Gompers et al. (2003). A set of dummy variables is included to control for industry and IPO-year effects, though estimates on the dummies are not reported in the output. Additionally, to ensure the results are not being driven by outliers, the 1% tails of all regression variables are excluded.[32]

The evidence, reported in the first four columns of Table IV, suggests that venture-backed firms grow significantly faster than non-venture-backed firms, and that this superior performance persists for several years following the IPO. For both the full and matched samples, the estimated coefficient on the *VC* dummy in each growth regression is positive, statistically

[32] The coefficient estimates are not as precise, but the results are generally the same if all firms and all observations are included.

significant and large. The coefficient on the interaction between venture backing and time is negative and (generally) significant, indicating that there is some convergence (at around one percentage point a year) in growth rates over time. For example, the regression estimates from the matched sample suggest that annual sales growth two years after the IPO is 5.7 percentage points greater for the venture-backed firms, while asset growth is 4.2 percentage points greater. The regression results suggest that venture-backed firms in the matched sample continue to experience faster sales growth for six to seven years after the IPO, and faster asset growth for more than five years. The results for the full sample are very similar, though asset growth is initially much faster for the venture-backed firms, and therefore convergence takes much longer (almost ten years). The fact that venture-backed firms in the full sample exhibit significantly faster growth is particularly impressive given that they are initially much larger and have lower exit rates than the non-venture-backed firms.

B. R&D, Knowledge Capital and Capital Expenditures

The last four columns of Table IV examine R&D investment in the years following the IPO. In addition to the rate of growth, the (log) level of R&D to sales in the post-IPO period is also examined. The regression specifications are exactly the same as above. Columns (5) and (6) indicate that growth in R&D investment is much faster for the venture-backed firms for many years following the IPO. In the matched sample, two years after the IPO the annual growth in spending on R&D is almost 12 percentage points greater for venture-backed firms. As with growth in sales and assets there is some evidence of convergence, but convergence in R&D growth rates take even longer. The estimates from the matched sample imply that venture-backed firms have faster R&D growth for over eight years following the IPO, and in the full sample venture-backed firms have faster R&D growth for more than a decade.

Since venture-backed firms have higher levels of R&D prior to the IPO, and much faster rates of growth in R&D spending after the IPO, they should accumulate a significantly larger stock of "knowledge" capital over time. Following Hall (1990), a stock of knowledge capital can be created for each firm, based on the firm's historical spending on R&D. Hall assumes that knowledge depreciates at a rate of 15% per year, and that the initial stock of knowledge is equal to the initial level of R&D divided by the sum of the depreciation rate (0.15) and the R&D growth rate (0.08). The stock of knowledge at any given *t* is then

$$K_t = 0.85*K_{t-1} + R\&D_t.^{33} \quad (3)$$

Looking ten years after the IPO, venture-backed firms have accumulated a stock of knowledge over three times larger (at both the mean and median) in the matched sample, and over five times larger in the full sample.

There is also evidence (not reported) that growth in capital expenditures is significantly faster for the venture-backed firms over the post-IPO period, though only for the full sample are the results statistically significant. For the full sample annual growth in capital spending is more that 15 percentage points greater for venture-backed firms two years after the IPO, and it takes more than eight years for growth rates to converge. In the matched sample the coefficient on the

[33] Occasionally, in the time series for a given firm, one or two observations on R&D were missing. In those cases R&D in the previous period is used when computing knowledge capital.

venture capital dummy is positive and in line with the estimate from the full sample, but it just misses significance at the 10% level.

Columns (7) and (8) in Table IV indicate that venture-backed firms continue to have a significantly greater R&D to sales ratio in the post-IPO period, and there is no evidence of convergence over time. For the matched sample, the R&D to sales ratio is, on average, almost 60% larger for venture-backed firms. Similarly, in the full sample the venture-backed firms have an R&D to sales ratio approximately 38% larger. The results for capital expenditures to sales are similar, though the differences are less pronounced, especially in the matched sample: on average, capital spending to sales is 33% greater for venture-backed firms in the full sample and 18% greater for venture-backed firms in the matched sample. There is no evidence in either sample that the higher level of capital spending to sales for venture-backed firms disappears over time. So, while non-venture-backed firms have significantly larger increases in both R&D to sales and capital expenditures to sales around the time of the IPO, they never reach the investment intensity of venture-backed firms in the post-IPO period, and in fact may fall further behind.[34]

C. Tobin's Q and Operating Performance

This section examines whether any empirical relationships exist between venture-backing and firm value and operating performance in the post-IPO period, where firm value is measured by Tobin's *Q*. Like Gompers et al. (2003), and Kaplan and Zingales (1997), *Q* is computed by dividing the market value of assets (book value of assets + market value of common stock – book value of common stock – deferred taxes) by the book value of assets. Common measures of operating performance are also examined, once again closely following Gompers et al. (2003). The regression specifications are the same as above, though in the *Q* regression the book-to-market ratio is replaced by the log of assets at the beginning of the current fiscal year. The results are reported in Table V.

Columns (1) and (2) contain estimates for the full and matched samples when the log of *Q* is the dependent variable. In the matched sample, *Q* is approximately 15% greater for the venture-backed firms, on average, during the decade following the IPO. The coefficient on the interaction between venture backing and time suggests no convergence over time. However, there is no evidence of a higher *Q* value for the venture-backed firms in the full sample, as the coefficient on the venture capital dummy is slightly negative and statistically insignificant.

The evidence regarding operating performance after the IPO appears in columns (3) – (8). While the coefficient estimates on the venture capital dummy are typically positive, only for return on assets (gross operating income divided by total assets) are the differences between venture- and non-venture-backed firms statistically significant in both the full and matched samples. Net profit margin (gross operating income divided by sales) is significantly greater for the venture-backed firms in the full sample, but not in the matched sample. In the return on equity (gross operating income divided by the book value of equity) regressions the coefficient on the venture capital dummy is positive but insignificant in the full sample, and slightly negative and insignificant in the matched sample. The interaction between venture backing and time is negative in the net profit margin and return on assets regressions, and positive in the

[34] The findings on R&D suggest that venture-backed firms are likely driving innovation as well. Though R&D is an input, it is often used as a proxy for innovative activity (see Griliches (1990)). For more on the relationship between venture capital and innovation, see Kortum and Lerner (2000).

return on equity regressions, but not statistically significant in any case. Overall then, there is some evidence that venture-backed firms have superior operating performance in the post-IPO period, at least when measured by sales growth, return on assets and (to a lesser extent) net profit margin, and no evidence that the operating performance of venture-backed firms is inferior.

D. Debt and Equity

Table VI examines the book value of equity and debt, as well as the use of new long-term debt and equity in the post-IPO period. Pooled regressions on stockholder equity over assets, long-term debt over assets and total debt over assets in the post-IPO period are reported in columns (1) – (6), and have the same general specification used throughout this section. The results are very similar to those for the pre-IPO period: the book value of stockholder equity to total assets is significantly larger for venture-backed firms, while long-term debt to total assets is slightly smaller, and total debt to total assets is significantly smaller. There is some evidence that the relative level of stockholder equity to assets diminishes over time for the venture-backed firms, but the coefficient estimates on the interaction term are small.

The remainder of Table VI contains output from cross-sectional regressions examining whether venture- and non-venture-backed firms differ in the amount of follow-up equity and new long-term debt that is issued after the IPO. In columns (7) and (8) the dependent variable is the log of cumulative net equity issued between t = 2 and t = 10, while in columns (9) and (10) the dependent variable is the log of cumulative new long-term debt. Controls in the cross section regressions include age, book-to-market and asset size at the end of the IPO year, as well as industry and IPO-year dummies. The findings indicate that venture-backed firms raise significantly more net new equity relative to non-venture-backed firms. For example, in the matched sample venture-backing is associated with a 68% increase in the cumulative amount of new equity raised. As for new long-term debt, the coefficient on the venture capital dummy is small and statistically insignificant in each sample, suggesting little difference between venture- and non-venture-backed firms.

VI. Impact on the High-Tech Sector

To get a sense of the relative impact that venture- and non-venture-backed IPOs from the 1980s have had on economic output in the U.S., the aggregate contribution that each group made to high-tech sales, R&D and market value between 1990 and 2003 is reported in Table VII. High-tech output is computed by summing across all of the publicly traded firms covered by Compustat in the seven industries from which the samples are drawn. The venture-backed firms have a much larger impact on the high-tech sector, and their influence is expanding over time, while the non-venture-backed firms have become relatively less important. These figures capture the cumulative impact that venture-backed firms have because of longer survival, faster growth and the presence of some very successful firms.

Looking first at the matched sample, the venture-backed firms account for around 3% of high-tech sales in 1990, but almost 6% by 2003. The non-venture-backed firms, on the other hand, account for 1.6% of sales in 1990 but just 0.7% by 2003. Similarly, the share of high-tech R&D attributable to the venture-backed firms increased from 5% in 1990 to 6.7% in 2003; but the share of R&D that the non-venture-backed firms were responsible for declined from just over 1% in 1990 to 0.4% in 2003. Even more dramatic is the share of high-tech market value, which increases from 5.5% to 10.2% between 1990 and 2003 for the venture-backed firms, but during this same time declines from 1.6% to 0.5% for the non-venture-backed firms. The fact that the

venture-backed firms in the matched sample actually increase the share of high-tech output they account for is particularly impressive since the number of firms in the matched sample is relatively small and declining throughout the 1990s, while the number of firms in the high-tech sector is expanding dramatically. By 2003 the venture-backed IPOs had cumulative sales over eight times larger than the non-venture-backed firms, cumulative R&D 15 times larger, and cumulative market value 22 times larger. The results for the full sample, while less surprising, are impressive nonetheless. Venture-backed IPOs accounted for 16% of sales, 15% of R&D, and 20% of high-tech market value in 2003. The corresponding values for the non-venture-backed firms were 1%, 0.8%, and 0.7%.

As the results suggest, almost all of the big winners from the set of firms that went public in the 1980s were financed with venture capital. If the firms in the matched sample are ranked based on sales in 2003, there are no non-venture-backed firms in the top five and only six non-venture-backed firms in the top 20. Looking across the seven high-tech industries, 13 firms in the full sample of IPOs from the 1980s are among the top ten firms in their industry (in terms of net sales) at the end of 2003; and of these 13 firms, all but one received venture capital financing.

VII. Conclusions

In the U.S., venture capital has emerged as an important source of external finance for many private, high-tech firms. Venture capitalists become actively involved with the firms they finance and are in a unique position to have a major impact on the long-run performance of the firm. Most of the prior research on venture capital financing has focused on the time leading up to and surrounding the firm's IPO. While this focus is understandable, the true importance of venture capital finance surely depends, as well, on how venture-backed firms perform in the years following their IPO.

To examine the relative performance of venture-backed firms over the long-run, this study focuses on U.S. firms that went public during the 1980s in seven key high-tech industries. The relative performance of venture-backed firms is examined with a full sample comprised of all IPOs from the decade, as well as a carefully matched sample based on industry and firm size prior to the IPO. The results indicate that venture-backed firms raise considerably more funds from the IPO, and that both types of firms exhibit significant increases in their size and investment spending as they move through the IPO. The IPO appears to be especially important for non-venture-backed firms in terms of financing capital spending and R&D. Following the IPO, venture-backed firms survive longer and have lower hazard rates. Estimates from a series of growth regressions indicate that venture-backed firms grow much faster than non-venture-backed firms for many years after the IPO, though growth rates do (slowly) converge over time. On average, in the matched and un-matched samples, venture-backed firms also have much faster growth in R&D spending in the post-IPO period, are much more R&D intensive, and accumulate a much larger stock of knowledge capital. In addition, the operating performance of venture-backed firms is generally superior in the post-IPO period, but the extent of this superior performance depends on the measure of operating performance employed. Venture-backed firms have a higher level of stockholder equity to total assets in the decade following the IPO, and they raise significantly more new equity during this period. Finally, by 2003 the venture-backed firms that went public in the 1980s had a far greater cumulative impact on sales, R&D and market capitalization in the high-tech sector.

These findings raise interesting questions about the role the venture capitalist plays in firm performance over the long-run. The superior long-run performance that venture-backed

firms exhibit is probably due to several factors: venture capitalists select the most promising ideas, they ensure adequate external financing, and they provide valuable support and governance. At a minimum, the results suggest that in the 1980s venture capitalists, on average, were doing a good job of providing resources to firms with promising long-run prospects. It is possible that some of these firms had sufficient access to other sources of early-stage, external finance and would have become just as successful without venture financing. For these firms, the contribution that venture capitalists make may be limited, but venture capitalists certainly do not appear to harm long-run performance. In fact, venture financing probably allows firms to go public sooner, and therefore helps, at least, to speed up the development of successful firms.

Given the problems associated with financing high-tech investment, the venture capitalist's contribution is likely much more crucial. Many of the firms that venture capitalists finance probably do not have sufficient access to other sources of external finance. The fact that entrepreneurs are willing to give so much ownership and control to the venture capitalist suggests that alternative financing sources are limited at best. It is not unreasonable to expect that many good projects may have been under funded, or not funded at all, without the private equity financing that venture capitalists provide. The findings show that venture-backed firms do engage in significantly more R&D before the IPO, and the fact that non-venture-backed firms exhibit a dramatic increase in R&D intensity as they move through the IPO suggests that their ability to finance investment was constrained beforehand. This constraint could have been a serious competitive disadvantage for the non-venture-backed firms because the R&D investments that venture-backed firms were able to make allowed them to acquire greater intellectual capital in the pre-IPO period, which would positively impact their performance after the IPO.

Besides relaxing financing constraints, there are other ways that venture capitalists add value to the firms they finance. The guidance, networking and experience that venture capitalists provide might very well contribute to the superior long-run performance that venture-backed firms exhibit. The extent to which this 'value-added' role impacts long-run performance is unclear, but the findings presented in this paper suggest that future research into the relative importance that various aspects of venture capitalist involvement have on long-run performance would be fruitful.

This paper highlights several other issues that warrant further study. In particular, the evidence presented here shows that venture-backed firms have been the driving force behind high-tech production in the U.S. These findings suggest that the availability of early stage venture financing may play a key role in determining whether a country or region is able to specialize in the production of high-tech goods, but more international evidence on venture capital financing and high-tech production is clearly needed. Additionally, the initial evidence that venture-backed firms in Europe do not significantly outperform in the years immediately following the IPO indicates that the nature of venture financing can differ considerably in different economies (Bottazzi and Da Rin (2002, 2003)). Documenting these differences, and understanding the implications they have for firm performance over time, would be especially valuable.

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Table I

Characteristics of IPO Firms

This table presents key firm characteristics the fiscal year before the IPO for a full and matched sample of venture- and non-venture-backed firms that went public between 1980 and 1989 in the U.S. high-tech sector. The data comes from Compustat, and all reported values are in millions of 2000 dollars. Return on assets is equal to gross operating income (operating income plus R&D) divided by total assets. Total debt is equal to long-term debt plus debt in current liabilities. Means are reported first, medians are in bold, and the number of observations is in italics. If a firm in the matched sample had missing data its match was also excluded from the values reported in the last three columns of the table. Including all possible observations has no significant impact. Tests of differences in medians are based on the Wilcoxon two-sample signed-rank test. *, **, and *** denote significance at the 10%, 5% and 1% levels.

	Full Sample			**Matched Sample**		
	VC	**NVC**	**t, z stat**	**VC**	**NVC**	**t, z stat**
Total Assets	23.53	15.41	2.41**	14.38	14.28	0.04
	14.92	**3.46**	**10.37*** **	**7.34**	**6.85**	**0.59**
	346	*287*		*183*	*183*	
IPO Proceeds	26.65	11.79	8.32***	21.06	14.82	2.65***
	19.15	**6.33**	**12.46*** **	**13.62**	**8.22**	**3.08*** **
	415	*376*		*183*	*183*	
Sales	29.02	18.52	3.00***	18.06	19.95	-0.06
	17.32	**5.62**	**7.57*** **	**8.21**	**9.89**	**-1.26**
	346	*283*		*169*	*169*	
Capital Spending	3.24	1.15	5.32***	1.94	1.38	1.39
	1.24	**0.26**	**10.04*** **	**0.60**	**0.46**	**1.63**
	343	*280*		*164*	*164*	
Capital Spending / Sales	0.40	0.42	-0.13	0.46	0.32	0.58
	0.07	**0.06**	**3.74*** **	**0.07**	**0.05**	**3.93*** **
	334	*266*		*153*	*153*	
R&D	3.45	1.14	7.79***	2.14	1.25	2.29**
	2.01	**0.43**	**11.58*** **	**1.00**	**0.49**	**4.52*** **
	324	*237*		*126*	*126*	
R&D / Sales	0.84	0.74	0.31	1.37	0.23	2.13**

Table I, continued

Characteristics of IPO Firms

	0.11	**0.08**	**3.59*** **	**0.11**	**0.06**	**5.10*** **
	315	*226*		*119*	*119*	
Return on Assets	0.21	0.10	2.81***	-0.16	0.24	-1.61
	0.27	**0.23**	**1.62**	**0.25**	**0.29**	**-1.08**
	324	*235*		*168*	*168*	
Total Debt / Total Assets	0.26	0.44	-3.93***	0.32	0.34	-0.69
	0.16	**0.30**	**-5.44*** **	**0.17**	**0.27**	**-2.53** **
	346	*287*		*171*	*171*	
Firm Age	7.13	8.8	-2.47**	8	10	-1.94*
	5	**6**	**-1.12**	**6**	**8**	**-1.78***
	362	*259*		*138*	*144*	

Table II

Percent Changes in Firm Characteristics around the IPO (t = -1 to t = 2)

Table values are the percentage change from the year before the IPO (t = -1) to two years after the IPO (t = 2) for venture- and non-venture-backed firms that went public between 1980 and 1989 in the U.S. high-tech sector. The mean percent change is reported first, the median percent change is in bold, and the number of observations is in italics. For the matched sample, if a firm had missing data in t = -1 then its match was also excluded from the calculations. The number of observations differs across firm type in the matched sample because some firms have already exited and others have missing data in t = 2. Tests of differences in medians across the two groups are based on the Wilcoxon two-sample signed-rank test. *, **, *** denote significance at the 10%, 5% and 1% levels, respectively.

	Full Sample			**Matched Sample**		
	VC	**NVC**	**t, z stat**	**VC**	**NVC**	**t, z stat**
Total Assets	373%	470%	-1.13	344%	293%	1.16
	200%	**183%**	**0.64**	**225%**	**175%**	**1.29**
	313	*239*		*162*	*161*	
Sales	632%	398%	0.99	782%	217%	1.45
	132%	**77%**	**3.39*** **	**118%**	**64%**	**3.37*** **
	307	*228*		*144*	*146*	
Capital Spending	358%	564%	-1.54	319%	583%	-1.41
	113%	**91%**	**0.37**	**101%**	**80%**	**0.03**
	307	*227*		*145*	*141*	
Capital Spending / Sales	67%	155%	-2.04**	49%	182%	-2.36**
	-14%	**-8%**	**-1.31**	**-16%**	**5%**	**-2.20** **
	300	*220*		*136*	*132*	
R & D	292%	385%	-0.97	321%	543%	-1.26
	146%	**115%**	**2.22** **	**143%**	**123%**	**0.79**
	289	*192*		*110*	*106*	
R & D / Sales	52%	335%	-1.48	59%	604%	-1.53
	2%	**5%**	**-0.50**	**2%**	**29%**	**-2.13** **
	281	*183*		*103*	*98*	

Table III

Cumulative Exit Rates and Proportional Hazard Estimates

This table presents cumulative exit rates and hazard estimates for the venture- and non-venture-backed firms that went public between 1980 and 1989 in the U.S. high-tech sector. The cumulative exit rate, reported in Panel A, is the percentage of firms initially in the sample that are no longer covered by Compustat. The share of exits due to merger or acquisition is based on information reported by Compustat. Panel B reports estimates from Cox proportional hazard regressions where the dependent variable is the number of years the firm survived after the IPO (time-to-exit). VC is a dummy variable indicating venture-backing, Size is a control for firm assets at the time of the IPO, and Age is firm age (in years) at the time of the IPO. Industry and IPO year dummies are also included. Firms that survive until the end of the sample period, as well as firms that are merged or acquired are treated as right-censored observations. *, **, *** denote significance at the 10%, 5% and 1% levels, respectively.

Panel A: Exit Rates

	Full Sample		**Matched Sample**	
	VC	**NVC**	**VC**	**NVC**
Cumulative Exit Rate to t = 5	**17.5%**	**29.1%**	**24.6%**	**23.5%**
Share Merger or Acquisition	*64.9%*	*55.4%*	*55.6%*	*53.5%*
Cumulative Exit Rate to t = 10	**39.8%**	**49.2%**	**48.8%**	**51.2%**
Share Merger or Acquisition	*63.1%*	*38.7%*	*62.2%*	*53.5%*

Panel B: Cox Proportional Hazard Estimates

Dependent Variable	***Time-To-Exit***			
Independent Variables	**Coefficient**	**Risk Ratio**	**Coefficient**	**Risk Ratio**
VC	**-0.586** *(0.161)***	**0.557**	**-0.491** *(0.236)***	**0.612**
ln(Size$_{t=-1}$)	**-0.313** *(0.071)***	**0.731**	**-0.621** *(0.142)****	**0.537**
ln(Age$_{t=0}$)	**-0.264** *(0.111)***	**0.768**	**-0.194** *(0.183)*	**0.823**
Industry Effects Included *IPO Yr. Effects Included*				
x^2	84.12		43.04	
model p-value	0.000		0.001	

Table IV
Firm Growth and R&D Investment after the IPO

This table presents regression results for sales growth, asset growth, growth in R&D spending and (log) R&D to sales between between years t = 2 and t = 10 following the IPO. Growth rates are measured as the annual log change from the previous year. The controls include a dummy variable equal to one if the firm received venture capital financing (VC), the number of years since the firm went public (t), an interaction between venture-backing and years since the IPO (VC*t), the book-to-market ratio at the end of the previous fiscal year (BM), and the age of the firm at the time of the IPO (Age). Controls for three-digit industry and IPO year are also included in the regression but omitted from the table. Book-to-market is measured as the book value of common equity (book value of common equity + deferred taxes) divided by the market value of common equity. The coefficients are in bold and robust standard errors are reported in parenthesis. Significance at the ten-, five- and one-percent level is indicated by *, **, and ***. Results are reported separately for the full and matched samples of high-tech IPOs (described in Section II).

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Dependent Variable	***Sales Growth***		***Asset Growth***		***R&D Growth***		***ln(R&D / Sales)***	
Sample	**Full**	**Matched**	**Full**	**Matched**	**Full**	**Matched**	**Full**	**Matched**
Mean Difference (VC - NVC)	0.042	0.044	0.045	0.036	0.069	0.074	0.385	0.617
t-stat	*3.58***	*2.87***	*4.32***	*2.60***	*4.99***	*3.73***	*10.45***	*11.88***
Median Difference (VC - NVC)	0.052	0.053	0.042	0.042	0.056	0.055	0.328	0.442
z-stat	*4.90***	*3.79***	*4.84***	*2.99***	*5.30***	*3.81***	*11.24***	*11.82***
Independent Variables								
VC	**0.077**	**0.081**	**0.109**	**0.066**	**0.172**	**0.156**	**0.378**	**0.587**
	*(0.030)***	*(0.041)***	*(0.026)****	*(0.034)***	*(0.035)****	*(0.049)****	*(0.084)****	*(0.118)****
t	**-0.010**	**-0.005**	**0.006**	**0.007**	**0.007**	**0.003**	**-0.007**	**-0.011**
	*(0.004)****	*(0.004)*	*(0.003)**	*(0.003)***	*(0.005)*	*(0.006)*	*(0.012)*	*(0.015)*
VC*t	**-0.006**	**-0.012**	**-0.011**	**-0.012**	**-0.017**	**-0.019**	**0.009**	**0.007**
	(0.005)	*(0.006)**	*(0.004)****	*(0.005)***	*(0.006)****	*(0.008)***	*(0.014)*	*(0.019)*
$\ln(BM_{t-1})$	**-0.089**	**-0.085**	**-0.103**	**-0.131**	**-0.077**	**-0.084**	**-0.177**	**-0.047**
	*(0.009)****	*(0.012)****	*(0.007)****	*(0.010)****	*(0.009)****	*(0.015)****	*(0.023)****	*(0.033)*
$\ln(Age_{t=0})$	**-0.023**	**-0.001**	**0.008**	**0.001**	**0.002**	**0.011**	**-0.202**	**-0.137**
	*(0.008)****	*(0.012)*	*(0.008)*	*(0.010)*	*(0.011)*	*(0.016)*	*(0.026)****	*(0.036)****

Table IV, continued
Firm Growth and R&D Investment after the IPO

Constant	**0.160**	**0.047**	**-0.106**	**-0.294**	**-0.126**	**-0.123**	**-1.125**	**-1.420**
	*(0.045)***	*(0.085)*	*(0.042)***	*(0.067)***	*(0.055)**	*(0.084)*	*(0.132)***	*(0.218)***
Industry Effects Included								
IPO-Year Effects Included								
Adjusted R^2	*0.07*	*0.06*	*0.07*	*0.12*	*0.04*	*0.03*	*0.28*	*0.26*
F-Stat	*11.22*	*4.41*	*13.40*	*10.92*	*7.60*	*3.67*	*54.11*	*23.21*
N	*4047*	*1920*	*4132*	*1968*	*3712*	*1764*	*3711*	*1757*

Table V
Tobin's Q and Operating Performance

This table presents regression results for Tobin's Q, net profit margin, return on equity and return on assets between years t = 2 and t = 10 following the IPO. Tobin's Q is computed by dividing the market value of assets (book value of assets + market value of common stock - book value of common stock - deferred taxes) by the book value of assets. Net profit margin is equal to gross operating income (operating income + R&D) divided by net sales. Return on equity is equal to gross operating income divided by the book value of stockholder equity, and return on assets is equal to gross operating income divided by the book value of assets. The controls include a dummy variable equal to one if the firm received venture capital financing (VC), the number of years since the firm went public (t), an interaction between venture-backing and years since the IPO (VC*t), the book-to-market ratio at the end of the previous fiscal year (BM), and the age of the firm at the time of the IPO (Age). Controls for three-digit industry and IPO year are also included in the regression but omitted from the table. Book-to-market is measured as the book value of common equity (book value of common equity + deferred taxes) divided by the market value of common equity. In the Q regression the book value of assets at the start of the current fiscal year replaces the book-to-market ratio. The coefficients are in bold and robust standard errors are reported in parenthesis. Significance at the ten-, five- and one-percent level is indicated by *, **, and ***. Results are reported separately for the full and matched samples of high-tech IPOs (described in Section II).

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Dependent Variable	***ln(Q)***		***Net Profit Margin***		***Return on Equity***		***Return on Assets***	
Sample	**Full**	**Matched**	**Full**	**Matched**	**Full**	**Matched**	**Full**	**Matched**
Mean Difference (VC - NVC)	-0.015	0.175	0.131	0.013	0.072	0.008	0.091	0.035
t-stat	*-0.75*	*6.13***	*6.32***	*0.47*	*3.20***	*0.29*	*10.45***	*3.25***
Median Difference (VC - NVC)	0.042	0.224	0.060	0.037	0.056	0.007	0.052	0.021
z-stat	*0.87*	*6.70***	*11.91***	*5.68***	*5.91***	*0.96*	*10.21***	*3.71***
Independent Variable								
VC	**-0.022**	**0.149**	**0.135**	**0.052**	**0.065**	**-0.004**	**0.087**	**0.059**
	(0.046)	*(0.062)***	*(0.061)***	*(0.080)*	*(0.065)*	*(0.067)*	*(0.025)****	*(0.031)***
t	**-0.017**	**-0.006**	**0.013**	**0.021**	**0.018**	**0.019**	**0.011**	**0.014**
	*(0.006)****	*(0.007)*	*(0.008)*	*(0.006)****	*(0.008)***	*(0.007)****	*(0.003)****	*(0.004)****
VC*t	**0.016**	**0.002**	**-0.005**	**-0.017**	**0.001**	**0.001**	**-0.003**	**-0.007**
	*(0.008)***	*(0.010)*	*(0.009)*	*(0.012)*	*(0.010)*	*(0.010)*	*(0.004)*	*(0.004)*

Table V, continued
Tobin's Q and Operating Performance

$ln(BM_{t-1})$	-	-	**0.027**	**-0.050**	**-0.051**	**-0.101**	**-0.009**	**-0.041**
	-	-	*(0.018)*	*(0.021)***	*(0.018)****	*(0.023)****	*(0.006)*	*(0.008)****
$ln(Age_{t=0})$	**-0.151**	**-0.110**	**0.043**	**0.043**	**0.019**	**0.043**	**0.020**	**0.027**
	*(0.014)****	*(0.022)****	*(0.015)****	*(0.015)****	*-(0.017)*	*(0.016)****	*(0.006)****	*(0.008)****
$ln(Size_{t-1})$	**-0.064**	**-0.056**						
	*(0.008)****	*(0.013)****						
Constant	**1.870**	**1.879**	**-0.351**	**-0.695**	**-0.220**	**-0.380**	**-0.079**	**-0.224**
	*(0.080)****	*(0.112)****	*(0.086)****	*(0.279)***	*(0.082)****	*(0.104)****	*(0.033)***	*(0.048)****
Industry Effects Included								
IPO-Year Effects Included								
Adjusted R^2	*0.17*	*0.17*	*0.07*	*0.09*	*0.05*	*0.14*	*0.11*	*0.16*
F-Stat	*33.41*	*19.08*	*7.53*	*5.72*	*11.11*	*9.29*	*18.57*	*12.80*
N	*4062*	*2034*	*3167*	*1501*	*3185*	*1518*	*3225*	*1539*

Table VI
Debt and Equity

Columns one through six present regression results for the book value of stockholder equity over assets, long-term debt over assets, and total debt over assets between years t = 2 and t = 10 following the IPO. Total debt is measured as long-term debt plus debt in current liabilities. The controls include a dummy variable equal to one if the firm received venture capital financing (VC), the number of years since the firm went public (t), an interaction between venture-backing and years since the IPO (VC*t), the book-to-market ratio at the end of the previous fiscal year (BM), and the age of the firm at the time of the IPO (Age). Controls for three-digit industry and IPO year are also included in the regressions but omitted from the table. Book-to-market is measured as the book value of common equity (book value of common equity + deferred taxes) divided by the market value of common equity. In columns seven through ten the dependent variables are the log of cumulative new equity issued and the log of cumulative new long-term debt issued between years t = 2 and t = 10. For these regressions the log of assets at t = 0 is included as an additional control. The coefficients are reported in bold and robust standard errors are reported in parenthesis. Significance at the ten-, five- and one-percent level is indicated by *, **, and ***. Results are reported separately for the full and matched samples of high-tech IPOs (described in Section II).

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Dependent Variable	***Equity / Assets***		***LT Debt / Assets***		***Total Debt / Assets***		***ln(New Equity)***		***ln(New LT Debt)***	
Sample	**Full**	**Matched**	**Full**	**Matched**	**Full**	**Matched**	**Full**	**Matched**	**Full**	**Matched**
Mean Difference (VC - NVC)	0.073	0.047	-0.012	-0.015	-0.050	-0.036	1.225	1.041	1.147	0.443
t-stat	*5.95***	*2.66***	*-2.60***	*-2.58***	*-6.76***	*-3.55***	*6.54***	*3.86***	*5.16***	*1.47*
Median Difference (VC - NVC)	0.060	0.063	-0.002	-0.011	-0.043	-0.044	1.715	1.663	1.018	0.375
z-stat	*6.00***	*4.63***	*-0.69*	*-2.71***	*-5.29***	*-4.02***	*6.75***	*4.12***	*5.01***	*1.53*
Independent Variable										
VC	**0.108**	**0.136**	**-0.007**	**-0.037**	**-0.053**	**-0.083**	**0.681**	**0.679**	**0.054**	**-0.042**
	*(0.026)***	*(0.033)***	*(0.014)*	*(0.018)***	*(0.019)***	*(0.024)***	*(0.189)***	*(0.248)***	*(0.215)*	*(0.280)*
t	**0.002**	**0.004**	**-0.001**	**-0.001**	**-0.005**	**-0.006**	-	-	-	-
	(0.003)	*(0.004)*	*(0.002)*	*(0.002)*	*(0.002)***	*(0.003)***	-	-	-	-
VC*t	**-0.009**	**-0.014**	**0.000**	**0.004**	**0.002**	**0.008**	-	-	-	-
	*(0.004)***	*(0.005)***	*(0.002)*	*(0.003)*	*(0.003)*	*(0.004)***	-	-	-	-
ln(BM_{t-1})	**0.032**	**-0.005**	**-0.005**	**-0.001**	**-0.011**	**0.012**	-	-	-	-
	*(0.006)****	*(0.009)*	*(0.003)*	*(0.004)*	*(0.005)***	*(0.007)**	-	-	-	-

Table VI, continued
Debt and Equity

ln($Age_{t=0}$)	**0.015**	**0.012**	**-0.013**	**-0.007**	**-0.016**	**-0.013**	**-0.437**	**-0.574**	**-0.471**	**0.082**
	*(0.007)***	*(0.011)*	*(0.004)****	*(0.005)*	*(0.005)****	*(0.009)*	*(0.145)****	*(0.221)****	*(0.171)****	*(0.211)*
ln($BM_{t=0}$)	-	-	-	-	-	-	**-0.817**	**-0.917**	**-0.523**	**-0.584**
	-	-	-	-	-	-	*(0.152)****	*(0.199)****	*(0.153)****	*(0.208)****
ln($Size_{t=0}$)	-	-	-	-	-	-	**0.615**	**0.632**	**1.062**	**1.037**
	-	-	-	-	-	-	*(0.081)****	*(0.125)****	*(0.091)****	*(0.124)****
Constant	**0.752**	**0.680**	**0.135**	**0.082**	**0.242**	**0.167**	**1.379**	**1.208**	**0.190**	**-2.983**
	*(0.037)****	*(0.054)****	*(0.018)****	*(0.027)****	*(0.027)****	*(0.036)****	*(0.610)***	*(0.670)**	*(0.720)*	*(0.832)****
Industry Effects Included										
IPO-Year Effects Included										
Adjusted R^2	*0.07*	*0.12*	*0.04*	*0.07*	*0.06*	*0.07*	*0.30*	*0.30*	*0.33*	*0.34*
F-Stat	*14.72*	*15.17*	*8.16*	*22.58*	*11.43*	*14.48*	*15.08*	*8.10*	*12.96*	*8.53*
N	*3503*	*1668*	*3527*	*1680*	*3525*	*1681*	*585*	*283*	*427*	*214*

Table VII

Impact on the High-Tech Sector

Table VII reports the share of high-tech sales, R&D and market value that venture- and non-venture-backed firms from the 1980s accounted for in 1990, 1995, 2000 and 2003. Aggregates for the high-tech sector are computed by summing across all publicly traded firms in SICs 283, 357, 366, 367, 382, 384 and 737 with coverage in Compustat. Results are reported separately for the full and matched samples of high-tech IPOs (described in Section II).

	I. Full Sample		*Matched Sample*	
	VC	**NVC**	**II. VC**	**NVC**
Share of Sales				
1990	0.151	0.027	0.030	0.016
1995	0.183	0.021	0.036	0.012
2000	0.192	0.013	0.051	0.007
2003	0.163	0.010	0.058	0.007
Share of R&D				
1990	0.198	0.020	0.050	0.012
1995	0.219	0.017	0.053	0.010
2000	0.163	0.009	0.061	0.005
2003	0.153	0.008	0.067	0.004
Share of Market Capitalization				
1990	0.151	0.022	0.055	0.016
1995	0.194	0.023	0.085	0.013
2000	0.208	0.019	0.096	0.004
2003	0.197	0.007	0.102	0.005