INNOVATION AND PERFORMANCE: EVIDENCE FROM VENTURE CAPITAL-BACKED IPOS

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2011

Innovation and Performance: Evidence from Venture Capital-backed IPOs

By

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Submitted to Lee Kong Chian School of Business in partial of fulfillment of the requirements for the Degree of Master of Science in Finance

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2011

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Abstract

I collect a comprehensive sample of 2213 Venture Capital-backed initial public offerings (VC-backed IPOs) between 1981 and 2004, including 842 VC-backed IPOs with successful patent application(s) five years before IPOs (VC-backed IPOs with patents) and 1371 VC-backed IPOs without patent filing(s) five years before IPOs (VC-backed IPOs without patents), and examine the two-year to five-year stock performance of these offerings. VC-backed IPOs with patents appear to outperform VC-backed IPOs without patents in both cross-sectional analyses and calendar-time portfolio analyses.

Keywords: Initial public offerings, Venture capital, Innovation

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Acknowledgement

I highly appreciate my supervisor, Prof Jerry CAO, who has supported me throughout my dissertation with his patience and knowledge whilst allowing me the room to work in my own way. The thesis owes much to his thoughtful and helpful comments. This paper would not have been completed or written without his guidance and inspiration.

I would like to express my gratitude to my thesis committee members, Prof FU Fangjian and Prof TU Jun. Thanks for providing excellent research support and giving valuable comments and suggestions during the oral defense. All errors are mine.

Besides, I want to thank the Lee Kong Chian School of Business for giving me this opportunity to study in Singapore, to do the research work and to use the library databases.

I also want to thank my classmates from Master of Science in Finance (by research) programme for all their help and support during my research work. Particularly, I am obliged to my senior classmate, JIANG Fuwei, for his generous help and encouragement.

I cannot end without thanking my parents, WANG Yi and CHEN Qiuhong, whose love and warmth enabled me to complete this work.

I. Introduction

Ritter (1991) and Loughran and Ritter (1995) document severe underperformance of initial public offerings (IPOs) from 1970 through 1990 suggesting that investors may systematically be too optimistic about the prospects of firms that are issuing equity for the first time. However, Brav and Gompers (1997) find that venture capitalists, who specialize in financing promising start-up companies and bringing them public, affect the long-run performance of newly public firms, and investigate that venture-backed IPOs outperform non-venture backed IPOs using equal weighted returns. They further point out that venture-backed IPOs do not significantly underperform in tests using several comparable benchmarks and the Fama-French (1993) three factor asset pricing model.

Governments around the globe have been eager to duplicate the success of the fast-growing US venture capital industry (Kortum and Lerner 2000). These efforts share a common rationale that venture capital has spurred innovations in the United States, and can do so elsewhere (European and Commission 1995). Increases in venture capital activity in an industry are associated with significantly higher patenting rates (Kortum and Lerner, 2000).

An extensive body of work on the economics of technological change documents that patenting activity and the characteristics of patents reflect the quality and extent of firms' innovations. Owing to the creation of the Court of Appeals for the Federal Circuit (CAFC) in 1982 and several well-documented

patent lawsuits, U.S. firms have increasingly recognized the necessity to patent their innovations and hence have been especially active in patenting activities since the early 1980s (Hall and Ziedonis 2001 and Hall 2005). Therefore, patents are the most important measure of contemporary firms' innovative performance (Griliches 1990); they are materialized innovations of business value and are actively traded in intellectual property markets (Lev 2001).

Unlike many other measures of corporate activity, patents are observable for pre-IPO firms, which is important when studying innovative activity before IPO. In fact, the use of patents as a measure of innovative activity is widely accepted (Lerner, Sorensen and Stromberg 2011).[1] Furthermore, increased competition at the worldwide level has increased the demand for innovation, and patents are the actual products of the innovation process (Zingales 2000 and Aghion, Reenen, and Zingales 2010).[2]

Information about innovations is hard to process, because it requires developing and applying a theory of how the economic fundamentals of a firm or its industry are changing, as well as an analysis of the road from patents to final products on the market, the profit of which can be highly uncertain and long deferred (Hirshleifer, Hsu and Li 2010). Moreover, individuals pay less attention

[1] Patenting activity allows us to measure firms' innovative output rather than merely R&D expenditures. Jensen (1993) argues that since not all research expenditures are well spent, and many corporate research activities are wasteful and yield a low return, changes in R&D expenditures would be more difficult to interpret.

[2] Aghion, Reenen, and Zingales (2010) focus on the actual productivity of the innovation process, rather than only on the quantity of innovative inputs (R&D expenses).

to, and place less weight upon, information that is harder to process (Song and Schwarz 2010).

Owing to limited investor attention, prices do not fully and immediately impound the arrival of relevant public information, especially when such information is less salient or arrives during a period of low investor attention (Klibanoff, Lamont, and Wizman 1998, Huberman and Regev 2001, DellaVigna and Pollet 2009, Hirshleifer, Lim, and Teoh 2009, and Hou, Peng, and Xiong 2009). Merton (1987), Hirshleifer and Teoh (2003), and Peng and Xiong (2006) have therefore built models predicting that limited investor attention affects stock prices and can cause market under-reaction.

Therefore, investors will under-react to the information content in innovations because of the difficulty evaluating the economic implications of patents granted. If so, I posit that firms that are more innovative may be undervalued, whereas firms that are less innovative may be overvalued.

This paper aims to examine the effect of innovations, proxid by patent filing(s), on VC-backed IPOs long-run performance. I test whether innovations can predict future abnormal return for venture-backed IPOs after controlling for other standard return predictors.

In this study, I find that consistent with Brav and Gompers (1997), VC-backed IPOs without patent filing(s) five years before IPOs (VC-backed IPOs without patents) perform as well the stock market. I further investigate that VC-backed IPOs with patent filing(s) five years before IPOs (VC-backed IPOs

with patents) outperform those without patents by 12% annual excess return. The results are robust by using both cross-sectional analyses and calendar-time portfolio analyses and after controlling for size effect and value effect.

The rest of this paper is organized as follows. Section II reviews the relevant literature. Section III discusses the construction of the data set employed in the study. Section IV presents the basic analyses of long-run performance. Supplemental analyses examining cross-sectional differences in VC-backed IPO returns are discussed in Section V. The final section concludes the paper.

II. Literature Review

There are three main related literatures. A number of research show that venture capital firms specialize in collecting and evaluating information on startup and bringing these growth companies to public. A second set of studies consider the underperformance of IPOs, and suggest that investors may systematically be too optimistic about the prospects of firms that are issuing equity for the first time. A third set of paper examines the investors will under-react to the information content in innovations because of the difficulty evaluating the economic implications of patents granted.

A. Venture Capital and the Creation of IPOs

Gompers (1995) shows that venture capital firms specialize in collecting and evaluating information on startup and growth companies. These types of companies are the most prone to asymmetric information and potential capital constraints discussed in Fazzari, Hubbard, and Petersen (1988) and Hoshi, Kashyap, and Scharfstein (1991). Brav and Gompers (1997) expect that the investment behavior of venture-backed firms would be less dependent upon internally generated cash flows because venture capitalists provide access to top-tier national investment and commercial bankers and may partly overcome informational asymmetries that are associated with startup companies.

Brav and Gompers (1997) claim that the greater availability of information and the higher institutional shareholding make VC-backed IPOs' prices less susceptible to investor sentiment. Firstly, as assessing to top-tier national investment and commercial bankers, venture capitalists may be able to attract more and higher quality analysts to follow their firms. In this way, venture capitalists lower potential asymmetric information problem between the stat-ups and investors. Secondly, institutional investors may be more willing to hold equity in firms that have been taken public by venture capitalists with whom they have invested.

Gompers (1996) demonstrates that reputational concerns affect the decisions venture capitalists make when they take firms public. If venture capitalists fail once in the public market, they may face difficulty in bringing firm public in the future. Consequently, venture capitalist may be less willing to hype a stock.

Furthermore, Kortum and Lerner (2000) argue that Governments around the globe have been eager to duplicate the success of the fast-growing US venture capital industry. These efforts share a common rationale that venture capital has spurred innovations in the United States, and can do so elsewhere (European and Commission 1995). Kortum and Lerner (2000) find that increases in venture capital activity in an industry are associated with significantly higher patenting rates.

B. IPOs and Underperformance

In a seminal study, Ritter (1991) show that IPOs underperform relative to benchmark indices and matching stocks in the three to five years after going public. Following the seminal study, many papers document that firms underperform relative to benchmark indices or to similar stocks following their IPOs for other markets and other times. Keloharju (1993), Levis (1993), and Lee, Taylor, and Walter (1996) report poor long-run performance in a number of other countries. Gompers and Lerner (2003) show that IPOs issued between 1935 and 1972 performed poorly in the years after issue when event-time buy-and-hold abnormal returns are used.

Ritter (1991), Lerner (1994), Loughran and Ritter (1995, 2000), Baker and Wurgler (2000), and Hirshleifer (2001) discuss a behavioral explanation for poor performance subsequent to equity offerings. The argue that stock prices periodically diverge from fundamental values, and that managers and investment bankers take advantage of overpricing by selling stock to overly optimistic investors.

However, the acceptance of IPO underperformance effect is far from universal. Schultz (2003) argues that measuring the performance of IPOs in event time spuriously induces IPOs to have low average returns even is there are no average abnormal returns ex ante. Schultz claims that there is no underperformance of IPOs in calendar time. Gompers and Lerner (2003) convincingly show that, in an earlier sample from 1935 to 1972, IPOs do not

underperform benchmark in contrast to the post-1970 sample initially examined by Ritter (1991). Gompers and Lerner suggest that the poor performance of offerings in the NASDAQ era could simply arise by chance, and that the IPO underperformance is the last three decades may be just a small sample effect.

C. Under-reaction to the Information Content in Patents

Klibanoff, Lamont, and Wizman (1998), Huberman and Regev (2001), DellaVigna and Pollet (2009), Hirshleifer, Lim, and Teoh (2009), and Hou, Peng, and Xiong (2009) have provided evidence suggesting that owing to limited investor attention, prices do not fully and immediately impound the arrival of relevant public information, especially when such information is less salient or arrives during a period of low investor attention. Merton (1987), Hirshleifer and Teoh (2003), and Peng and Xiong (2006) have therefore built models predicting that limited investor attention affects stock prices and can cause market under-reaction.

Innovations are usually officially introduced to the public in the format of approved patents that provide necessary detailed information. Owing to the creation of the Court of Appeals for the Federal Circuit (CAFC) in 1982 and several well-documented patent lawsuits (e.g., the Kodak-Polaroid case), U.S. firms have increasingly recognized the necessity to patent their innovations and hence have been especially active in patenting activities since the early 1980s

(Hall and Ziedonis 2001; Hall 2005). Patents are thus the most important measure of contemporary firms' innovative performance (Griliches 1990); they are materialized innovations of business value and are actively traded in intellectual property markets (Lev 2001).

Hirshleifer, Hsu and Li (2010) argue that a firm's past innovations is not necessarily as salient to investors as explicitly forward-looking information about the prospects for the particular R&D projects that the firm is examining. Moreover, Song and Schwarz (2010) claim that individuals pay less attention to, and place less weight upon, information that is harder to process. Hirshleifer, Hsu and Li (2010) argue that information about innovations is hard to process, because it requires developing and applying a theory of how the economic fundamentals of a firm or its industry are changing, as well as an analysis of the road from patents to final products on the market, the profit of which can be highly uncertain and long deferred. Therfore, investors will under-react to the information content in innovations because of the difficulty evaluating the economic implications of patents granted. If so, I posit that firms that are more innovative may be undervalued, whereas firms that are less innovative may be overvalued.

III. Data

Our sample consists of firms in the intersection of Thomson VentureXpert, NBER patent dataset, Securities Data Company (SDC) and Center for Research in Security Prices (CRSP) database. I retrieve the data on all VC-backed companies in US from the Thomson VentureXpert database for the sample period 1976 to 2005, a total of 27,837 start-up companies. Thomson VentureXpert covers comprehensive information on buyout and venture capital firms and their investment. I then collect the patent data from the updated NBER patent dataset and match them to the VC-backed companies using GVKEY and CUSIP identifiers. This patent dataset contains information about all patents granted by the USPTO and their assignees (signaled by identifiers) in the 1976–2006 period. To ensure data quality and prevent selection bias, I focus our empirical analysis on only those VC-backed firms that have CUSIP information (38% of the Thomson VentureXpert database), for a total of 10, 572 VC-backed firms with 71,894 patent counts. It is also worth noting that, following Kortum and Lerner (2000) and Hirukawa and Ueda (2008), I date all patents by their application dates.[3]

I obtain IPO date, offering pricing, and underpricing from the Securities Data Company (SDC) new issues database from 1981 to 2004. I then collect the

[3] As argued in Hall, Jaffe, and Trajtenberg (2001) and many other studies, application dates are the most appropriate time placer for patents because inventions begin entering real economies once they appear.

monthly stock returns on the common stocks listed on the New York Stock Exchange (NYSE), American Stock Exchange (AMEX), and National Association of Securities Dealers Automated Quotations (NASDAQ) from the Center for Research in Security Prices (CRSP) database, and the accounting data of the issuing firms from the COMPUSTAT database. These sources leaves us with a final sample of 2,231 VC baked IPOs.

The patent database also records the number of citations received by the patents from the year granted till 2006. Patent citations reflect the technology or economic significance of patents (e.g., Trajtenberg 1990; Harhoff, Narin, Scherer, and Vopel 1999), but given the long time span in which they occur in the years after a patent is granted, citations are a less obvious candidate for predicting stock returns. Although patent citations are another measure of innovation output, they are subject to the forward-looking bias because the number of citations to be received by a patent through 2006 is unknown when it is granted. Nevertheless, Hirshleifer, Hsu and Li (2010) find the Pearson correlation between patent counts scaled by R&D capital and patent citations scaled by R&D capital is 0.85. This high correlation suggests that patent counts are likely to capture much of the valuation-relevant information contained in patent citations.

[Insert Table 1 Here]

Table 1 presents the distribution of the sample by year. The sample consists

of 2213 venture capital (VCs) backed initial public offerings (IPOs) between January 1981 and December 2004. The table reports total number of VC-backed IPOs and all patents filings by those new listed companies. The last two columns show the percentage of VC-backed IPOs among all VC-backed IPOs that have patents filing either before or after their IPOs.

This table highlights the increase in VC-backed IPOs activity in the 1990s. The number of VC-backed firms going public hit the peak in 1999 and 2000 during the tech bubble. The time series suggest that VCs time the market in IPOs. As regards to the patenting activities of the sample firm, I observe a sharp drop in the patent application process during 2003 and 2004 because of the application-grant lag (i.e., it takes about two years for the USPTO to grant a valid patent application). The percentage of VC-backed companies having new patents from +1 to +5 following IPO is 42.25%, while the percentage of VC-backed companies having patents from -5 to -1 prior to IPO is only 38.05%. This result suggests that after going public, VC-backed companies have more money to spur innovations.

[Insert Figure 1 Here]

Figure 1 reports year average of patent counts before and after initial public offerings (IPOs). The sample consists of 2213 venture capital (VCs) backed IPOs between January 1981 and December 2004. Panel A reports the average patent

counts from 5 years before IPO through 5 years after IPO, centering in the year of IPOs for all VC-backed firms; Panel B reports the average patent counts from 5 years before IPO through 5 years after IPO, centering in the year of IPOs for VC-backed firms with patent records prior to IPOs.

Panel A shows the average total patent number of all VC-backed firms for an 11-year window centered on the year of receiving first-round VC investment. Perhaps not surprisingly, I observe a steep uptrend in the average total number of patents from year -5 (five years before IPO) to year 3 (three years after IPO) following by a less steep uptrend from year 3 to year 4, and then a downtrend after year 4.

In Panel B, I further restrict the sample to include only firms with patent records before IPO. The patent filings increase from 1.5 in 5 years before IPO to more than 5, the peak, 3 years after IPO, and then drop to slightly below 5 in 5 years after IPO. The pattern of Panel B is very similar that of Panel A.

IV. The impact of Innovation on VC-backed IPOs Performance

I now turn to the question at the heart of this study: whether VC-backed IPOs with patent counts before IPOs earn higher returns than those without patent filings.

A. Underpricing

An extensive evidence on IPOs in general suggests sizeable positive returns on the first day of trading. Levis (2011) argues that the positive first day returns are often related to the characteristics of the IPOs themselves or their sponsors, various types of information asymmetries or just market overreaction. Megginson and Weiss (1991) show VC-backed IPOs to have relatively lower first day returns which they attribute to venture capital certification reducing information asymmetry between investors and issuing firms. They also find that consistent with Gompers' (1996) grandstanding hypothesis, VC-backed IPOs are younger relative to their non-backed counterparts.

[Insert Table 2 Here]

Table 2 reports summary statistics for first day returns for VC-backed IPOs

without and with patent(s). The sample consists of 2213 venture capital (VCs) backed initial public offerings (IPOs) between January 1981 and December 2004, including 1371 VC backed IPOs without successful patent application(s) before IPOs, and 842 VC backed IPOs with successful patent application(s) before IPOs.

The average first day return across VC-backed firms with successful patent filings before IPOs during the period Jan 1981 to December 2004 was 33%, a level somewhat higher than that of VC-backed firms without patent records before IPOs. However, the median first day returns for the two groups are quite similar, 10.00% for VC-backed IPOs without patents, and 10.47% for VC-backed IPOs with patents. The 1999-2000 dotcom bubble had a striking effect on first day returns for VC-backed firm with and without patent records before IPOs; they reached average levels of 111.91% and 87.12%, respectively during this period. These results verify our concerns that the market does not price the IPO with previous patent filings correctly. The similar picture emerges from the average money left on the table by each of the two IPO groups. VC-backed firms without patent filings 5 years before IPOs leave only $151.38 million on the table while the equivalent amounts for its VC-backed firms with patent filings 5 years before IPOs are $185.66 million.

B. Firm Level Stock Performance

The weight of international evidence on IPOs in general suggests significant

underperformance in the aftermarket. Brav and Gompers (1997) find that VC-backed IPOs outperform non-VC-backed IPOs, at least in equal weighted returns. Levis (2011) claim that superior performance by VC-backed IPOs is often attributed to better management teams and corporate governance structures that helps venture-backed firms perform better in the long-run and possible less exposure to investor sentiment. In this section, I present the firm level analyses of long-run performance of VC-backed IPOs with and without patents.

[Insert Table 3 Here]

Table 3 summarizes the cross-sectional performance measures of VC-backed companies with and without patent(s) in the five years following the IPOs. The measures are the raw (unadjusted) buy-and-hold returns, the buy-and-hold returns adjusted by the market (the value-weighted NYSE/Amex/Nasdaq index), the average monthly excess returns relative to the same value-weighted market return, and the alphas (excess returns) from the capital asset pricing model (CAPM) (also known as Jensen's alpha) and from a three-factor Fama and French model.

The sample consists of 2213 venture capital VC-backed IPOs between January 1981 and December 2004. The returns are computed ending 24, 36, 48, and 60 months after the IPO date. If the sample firm delists, the raw returns, market-adjusted returns, Jensen's alphas, and FF alphas are set equal to zero after the delisting date. Panel A reports the results of 1371 VC-backed IPOs without successful patent application(s) 5 years before IPOs, while Panel B shows the

results of 842 VC-backed IPOs with successful patent application(s) 5 years before IPOs.

I run the firm-specific capital asset pricing model (CAPM) regressions of monthly firm excess returns on the market factor for 24, 36, 48, and 60 months after the IPO,

$$R_{i,t} - R_{f,t} = \alpha_i + \beta_i\left(R_{m,t} - R_{f,t}\right) + e_{i,t}$$

where $R_{i,t} - R_{f,t}$ is the return on stock i in excess of the risk-free interest rate (the one-month Treasury bill rate) at time t; $R_{m,t} - R_{f,t}$ is the value-weighted market return on all NYSE/Amex/Nasdaq firms minus risk-free rate at time t.

In addition, I run the Fama and French regression for both VC-backed IPOs with and without patents, respectively

$$R_{i,t} - R_{f,t} = \alpha_i + \beta_i\left(R_{m,t} - R_{f,t}\right) + s_i SMB_t + h_i HML_t + e_{i,t}$$

I employ as independent variables (in addition to the alpha, or constant, term) $R_{mt} - R_{ft}$, the value-weighted market return on all NYSE/Amex/Nasdaq firms (RM) minus the risk free rate (RF), that is, the one-month Treasury bill rate; SMB_t (small minus big), the difference each month between the return of small-and large-capitalization firms; and HML_t (high minus low), the difference each month between high book-to-market stocks and the return on low book-to-market stocks; the dependent variable, $R_{i,t} - R_{f,t}$, is the return on stock i in excess of the risk-free interest rate.

The VC-backed firms with successful patent filings before IPOs deliver a raw buy-and-hold return of 39.49% over three years, and 61.44% over five years after the IPOs. While the VC-backed firms without successful patent filings

before IPOs only deliver a raw buy-and-hold return of 18.98% over three years, and 33.06% over five years after the IPOs. The differences of raw buy-and-hold returns between VC-backed IPOs with patents and VC-backed IPOs without patents are 6.97% over two years, 20.51% over three years, 24.39% over four years, and 28.08% over five years after the IPOs, respectively. The results are consistent with our assumption that VC-backed IPOs with successful patent application(s) outperform VC-backed companies without patent count(s).

When this return is adjusted by value-weighted buy-and-hold market return, the returns of VC-backed IPOs with patents are all positive over two years to five years; while the buy-and-hold excess returns of VC-backed IPOs without patents are all negative. Moreover, the difference of average monthly excess returns between the VC-backed IPOs with patent(s) and the VC-backed IPOs without patent(s) are positive over all the years after the IPOs. These empirical results further verify our assumption that VC-backed IPOs with previous patents outperform VC-backed IPOs without previous patents

Jensen's alpha terms suggest that VC-backed IPOs with patents outperform VC-backed IPOs without patents by between 0.4% and 0.7% per month in the five years after going public, and the coefficients on Fama and French's alphas suggest that VC-backed IPOs with patents outperform VC-backed IPOs without patents by between 0.6% and 0.8% per month in the five years after going public. The alpha results are consistent with the average monthly excess returns. The evidence from Table 3 suggests that VC-backed IPOs with previous patents outperform

VC-backed IPOs without previous patents, and the outperformance is robust on different evaluation methods.

[Insert Table 4 Here]

To further examine how size (market capitalization) affects the innovations and return relation, I sort the sample into three size groups, namely, "Small", "Medium", and "Large", based on the real size at the first closing price listed by the Center for Research in Security Prices (CRSP). Size breakpoints are the same for the venture-backed IPOs with and without patents. Table 4 summarizes the cross-sectional returns of VC-backed IPOs with and without patents across the three size groups. The buy-and-hold excess returns and average excess monthly returns are both adjusted by the value-weighted (VW) NYSE/Amex/Nasdaq market index. Jensen alphas are the intercepts estimated by running firm-specific time-series regressions of monthly firm excess returns on the value-weighted NYSE/Amex/Nasdaq excess returns for 36 months after the IPO; RMRF is the value-weighted market return on all NYSE/Amex/Nasdaq firms (RM) minus the risk free rate (RF), that is, the one-month Treasury bill rate. FF alphas are similar intercepts estimated using Fama and French factors as independent variables; RMRF is the value-weighted market return on all NYSE/Amex/Nasdaq firms (RM) minus the risk free rate (RF), that is, the one-month Treasury bill rate; SMB (small minus big), the difference each month between the return of

small-and large-capitalization firms; and HML (high minus low), the difference each month between high book-to-market stocks and the return on low book-to-market stocks. If the sample firm delists, the raw returns, market-adjusted returns, Jensen's alphas, and FF alphas are set equal to zero after the delisting date.

Table 4 shows that VC-backed IPOs with patent(s) outperform those without patents(s) by using different return measures and after controlling for size effect. The buy-and-hold raw returns of large groups for both VC-backed IPOs with and without patent(s) are significantly lower than those of small and medium groups, while the buy-and-hold excess returns relative to the value-weighted market of large groups are higher than those of small groups. The reason of this pattern is that the large firms were taken public mostly during the tech-bubble period (1999-2000). In terms of Fama-French alpha, VC-backed IPOs with patent(s) outperform VC-backed IPOs without patent(s) by 0.66%, 0.58%, and 1.13% for small, medium and large group, respectively.

[Insert Table 5 Here]

To further examine how book-to-market ratio affects the innovations and return relation, I sort the sample into three book-to-market groups, namely, "Low", "Medium", and "High", based on the real book-to-market ratio at the first closing price listed by the Center for Research in Security Prices (CRSP) and book value

of equity at IPO quarter from COMPUSTAT database. Book-to-market ratio breakpoints are the same for the venture-backed IPOs with and without patents. Table 4 summarizes the cross-sectional returns of VC-backed IPOs with and without patents across the three book-to-market groups. I first report the buy-and-hold raw return, and then, obtain the buy-and-hold excess returns and average excess monthly returns both adjusted by the value-weighted (VW) NYSE/Amex/Nasdaq market index. I also calculate Jensen's alpha for each group, which is the intercepts estimated by running firm-specific time-series regressions of monthly firm excess returns on the value-weighted NYSE/Amex/Nasdaq excess returns for 36 months after the IPO. Lastly, I calculate FF alphas, which are the intercepts estimated using Fama and French factors as independent variables. If the sample firm delists, the raw returns, market-adjusted returns, Jensen's alphas, and FF alphas are set equal to zero after the delisting date.

Table 5 shows that by using different return measures, VC-backed IPOs with patent(s) outperform those without patents(s) after controlling for value effect. All alphas of VC-backed IPOs without patent(s) estimated from CAPM are negative, while all alphas of VC-backed IPOs without patent(s) calculated from CAPM are positive with 0.9%, 0.16% and 0.01% for low, medium and high groups, respectively. In terms of Fama-French alpha, VC-backed IPOs with patent(s) outperform VC-backed IPOs without patent(s) by 0.81%, 0.66%, and 0.49% for small, medium and large group, respectively. The reason why the Jensen's alpha is lower than Fama-French alpha within each group is that the loadings for all

HML, the difference each month between high book-to-market stocks and the return on low book-to-market stocks, are negative. The results are consistent with Brav and Gompers (1997).

C. Calendar-time Portfolios Analysis

In this section, I shed light into the calendar-time portfolio analyses of the long-run performance of VC-backed IPOs with and without patents. From the previous section's firm level analyses, I have found that VC-backed IPOs with patents outperform those without patents by using different performance measures, such as buy-and-hold return, average monthly return, Jensen's alpha and Fama-French alpha. Now, I use calendar-time portfolio analyses to examine the stock performance of VC-backed IPOs with and without patents. To further examine how size (market capitalization) and book-to-market ratio affect the innovations and return relation, I sort firms into three size groups and three book-to-market ratio groups, and find the results of the sub-groups are also consistent with my assumption that venture-backed IPO portfolios with patent(s) outperform those without patent(s).

[Insert Table 6 Here]

Table 6 summarizes the characteristics and accounting performance of

VC-backed IPO portfolios with and without patents(s). The variables are computed at the initial public offering (IPO) year, one, two, and three years after IPOs, as reported by COMPUSTAT. The firm characteristics include the following: equity market capitalization, the ratio of market value to the book value of firm's equity, assets, the ratio of net income to assets (ROA), the capital expenditures (CAPEX)-to-sales ratio, the debt-to-assets ratio, the long-term debt-to-assets ratio, and the R&D-to-sales ratio. All variables are computed using data during or at the end of the fiscal year of the VC-backed IPOs, as reported by COMPUSTAT.

According to Table 6, VC backed IPOs with patent(s) have significant higher ratio of R&D-to-sales than those without patent(s). The differences of R&D-to-sales ratio between VC backed IPO portfolio with and without patent(s) are 3.65, 1.18, 1.07 and 0.85 for at IPO year, one, two, and three years after IPOs, respectively. Table 6 also show a downtrend in the R&D-to-sales ratio from IPO year to three years after IPO. This finding suggest that venture-backed firms focus on marketing their innovations after IPO, rather than spurring their innovations. VC backed IPO portfolio without patent(s) are more levered than VC backed IPO portfolio with patent(s) at IPO year, and three-year post IPOs. Similar results hold for long-term debt-to-assets ratio.

[Insert Table 7 Here]

Table 7 presents calendar-time portfolio analysis for VC-backed IPOs

without and with patent(s). The sample consists of 1371 VC-backed IPOs without patent(s), and 842 VC-backed IPOs with patent(s) between January 1981 and December 2004. VC-backed IPOs without patents portfolio is presented in Panel A, and VC-backed IPOs with patents portfolio is presented in Panel B. I exclude American Depository Receipts, closed-end funds, Real Estate Investment Trusts, unit offerings, and IPOs with an offering size smaller than $1.5 million, firm market capitalization less than $5million, or an offering price of under $5 per share. I form the monthly portfolios of VC-backed IPOs without and with patent(s) by including all issues that were undertaken in the three years previous to the month of the observation. (The analysis extends between January 1982 and December 2006.) I use as the dependent variable monthly excess return, monthly returns of the equal- or value- weighted return of these portfolios less the risk-free rate (the one-month Treasury bill rate). Both equal- and value- weighted VC-backed IPOs without and with patent(s) portfolios are rebalanced every month, and the value weights are based on previous month's market values of the firms.

Fama-French (1993) three-factor regressions on calendar-time portfolio returns of VC-backed IPOs without and with patent(s) portfolios:

$$R_{p,t} - R_{f,t} = \alpha_p + \beta_p\left(R_{m,t} - R_{f,t}\right) + s_p SMB_t + h_p HML_t + e_{p,t}$$

where $R_{p,t} - R_{f,t}$ is the equal- or value- weighted monthly return of either VC-backed IPOs without or with patent(s) portfolio less the risk-free rate (the one-month Treasury bill rate); $R_{m,t} - R_{f,t}$ is the value-weighted market return on all NYSE/Amex/Nasdaq firms minus risk-free rate; SMB_t (small minus big), the

difference each month between the return of small-and large-capitalization firms; and HML_t (high minus low), the difference each month between a portfolio of high book-to-market stocks and the return on a portfolio of low book-to-market stocks.

Table 7 shows that consistent with Brav and Gompers (1997), VC-backed IPOs without patent(s) portfolio perform as well as the market. Neither its equal- nor its value- weighted average monthly excess returns is higher than 0.45% and none is significant. Moreover, as for the equal- or value- weighted Fama-French alphas of VC-backed IPOs without patent(s) portfolio, neither is lower than -0.25% and none is significant.

I further find that VC-backed IPOs without patent(s) portfolio earn lower monthly excess return than VC-backed IPOs with patent(s) portfolio. The value-weighted monthly excess returns on the VC-backed IPO without patents portfolio is 45 basis points (t =0.80) while VC-backed IPOs with patents portfolio presented is 143 basis points (t = 2.07). For equal-weighted returns, the difference of monthly excess returns between the VC-backed IPOs with patent(s) and without patent(s) portfolios is 78 basis points per month, which is economically significant.

I also examine whether the significant return spread between the VC-backed IPOs with and without patents portfolios is explained by the Fama-French (1993) three-factor model. Table 7 presents the three-factor time series regression results. For both equal and value weighted VC-backed IPO without patents portfolio

presented in Panel A, the results cannot reject the three-factor model. The intercepts are -25 and -8 basis points. Panel B presents results for VC-backed IPO with patents portfolio. When the VC-backed IPO with patents returns are weighted equally, the intercept is 66 basis points per month with a t-statistic of 2.53 indicating an outperformance. Value weighting VC-backed IPO with patents portfolio returns produces a larger intercept, 105 basis points with a t-statistic of 3.1, indicating 1% level of significance. So the results of VC-backed IPO with patents portfolio cannot be explained by the Fama-French (1993) three-factor model.

The coefficients on HML for both VC-backed IPO groups, VC-backed IPO without patents portfolio and VC-backed IPO with patents portfolio, indicate that their returns covary with low book-to-market (growth) firms. Compared to equal-weighted returns, when returns are value weighted, loadings on SMB decline but the loadings on HML become more negative for both VC-backed IPO groups. The returns on larger VC-backed IPO firms (in market value) tend to covary more with the returns of growth companies.

To further examine how size (market capitalization) and the value factor affect the innovations and return relation, I sort firms into three size groups based on the 30^{th} and 70^{th} percentiles of size at the end of December and June of each year using all VC-backed IPOs to determine the breakpoints, and sort firms into three book-to-market groups based on the 30^{th} and 70^{th} percentiles of size at the end of December and June of each year using all VC-backed IPOs to determine

the breakpoints.

[Insert Table 8 Here]

Table 8 summarizes the characteristics and accounting performance of VC-backed IPO portfolios with and without patents(s) sorted on the basis of both size and book-to-market portfolios. The table reports the summary statistics for the three size portfolios (“Small”, “Medium”, and “Large”). Every six months I divide the sample into three size portfolios based on the previous month's VC-backed IPO market capitalization distribution using all VC-backed IPOs to determine the breakpoints. The table also reports the summary statistics for the three book-to-market portfolios (“Low”, “Medium”, and “High”). Every six months I divide the sample into three book-to-market ratio portfolios based on the previous month's VC-backed IPO book-to-market distribution using all VC-backed IPOs to determine the breakpoints.

The firm characteristics include the following: equity market capitalization, the ratio of market value to the book value of firm’s equity, assets, the ratio of net income to assets (ROA), the capital expenditures (CAPEX)-to-sales ratio, the debt-to-assets ratio, the long-term debt-to-assets ratio, and the R&D-to-sales ratio. All variables are computed using data during or at the end of the fiscal year of the VC-backed IPOs, as reported by COMPUSTAT.

According to Table 8, VC backed IPOs with patent(s) have significant higher

ratio of R&D-to-sales than those without patent(s) across different size portfolios. The R&D-to-sales ratios of VC backed IPO portfolios with patent(s) are 3.01, 3.84 and 2.01 for “Small”, “Medium”, and “High” portfolio, respectively, while the ratios are 0.79, 1.30, and 0.58 for VC backed IPO size portfolios without patent(s). VC backed IPO portfolio without patent(s) are more levered than VC backed IPO portfolio with patent(s) across different size groups. Similar results hold for long-term debt-to-assets ratio. The larger VC-backed IPOs have better financial performance than smaller VC-backed IPOs. As for VC-backed IPO portfolio without patent(s), the “Large” portfolio outperform the “Small” portfolio by 30% net income-to-assets ratio (ROA); while as for VC-backed IPO portfolio with patent(s), the “Large” portfolio has 32% higher ROA than the “Small” portfolio.

Table 8 shows that VC backed IPOs with patent(s) have remarkable higher R&D-to-sales ratio than those without patent(s) across different book-to-market portfolios. The differences of R&D-to-sales ratio between VC backed IPO portfolio with and without patent(s) are 1.99, 2.52 and 1.99 for low, medium and high portfolio, respectively. VC backed IPO portfolio without patent(s) are more levered than VC backed IPO portfolio with patent(s) across different book-to-market groups, and similar results hold for long-term debt-to-assets ratio.

[Insert Table 9 Here]

Table 9 presents the monthly raw return on VC-backed IPO without and with patent(s) portfolios sorted on the basis of size. The sample consists of 1371 VC-backed IPOs without patent(s), and 842 VC-backed IPOs with patent(s) between January 1981 and December 2004. The results of VC-backed IPOs without patents portfolio are presented in Panel A, and the results of VC-backed IPOs with patents portfolio are presented in Panel B. I exclude American Depository Receipts, closed-end funds, Real Estate Investment Trusts, unit offerings, and IPOs with an offering size smaller than $1.5 million, firm market capitalization less than $5million, or an offering price of under $5 per share.

I form the monthly portfolios of VC-backed IPOs without and with patent(s) by including all issues that were undertaken in the three years previous to the month of the observation. (The analysis extends between January 1982 and December 2006.) Every six months I divide the sample into three size portfolios ("Small", "Medium", and "Large") based on the previous month's VC-backed IPO size distribution using all VC-backed IPOs to determine the breakpoints, 30^{th} and 70^{th} percentiles. The portfolios are rebalanced monthly and VC-backed IPOs are allowed to switch portfolios every half year. I use as the dependent variable monthly excess return, monthly returns of the equal- or value- weighted return of these portfolios less the risk-free rate (the one-month Treasury bill rate). I estimate equal- and value- weighted monthly excess returns within each size group.

From Panel A of Table 9, I can see that consistent with Brav and Gompers (1997), the VC-backed IPO without patents portfolios perform as well as the

market. No intercept is above 61 basis points and none is significant. VC-backed IPOs with patents outperform the market using equal weighted returns. Value weighting significantly reduces the outperformance. For value weighted return portfolios, outperformance is concentrated in the largest terciles. Intercepts for the largest size terciles in the VC-backed IPO with patents portfolios sample are large, 1.43% for equal-weighted return portfolio and 1.63% for value-weighted return portfolio, and both are at the 5% level of statistical significance.

[Insert Table 10 Here]

Table 10 presents the Fama-French three-factor time series regression on VC-backed IPO without and with patent(s) portfolios sorted on the basis of size, 30^{th} and 70^{th} percentiles of size at the end of December and June of each year. The sample consists of 1371 VC-backed IPOs without patent(s), and 842 VC-backed IPOs with patent(s) between January 1981 and December 2004. The results of VC-backed IPOs without patents portfolio is presented in Panel A, and the results of VC-backed IPOs with patents portfolio is presented in Panel B. I exclude American Depository Receipts, closed-end funds, Real Estate Investment Trusts, unit offerings, and IPOs with an offering size smaller than $1.5 million, firm market capitalization less than $5million, or an offering price of under $5 per share.

Monthly portfolios of VC-backed IPOs without and with patent(s) are

formed by including all issues that were undertaken in the three years previous to the month of the observation. (The analysis extends between January 1982 and December 2006.) Every six months I divide the sample into three size portfolios ("Small", "Medium", and "Large") based on the previous month's VC-backed IPO size distribution using all VC-backed IPOs to determine the breakpoints, 30th and 70th percentiles. The portfolios are rebalanced monthly and VC-backed IPOs are allowed to switch portfolios every half year. I use as the dependent variable monthly excess return, monthly returns of the equal- or value- weighted return of these portfolios less the risk-free rate (the one-month Treasury bill rate). I estimate equal- and value- weighted monthly excess returns within each size group. Fama-French three-factor time series regression on VC-backed IPO without and with patent(s) portfolios sorted on the basis of size:

$$R_{p,t}^{S} - R_{f,t} = \alpha_p^S + \beta_p^S\left(R_{m,t} - R_{f,t}\right) + s_p^S SMB_t + h_p^S HML_t + e_{p,t}^S$$

where $R_{p,t}^{S} - R_{f,t}$ is the equal- or value- weighted return of these size portfolios less the risk-free rate (the one-month Treasury bill rate); $R_{m,t} - R_{f,t}$ is the value-weighted market return on all NYSE/Amex/Nasdaq firms minus risk-free rate; SMB_t (small minus big), the difference each month between the return of small-and large-capitalization firms; and HML_t (high minus low), the difference each month between a portfolio of high book-to-market stocks and the return on a portfolio of low book-to-market stocks.

The patterns for both VC-backed IPO with and without patents portfolios further verify our earlier results in Table 9. The VC-backed IPO without patents

portfolios perform as well as the market. No intercept is below -38 basis points and none is significant. As for VC-backed IPO without patents portfolios, outperformance is concentrated in the largest terciles. Intercepts for the largest size terciles in the VC-backed IPO with patents portfolios sample are large, 1% under equal-weighted returns and 1.29% under value-weighted returns, and both are at the 1% level of statistical significance.

For both VC-backed IPO with and without patents portfolios, coefficients on SMB decline monotonically from the portfolio of smallest issuers to largest issuers, regardless of equal- or value- weighted returns. Returns of the smallest IPOs covary more with returns on small stocks. Coefficients on HML also decline monotonically. The larger the firm, the more it covaries with low book-to-market firms. Venture-backed firms are similar in age and amount of capital invested (book value of assets). Venture-backed firms become large by having high market values. Large firms (in market value) will have low book-to-market ratios and hence covary with growth companies. However, coefficients on HML show an interesting pattern. VC-backed IPOs with patents load more negatively on HML than VC-backed IPOs without patents, indicating that VC-backed IPOs with patents returns covary more with the returns of growth companies.

[Insert Table 11 Here]

Table 11 presents the monthly raw return on VC-backed IPO without and

with patent(s) portfolios sorted on the basis of book-to-market ratio. The sample consists of 1371 VC-backed IPOs without patent(s), and 842 VC-backed IPOs with patent(s) between January 1981 and December 2004. The results of VC-backed IPOs without patents portfolio are presented in Panel A, and the results of VC-backed IPOs with patents portfolio are presented in Panel B. I exclude American Depository Receipts, closed-end funds, Real Estate Investment Trusts, unit offerings, and IPOs with an offering size smaller than $1.5 million, firm market capitalization less than $5million, or an offering price of under $5 per share.

I form the monthly portfolios of VC-backed IPOs without and with patent(s) by including all issues that were undertaken in the three years previous to the month of the observation. (The analysis extends between January 1982 and December 2006.) Every six months I divide the sample into three size portfolios (“Low”, “Medium”, and “High”) based on the previous month's VC-backed IPO book-to-market ratio distribution using all VC-backed IPOs to determine the breakpoints, 30^{th} and 70^{th} percentiles. The portfolios are rebalanced monthly and VC-backed IPOs are allowed to switch portfolios every half year. I use as the dependent variable monthly excess return, monthly returns of the equal- or value-weighted return of these portfolios less the risk-free rate (the one-month Treasury bill rate). I estimate equal- and value- weighted monthly excess returns within each book-to-market ratio group.

From Panel A of table 11, I can see that consistent with Brav and Gompers

(1997), the VC-backed IPO without patents portfolios perform as well as the market. No intercept is above 95 or below 5 basis points and none is significant. However, Panel B shows that all book-to-market portfolios outperform. Outperformance ranges from 0.62% to 1.43%. The results are consistent with our assumption that VC-backed IPO portfolios with patents outperform those without patents.

[Insert Table 12 Here]

Table 12 presents the Fama-French three-factor time series regression on VC-backed IPO without and with patent(s) portfolios sorted on the basis of book-to-market ratio, 30^{th} and 70^{th} percentiles of book-to-market ratio at the end of December and June of each year. The sample consists of 1371 VC-backed IPOs without patent(s), and 842 VC-backed IPOs with patent(s) between January 1981 and December 2004. The results of VC-backed IPOs without patents portfolio is presented in Panel A, and the results of VC-backed IPOs with patents portfolio is presented in Panel B. I exclude American Depository Receipts, closed-end funds, Real Estate Investment Trusts, unit offerings, and IPOs with an offering size smaller than $1.5 million, firm market capitalization less than $5million, or an offering price of under $5 per share.

I form the monthly portfolios of VC-backed IPOs without and with patent(s) by including all issues that were undertaken in the three years previous to the

month of the observation. (The analysis extends between January 1982 and December 2006.) Every six months I divide the sample into three book-to-market ratio portfolios ("Low", "Medium", and "High") based on the previous month's VC-backed IPO size distribution using all VC-backed IPOs to determine the breakpoints, 30th and 70th percentiles. The portfolios are rebalanced monthly and VC-backed IPOs are allowed to switch portfolios every half year. I use as the dependent variable monthly excess return, monthly returns of the equal- or value-weighted return of these portfolios less the risk-free rate (the one-month Treasury bill rate). I estimate equal- and value- weighted monthly excess returns within each size group. Fama-French three-factor time series regression on VC-backed IPO without and with patent(s) portfolios sorted on the basis of size:

$$R_{p,t}^{BM} - R_{f,t} = \alpha_p^{BM} + \beta_p^{BM}\left(R_{m,t} - R_{f,t}\right) + s_p^{BM} SMB_t + h_p^{BM} HML_t + e_{p,t}^{BM}$$

where $R_{p,t}^{BM} - R_{f,t}$ is the equal- or value- weighted return of these size portfolios less the risk-free rate (the one-month Treasury bill rate); $R_{m,t} - R_{f,t}$ is the value-weighted market return on all NYSE/Amex/Nasdaq firms minus risk-free rate; SMB_t (small minus big), the difference each month between the return of small-and large-capitalization firms; and HML_t (high minus low), the difference each month between a portfolio of high book-to-market stocks and the return on a portfolio of low book-to-market stocks.

The patterns for both VC-backed IPO with and without patents portfolios further verify our earlier results: the VC-backed IPO portfolios without patents underperform those with patents. From Panel A, we can see that for the equal

weighted venture-backed IPO portfolios, low book-to-market portfolio underperform with -0.73% Fama-French alpha at 5% significance level. For the value weighted venture-backed IPO portfolios, the alpha of medium book-to-market portfolio is significantly negative, while the performance of the other two portfolios are insignificant.

Panel B shows that for all equal- and value- weighted venture-backed IPO portfolios with patents, the Fama-French alphas are positive, except for the value weighted high book-to-market ratio portfolio, whose alpha is negative 15 basis points but insignificant. The outperformance of venture-backed IPO portfolios with patents ranges from 39 to 97 basis points per month. The Fama-French results provide evidence that outperformance of venture-backed IPO portfolios with patents remains even after controlling for size and book-to-market in time series regressions. Venture-backed IPO portfolios with patents outperform those without patents whether the results are run on the entire sample or sorting based on size or book-to-market.

V. Cross-sectional differences across VC-backed IPOs

Are the characteristics of the VC-backed companies related to performance? In this section, I seek to answer these questions with multivariate analyses that explain performance of VC-backed companies in the three years after going public. Table 7 reports the multivariate regression results, conditional on the offering being a VC-backed IPO. The sample consists of 2213 venture capital (VCs) backed initial public offerings (IPOs) between January 1981 and December 2004. When I include independent variables from COMPUSTAT database, the sample size falls to 1822. The dependent variable for (1) and (2) is 3-year buy-and-hold excess returns adjusted by the value-weighted (VW) NYSE/Amex/Nasdaq market index. The dependent variable for (3) and (4) is Fama and French alpha estimated by running firm-specific time-series regressions of monthly firm excess returns on the value-weighted NYSE/Amex/Nasdaq excess returns for 36 months after the IPO. The independent variables include the logarithm of sales after the IPO, Tobin's Q after the IPO, underpricing, the debt-to-total assets ratio after the IPO, and R&D expenses-to-sales ratio. All variables are computed using data at the end of the quarter of the IPO. All the regressions have industry and year fixed effects. Nevertheless, similar results are obtained in the Fama-MacBeth regressions without year or industry dummies.

[Insert Table 13 Here]

Table 13 reports the average slopes and their time-series *t*-statistics from the cross-sectional regressions. There is a significantly positive relation between innovations and stock returns which is robust to the inclusion of different sets of control variables. The slopes on patent(s) dummy are always positive and significant, regardless of the model specifications.

For the univariate regression in Model (1), the slope on patent(s) dummy is 0.359 with a *t*-statistic of 3.39. In other words, a one standard deviation of increase in patent(s) dummy leads to an increase of 0.359 in three-year buy-and-hold return. Models (2) add sales, Tobin's Q, Underpricing, debt-to-market ratio and R&D intensity to the regression, and the slope on patent(s) dummy increase slightly to 0.387 but its *t*-statistics are lower: 2.94 in Models (2).

For the univariate regression in Model (3), the slope on patent(s) dummy is 0.9% with a *t*-statistic of 5.72. In other words, a one standard deviation of increase in patent(s) dummy leads to an increase of 10.8% in compounded annual return. Models (4) add sales, Tobin's Q, Underpricing, debt-to-market ratio and R&D intensity to the regression, and the slope on patent(s) dummy increase slightly to 1% but its *t*-statistics drop to 5.44 in Models (4).

I find some other distinct patterns. In general, VC-backed companies with larger sales, in general, perform better. (This result is significant at the 1% confidence level when the dependent variable is buy-and-hold excess returns adjusted by the value-weighted NYSE/Amex/Nasdaq market index, and 10%

confidence level when the dependent variable is Fama and French alpha.) Greater leverage does not have a significant impact on the returns. In fact, the sign of the coefficient is negative, though insignificant. The coefficients for the Tobin's Q, the underprcing, and research and development expenses-to-sales ratio have no significant explanatory power.

Venture-backed firm's decisions about patent filings are not homogeneous across different firms. Therefore, any analysis of the effect of patent filings on performance must take into account this self-selection issue. To control for this problem, I investigate the likelihood of patent dummy and its effects on subsequent firm performance using Heckman's selection regressions, a two-step estimation procedure:

Step 1: Probit (*Patent Dummy*) = $\alpha_0 + \alpha_1 Control\ Variables + \varepsilon$

Step 2: *Performance* = $\alpha_0 + \alpha_1 Patent\ Dummy + \alpha_2 Control\ Variables + \alpha_3 Lambda + \varepsilon$

The first-step is a probit regression in which the dependent variable is a dummy equal to 1 when the venture-backed IPOs successfully file patent(s) five year before taking public, 0 otherwise. The identifying instruments on the right-hand side include the VC-backed firm's R&D activity, operating performance and assets at IPO. The scond-step regression includes, *lambda*, the inverse Mills ratio imputed from the first-step probit regression, as an additional control variable for selection bias. The dependent variable in the second stage is either a long-run performance measure of buy-and-hold excess return or Fama-French alpha or delisting dummy (measured within the three post-IPO

years).

[Insert Table 14 Here]

As Table 14 shows, the ratio of R&D-to-sales is positively associated with the likelihood of patent dummy at 1% significance level. The result is consistent with the evidence in Table 6 and 8, suggesting that VC-backed IPOs with patents are more likely to invest in innovations. In the second Heckman analysis, patent dummy is significantly and negatively associated with the likelihood of a firm being delisted within three years after IPO. The evidence also reveals that, once the selection bias is controlled for, the long-run performance of VC-backed IPOs without patent(s) is significantly worse than VC-backed IPOs with patent(s).

VI. Conclusions

In this paper, I take a comprehensive view of VC-backed IPOs from 1981 through 2004, including 842 VC-backed IPOs with patent(s) and 1371 VC-backed IPOs without patent(s). By examining a sample of more than 2000 offerings, I find that VC-backed IPOs with patents appear to outperform VC-backed IPOs without patents in both cross-sectional analyses and calendar-time portfolios analyses.

In cross-sectional analyses of different performance measures, including buy-and-hold return, monthly excess return, Jensen's alpha and Fama-French alpha, VC-backed IPOs with patents consistently outperform VC-backed IPOs without patents. The results of outperformance for VC-backed IPOs with patents are robust after I control for size and value effects.

The results of calendar-time analyses are consistent with that of cross-sectional analyses. According to the Fama-French three-factor model, VC-backed IPO portfolio with patent(s) earns 12% annual excess return than VC-backed IPO portfolio without patent(s). The results are also in line with Brav and Gompers (1997) that VC-backed IPOs without patents perform as well the stock market.

VC-backed IPOs with patents earn higher subsequent returns than VC-backed IPOs without patents. This relation is robust to controlling for other firm characteristics, such as sales, Tobin's Q, underpricing, the debt-to-total assets

ratio, and R&D expenses-to-sales ratio. Traditional empirical factor pricing models do not explain this relation. Our innovation proxy, patents dummy, is a strong positive predictor of future returns even after adjusting for the Fama-French three factor model.

In the Heckman's selection regressions, I find that patent dummy is significantly and negatively associated with the likelihood of a firm being delisted within three years after IPO. The evidence also reveals that, once the selection bias is controlled for, the long-run performance of VC-backed IPOs without patents is significantly worse than VC-backed IPOs with patents.

The empirical results of this research suggest that investors under-react to the information content in patents because of the difficulty evaluating the economic implications of patents granted. In this case, VC-backed IPOs that are more innovative may be undervalued, whereas venture-backed firms that are less innovative may be overvalued.

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Appendixes

Table 1
Year Distribution for VC-backed IPOs and Patent Filings

The sample consists of 2213 venture capital (VCs) backed initial public offerings (IPOs) between January 1981 and December 2004. The table reports total number of VC-backed IPOs and all patent filings by those new listed companies. The last two columns show the percentage of VC-backed IPOs among all VC-backed IPOs that have patents filing either before or after their IPOs.

Year	Number of VC-backed IPOs	Patents of VC-backed companies from -5 to -1 years prior to IPO	Patents of VC-backed companies from +1 to +5 years following IPO	Percentage of VC-backed companies having patents from -5 to -1 year prior to IPO	Percentage of VC-backed companies having new patents from +1 to +5 year following IPO
1981	50	74	274	30.00%	44.00%
1982	28	18	83	17.86%	32.14%
1983	111	296	1000	34.23%	43.24%
1984	42	69	187	30.95%	35.71%
1985	40	10	45	15.00%	35.00%
1986	89	740	1152	26.97%	39.33%
1987	58	232	746	32.76%	44.83%
1988	34	48	326	26.47%	35.29%
1989	34	169	368	47.06%	58.82%
1990	33	130	566	33.33%	39.39%
1991	106	200	1072	35.85%	45.28%
1992	128	291	1076	38.28%	44.53%
1993	145	517	2207	47.59%	56.55%
1994	111	203	724	37.84%	48.65%
1995	156	552	1596	35.90%	46.15%
1996	201	739	1966	40.80%	48.76%
1997	124	435	1724	41.13%	43.55%
1998	79	348	2194	37.97%	45.57%
1999	250	817	2031	33.20%	34.00%
2000	221	1387	1583	49.32%	44.34%
2001	31	152	101	48.39%	48.39%
2002	29	2380	388	31.03%	24.14%
2003	24	284	25	33.33%	25.00%
2004	89	943	21	50.56%	10.11%
Total	2213	11034	21455	38.05%	42.25%

Table 2
Underpricing for VC-backed IPOs without and with Patent(s)

The sample consists of 2213 venture capital (VCs) backed initial public offerings (IPOs) between January 1981 and December 2004. "No" represents the 1371 VC backed IPOs without successful patent application(s) 5-year before IPOs, and "Yes" represents 842 VC backed IPOs with successful patent application(s) 5-year before IPOs.

	No	Yes
Average underpricing (equal weighted %)	27.67	33.00
Median (%)	10.00	10.47
Standard deviation (%)	56.10	63.49
Normal period average (equal weighted %)	18.62	21.64
Bubble period average *(equal weighted %)	87.12	111.91
Proportion starting below offer price (%)	13.93	10.93
Average money left on the table (million)	151.38	185.66
Total number of issues	1371	842

*****Bubble period: July 1999 to June 2000

Table 3
Firm Level Analysis of Stock Performance for VC-backed IPOs without and with Patent(s)

The sample consists of 2145 VC-backed IPOs between January 1981 and December 2004. Panel A reports the results of 1324 VC-backed IPOs without Patents, and Panel B presents the results of 821 VC-backed IPOs with Patents. I exclude American Depository Receipts, closed-end funds, Real Estate Investment Trusts, unit offerings, and IPOs with an offering size smaller than $1.5 million, firm market capitalization less than $5million, or an offering price of under $5 per share. The returns are computed ending 24, 36, 48, and 60 months after the IPO date. The buy-and-hold excess returns and average excess monthly returns are both adjusted by the value-weighted (VW) NYSE/Amex/Nasdaq market index. Jensen alphas are the intercepts estimated by running firm-specific time-series regressions of monthly firm excess returns on the value-weighted NYSE/Amex/Nasdaq excess returns for 24, 36, 48, and 60 months after the IPO. FF alphas are similar intercepts estimated using Fama and French factors as independent variables. If the sample firm delists, the raw returns, market-adjusted returns, Jensen's alphas, and FF alphas are set equal to zero after the delisting date. Absolute robust t-statistics are reported in parentheses. *, **, and*** indicate significance at the 10%, 5%, and 1% level of confidence, respectively. All stock return measures are expressed in percentages.

	Buy-and-hold raw return	Buy-and-hold excess return relative to the VW market	Average monthly excess return relative to the VW market	Jensen's alpha	FF alpha
Panel A: VC-backed IPOs without Patents					
24 months	20.86***	-2.77	-0.43***	-0.55***	-0.10
	(4.22)	(-0.57)	(-4.01)	(-5.25)	(-0.90)
36 months	18.98***	-15.74***	-0.20***	-0.28***	0.07
	(4.61)	(-3.93)	(-2.86)	(-3.92)	(0.96)
48 months	29.26***	-15.15**	0.02	-0.12**	0.15**
	(4.85)	(-2.56)	(0.35)	(-2.21)	(2.49)
60 months	33.06***	-16.15**	0.10**	-0.02	0.17***
	(5.04)	(-2.50)	(2.13)	(-0.49)	(3.46)
Panel B: VC-backed IPOs with Patents					
24 months	27.83***	6.09	0.11	0.08	0.60***
	(3.73)	(0.83)	(0.80)	(0.57)	(3.96)
36 months	39.49***	4.87	0.43 ***	0.36***	0.82***
	(4.59)	(0.58)	(4.14)	(3.22)	(7.34)
48 months	54.65***	9.49	0.70***	0.55***	0.86***
	(4.78)	(0.85)	(8.52)	(6.24)	(9.47)
60 months	61.14***	11.32	0.66***	0.47***	0.77***
	(5.38)	(1.03)	(9.74)	(6.90)	(10.45)

Table 4
Firm Level Analysis of Three-Year Stock Performance for VC-backed IPOs without and with Patent(s) Sorted on the Basis of Size

The sample consists of 2145 VC-backed IPOs between January 1981 and December 2004. Panel A reports the results of 1324 VC-backed IPOs without Patents, and Panel B presents the results of 821 VC-backed IPOs with Patents. The buy-and-hold excess returns and average excess monthly returns are both adjusted by the value-weighted (VW) NYSE/Amex/Nasdaq market index. Jensen alphas are the intercepts estimated by running firm-specific time-series regressions of monthly firm excess returns on the value-weighted NYSE/Amex/Nasdaq excess returns for 36 months after the IPO. FF alphas are similar intercepts estimated using Fama and French factors as independent variables. If the sample firm delists, the raw returns, market-adjusted returns, Jensen's alphas, and FF alphas are set equal to zero after the delisting date. Each sample of IPOs is sorted into three size groups ("Small", "Medium", and "Large") based on the real size at the first closing price listed by the Center for Research in Security Prices (CRSP). Size breakpoints are the same for the venture-backed IPOs with and without patents. All stock return measures are the average returns for IPOs in that group, and expressed in percentages.

	Small	Medium	Large
Panel A: VC-backed IPOs without Patents			
Buy-and-hold raw return	27.05	17.73	6.38
Buy-and-hold excess return relative to the VW market	-21.74	-21.17	-5.06
Average monthly excess return relative to the VW market	-0.29	-0.14	-0.26
CAPM - Alpha	-0.53	-0.41	0.10
CAPM - RMRF	1.40	1.69	2.31
FF - Alpha	-0.11	0.09	0.21
FF - RMRF	1.20	1.31	1.40
FF - SMB	1.29	1.14	0.73
FF - HML	-0.28	-0.62	-1.11
Number of observations	443	496	385
Panel B: VC-backed IPOs with Patents			
Buy-and-hold raw return	46.46	58.60	9.56
Buy-and-hold excess return relative to the VW market	-6.71	14.23	3.58
Average monthly excess return relative to the VW market	0.26	0.43	0.59
CAPM - Alpha	-0.07	0.04	1.17
CAPM - RMRF	1.40	1.86	2.55
FF - Alpha	0.55	0.67	1.34
FF - RMRF	1.06	1.34	1.66
FF - SMB	1.45	1.33	1.31
FF - HML	-0.59	-0.81	-1.00
Number of observations	201	362	258

Table 5
Firm Level Analysis of Three-Year Stock Performance for VC-backed IPOs without and with Patent(s) Sorted on the Basis of Book-to-Market Ratio

The sample consists of 2145 VC-backed IPOs between January 1981 and December 2004. Depending on the measures, I have data for 1865 VC-backed IPOs with and without patents. Panel A reports the results of 1052 VC-backed IPOs without Patents, and Panel B presents the results of 813 VC-backed IPOs with Patents. The buy-and-hold excess returns and average excess monthly returns are both adjusted by the value-weighted (VW) NYSE/Amex/Nasdaq market index. Jensen alphas are the intercepts estimated by running firm-specific time-series regressions of monthly firm excess returns on the value-weighted NYSE/Amex/Nasdaq excess returns for 36 months after the IPO. FF alphas are similar intercepts estimated using Fama and French factors as independent variables. If the sample firm delists, the raw returns, market-adjusted returns, Jensen's alphas, and FF alphas are set equal to zero after the delisting date. Each sample of IPOs is sorted into three book-to-market ratio groups ("Low", "Medium", and "High") based on the real market value at the first closing price listed by the Center for Research in Security Prices (CRSP) and book value of equity at IPO quarter from COMPUSTAT database. Book-to-market ratio breakpoints are the same for the venture-backed IPOs with and without patents. All stock return measures are the average returns for IPOs in that group, and expressed in percentages.

	Low	Medium	High
Panel A: VC-backed IPOs without Patents			
Buy-and-hold raw return	15.28	9.67	31.63
Buy-and-hold excess return relative to the VW market	-9.53	-22.45	-7.84
Average monthly excess return relative to the VW market	-0.19	-0.20	0.04
CAPM - Alpha	-0.06	-0.28	-0.12
CAPM - RMRF	1.98	1.79	1.40
FF - Alpha	0.35	0.03	0.13
FF - RMRF	1.39	1.24	1.19
FF - SMB	1.02	1.13	1.05
FF - HML	-0.94	-0.66	-0.23
Number of observations	344	372	336
Panel B: VC-backed IPOs with Patents			
Buy-and-hold raw return	53.33	35.46	38.99
Buy-and-hold excess return relative to the VW market	34.30	0.32	-11.79
Average monthly excess return relative to the VW market	0.49	0.39	0.35
CAPM - Alpha	0.90	0.16	0.01
CAPM - RMRF	2.31	1.89	1.59
FF - Alpha	1.16	0.69	0.62
FF - RMRF	1.59	1.30	1.18
FF - SMB	1.37	1.32	1.35
FF - HML	-1.01	-0.78	-0.65
Number of observations	224	370	219

Table 6
Summary Statistics for VC-backed IPOs without and with Patent(s)

The sample consists of 2213 venture capital (VCs) backed initial public offerings (IPOs) between January 1981 and December 2004. Depending on the measures, I have data for 1865 VC-backed IPOs with and without patents. Panel A reports the summary statistics of 1052 VC-backed IPOs without Patents, and Panel B presents the summary statistics of 813 VC-backed IPOs with Patents. I exclude American Depository Receipts, closed-end funds, Real Estate Investment Trusts, unit offerings, and IPOs with an offering size smaller than $1.5 million, firm market capitalization less than $5million, or an offering price of under $5 per share. The variables are computed at the initial public offering (IPO) year, one, two, and three years after IPOs, as reported by COMPUSTAT. The firm characteristics include the following: equity market capitalization, the ratio of book value to the market value of firm's equity, assets, the ratio of net income to assets (ROA), the capital expenditures (CAPEX)-to-sales ratio, the debt-to-assets ratio, the long-term debt-to-assets ratio, and the R&D-to-sales ratio.

	IPO year	One -Year	Two -Year	Three - Year
Panel A: VC-backed IPOs without Patents				
Market value (millions of dollars)	388.81	367.97	342.48	344.53
Book-to-market ratio	0.24	0.41	0.51	0.59
Assets (millions of dollars)	144.96	204.45	247.87	286.09
Net income/assets (ROA)	-0.06	-0.10	-0.15	-0.12
CAPEX/sales	0.53	0.20	0.22	0.11
Total debt/sales	0.17	0.16	0.19	0.21
Long-term debt/sales	0.14	0.13	0.15	0.17
R&D/sales	1.51	0.54	0.45	0.31
Panel B: VC-backed IPOs with Patents				
Market value (millions of dollars)	431.62	431.19	411.38	395.60
Book-to-market ratio	0.24	0.35	0.44	0.51
Assets (millions of dollars)	102.40	170.27	180.85	205.06
Net income/assets (ROA)	-0.12	-0.16	-0.21	-0.22
CAPEX/sales	1.03	0.44	0.30	0.23
Total debt/sales	0.09	0.08	0.10	0.12
Long-term debt/sales	0.06	0.06	0.07	0.09
R&D/sales	5.16	1.72	1.52	1.16

Table 7

Calendar-time Portfolio Analysis of Stock Performance for VC-backed IPOs without and with Patent(s)

This table reports onthly excess returns and Fama and French (1992) three-factor regressions on calendar-time portfolio returns of VC-backed IPOs. The sample consists of 1324 VC-backed IPOs without patent(s), and 821 VC-backed IPOs with patent(s) between January 1981 and December 2004. VC-backed IPOs without patents portfolio is presented in Panel A, and VC-backed IPOs with patents portfolio is presented in Panel B. I exclude American Depository Receipts, closed-end funds, Real Estate Investment Trusts, unit offerings, and IPOs with an offering size smaller than $1.5 million, firm market capitalization less than $5million, or an offering price of under $5 per share. I form the monthly portfolios of VC-backed IPOs without and with patent(s) by including all issues that were undertaken in the three years previous to the month of the observation. (The analysis extends between January 1982 and December 2006.) I use as the dependent variable monthly excess return, monthly returns of the equal- or value- weighted return of these portfolios less the risk-free rate (the one-month Treasury bill rate). Both equal- and value- weighted VC-backed IPOs without and with patent(s) portfolios are rebalanced every month, and the value weights are based on previous month's market values of the firms. Absolute robust t-statistics are reported in parentheses. *, **, and*** indicate significance at the 10%, 5%, and 1% level of confidence, respectively. Alpha measures are expressed in percentages.

	Excess Return		Fama and French	
	Equal-weighted	Value-weighted	Equal-weighted	Value-weighted
Panel A: VC-backed IPOs without Patents				
Alpha	0.44	0.45	-0.25	-0.08
	(0.81)	(0.80)	(-1.01)	(-0.31)
RMRF			1.32***	1.37***
			(20.74)	(21.89)
SMB			1.02***	0.70 ***
			(12.71)	(8.98)
HML			-0.63***	-0.99***
			(-6.55)	(-10.53)
Number of monthly observations	300	300	300	300
Adjusted R^2			0.81	0.83
Panel B: VC-backed IPOs with Patents				
Alpha	1.22**	1.43**	0.66**	1.05***
	(1.97)	(2.07)	(2.53)	(3.10)
RMRF			1.30***	1.43***
			(19.68)	(16.57)
SMB			1.31***	0.87***
			(15.71)	(7.97)
HML			-0.94***	-1.44***
			(-9.44)	(-11.04)
Number of monthly observations	300	300	300	300
Adjusted R^2			0.84	0.78

Table 8

Summary Statistics for VC-backed IPOs without and with Patent(s) Sorted on the Basis of Size and Book-to-Market Ratio

The sample consists of 2213 venture capital (VCs) backed initial public offerings (IPOs) between January 1981 and December 2004. Depending on the measure, I have data for 1865 VC-backed IPOs with and without patents. Panel A reports the results of 1052 VC-backed IPOs without Patents, and Panel B presents the results of 813 VC-backed IPOs with Patents. The firm characteristics include the following: equity market capitalization, the ratio of book value to the market value of firm's equity, assets, the ratio of net income to assets (ROA), the capital expenditures (CAPEX)-to-sales ratio, the debt-to-assets ratio, the long-term debt-to-assets ratio, and the R&D-to-sales ratio. All variables are computed using data during or at the end of the fiscal year of the VC-backed IPOs, as reported by COMPUSTAT. The three columns under "Size Terciles" report the summary statistics for the three size portfolios ("Small", "Medium", and "Large"), which are divided every six months based on the previous month's VC-backed IPO size distribution using all VC-backed IPOs to determine the breakpoints, 30^{th} and 70^{th} percentiles. The last three columns report the summary statistics for the three book-to-market portfolios ,"Low", "Medium", and "High". Every six months I divide the sample into three book-to-market ratio portfolios based on the previous month's VC-backed IPO book-to-market distribution using all VC-backed IPOs to determine the breakpoints, 30^{th} and 70^{th} percentiles.

	Size Terciles			Book-to-Market Terciles		
	Small	Medium	Large	Low	Medium	High
Panel A: VC-backed IPOs without Patents						
Market value (millions of dollars)	209.93	297.88	657.71	412.37	400.57	354.71
Book-to-market ratio	0.30	0.38	0.44	0.21	0.39	0.50
Assets (millions of dollars)	68.01	135.09	387.68	167.00	207.61	206.91
Net income/assets (ROA)	-0.20	-0.05	0.01	-0.07	-0.06	-0.13
CAPEX/sales	0.25	0.47	0.28	0.49	0.41	0.30
Total debt/sales	0.16	0.17	0.18	0.19	0.15	0.17
Long-term debt/sales	0.11	0.14	0.16	0.16	0.12	0.13
R&D/sales	0.79	1.30	0.58	1.81	0.99	0.65
Panel B: VC-backed IPOs with Patents						
Market value (millions of dollars)	153.37	316.61	810.65	532.48	412.38	289.97
Book-to-market ratio	0.30	0.32	0.39	0.26	0.32	0.43
Assets (millions of dollars)	43.82	88.50	303.69	136.70	133.85	145.65
Net income/assets (ROA)	-0.28	-0.15	-0.04	-0.17	-0.14	-0.16
CAPEX/sales	0.47	0.77	0.62	0.84	0.65	0.69
Total debt/sales	0.09	0.08	0.10	0.10	0.07	0.08
Long-term debt/sales	0.06	0.05	0.08	0.07	0.05	0.06
R&D/sales	3.01	3.84	2.01	3.80	3.51	2.64

Table 9
Monthly Raw Returns of VC-backed IPO Portfolios without and with Patent(s) Sorted on the Basis of Size

The sample consists of 1324 VC-backed IPOs without patent(s), and 821 VC-backed IPOs with patent(s) from January 1981 through December 2004. We form the monthly portfolios of VC-backed IPOs without and with patent(s) by including all issues that were undertaken in the three years previous to the month of the observation. (The analysis extends between January 1982 and December 2006.) Every six months we divide the sample into three size portfolios ("Small", "Medium", and "Large") based on the previous month's VC-backed IPO size distribution using all VC-backed IPOs to determine the breakpoints, 30^{th} and 70^{th} percentiles. The portfolios are rebalanced monthly and VC-backed IPOs are allowed to switch portfolios every half year. I use as the dependent variable monthly raw return, monthly returns of the equal- or value-weighted return of these portfolios less the risk-free rate (the one-month Treasury bill rate). I estimate equal- and value- weighted monthly raw returns within each size group. Absolute robust t-statistics are reported in parentheses. *, **, and*** indicate significance at the 10%, 5%, and 1% level of confidence, respectively. Intercept measures are expressed in percentages.

	Small		Medium		Large	
	Equal-weighted	Value-weighted	Equal-weighted	Value-weighted	Equal-weighted	Value-weighted
Panel A: VC-backed IPOs without Patents						
Raw Return	0.46	0.61	0.47	0.59	0.43	0.45
	(0.79)	(1.05)	(0.82)	(1.05)	(0.74)	(0.76)
Number of monthly observations	300	300	300	300	300	300
Panel B: VC-backed IPOs with Patents						
Raw Return	1.38**	1.07	1.05*	0.89	1.43**	1.63**
	(2.00)	(1.60)	(1.66)	(1.38)	(2.02)	(2.21)
Number of monthly observations	300	300	300	300	300	300

Table 10

Fama-French Three Factor Regressions on VC-backed IPO Portfolios without and with Patent(s) Sorted on the Basis of Size

The sample consists of 1324 VC-backed IPOs without patent(s), and 821 VC-backed IPOs with patent(s) from January 1981 through December 2004. We form the monthly portfolios of VC-backed IPOs without and with patent(s) by including all issues that were undertaken in the three years previous to the month of the observation. (The analysis extends between January 1982 and December 2006.) Every six months we divide the sample into three size portfolios ("Small", "Medium", and "Large") based on the previous month's VC-backed IPO size distribution using all VC-backed IPOs to determine the breakpoints, 30th and 70th percentiles. The portfolios are rebalanced monthly and VC-backed IPOs are allowed to switch portfolios every half year. I use as the dependent variable monthly raw return, monthly returns of the equal- or value-weighted return of these portfolios less the risk-free rate (the one-month Treasury bill rate). I estimate equal- and value- weighted monthly excess returns within each size group. Absolute robust t-statistics are reported in parentheses. *, **, and*** indicate significance at the 10%, 5%, and 1% level of confidence, respectively. Intercept measures are expressed in percentages.

	Small		Medium		Large	
	Equal-weighted	Value-weighted	Equal-weighted	Value-weighted	Equal-weighted	Value-weighted
Panel A: VC-backed IPOs without Patents						
Alpha	-0.38	-0.19	-0.28	-0.11	-0.08	-0.02
	(-0.91)	(-0.49)	(-1.04)	(-0.41)	(-0.32)	(-0.06)
RMRF	1.25***	1.28***	1.38***	1.34***	1.36***	1.39***
	(11.92)	(13.16)	(20.02)	(20.28)	(20.69)	(19.15)
SMB	1.14***	1.09***	1.09***	1.07***	0.79***	0.58***
	(8.63)	(8.88)	(12.55)	(12.85)	(9.62)	(6.40)
HML	-0.24	-0.37**	-0.61***	-0.67***	-1.03***	-1.14***
	(-1.53)	(-2.50)	(-5.86)	(-6.70)	(-10.42)	(-10.34)
Number of monthly observations	300	300	300	300	300	300
Adjusted R^2	0.56	0.61	0.80	0.81	0.82	0.79
Panel B: VC-backed IPOs with Patents						
Alpha	0.67	0.49	0.47	0.33	1.00 ***	1.29 ***
	(1.34)	(1.08)	(1.63)	(1.10)	(3.11)	(3.22)
RMRF	1.11***	1.07 ***	1.31***	1.35***	1.43***	1.47***
	(8.70)	(9.19)	(17.73)	(17.83)	(17.43)	(14.44)
SMB	1.62***	1.55***	1.32***	1.27***	1.12***	0.78***
	(10.11)	(10.62)	(14.19)	(13.31)	(10.84)	(6.08)
HML	-0.42**	-0.62***	-0.94***	-1.00***	-1.39***	-1.56***
	(-2.16)	(-3.56)	(-8.38)	(-8.75)	(-11.24)	(-10.16)
Number of monthly observations	300	300	300	300	300	300
Adjusted R^2	0.53	0.58	0.81	0.81	0.81	0.73

Table 11

Monthly Raw Returns of VC-backed IPO Portfolios without and with Patent(s) Sorted on the Basis of Book-to-Market Ratio

The sample consists of 1052 VC-backed IPOs without patent(s), and 813 VC-backed IPOs with patent(s) from January 1981 through December 2004. We form the monthly portfolios of VC-backed IPOs without and with patent(s) by including all issues that were undertaken in the three years previous to the month of the observation. (The analysis extends between January 1982 and December 2006.) Every six months we divide the sample into three book-to-market portfolios ("Low", "Medium", and "High") based on the previous month's VC-backed IPO book-to-market distribution using all VC-backed IPOs to determine the breakpoints, 30^{th} and 70^{th} percentiles. The portfolios are rebalanced monthly and VC-backed IPOs are allowed to switch portfolios every half year. I use as the dependent variable monthly raw return, monthly returns of the equal- or value- weighted return of these portfolios less the risk-free rate (the one-month Treasury bill rate). I estimate equal- and value- weighted monthly raw returns within each size group. Absolute robust t-statistics are reported in parentheses. *, **, and*** indicate significance at the 10%, 5%, and 1% level of confidence, respectively. Intercept measures are expressed in percentages.

	Low		Medium		High	
	Equal-weighted	Value-weighted	Equal-weighted	Value-weighted	Equal-weighted	Value-weighted
Panel A: VC-backed IPOs without Patents						
Raw Return	-0.01	0.73	0.48	-0.05	0.95	0.32
	(-0.02)	(1.11)	(0.84)	(-0.10)	(1.58)	(0.56)
Number of monthly observations	300	300	300	300	300	300
Panel B: VC-backed IPOs with Patents						
Raw Return	0.96	1.29*	1.34**	1.43**	1.32*	0.62
	(1.47)	(1.69)	(2.05)	(2.02)	(1.87)	(0.92)
Number of monthly observations	300	300	300	300	300	300

Table 12

Fama-French Three Factor Regressions on VC-backed IPO Portfolios without and with Patent(s) Sorted on the Basis of Book-to-Market Ratio

The sample consists of 1371 VC-backed IPOs without patent(s), and 842 VC-backed IPOs with patent(s) from January 1981 through December 2004. We form the monthly portfolios of VC-backed IPOs without and with patent(s) by including all issues that were undertaken in the three years previous to the month of the observation. (The analysis extends between January 1982 and December 2006.) Every six months we divide the sample into three book-to-market portfolios ("Low", "Medium", and "High") based on the previous month's VC-backed IPO book-to-market distribution using all VC-backed IPOs to determine the breakpoints, 30^{th} and 70^{th} percentiles. The portfolios are rebalanced monthly and VC-backed IPOs are allowed to switch portfolios every half year. I use as the dependent variable monthly raw return, monthly returns of the equal- or value- weighted return of these portfolios less the risk-free rate (the one-month Treasury bill rate). I estimate equal- and value- weighted monthly excess returns within each size group. Absolute robust t-statistics are reported in parentheses. *, **, and*** indicate significance at the 10%, 5%, and 1% level of confidence, respectively. Intercept measures are expressed in percentages.

	Low		Medium		High	
	Equal-weighted	Value-weighted	Equal-weighted	Value-weighted	Equal-weighted	Value-weighted
Panel A: VC-backed IPOs without Patents						
Alpha	-0.73**	0.25	-0.39	-0.78***	0.19	-0.61
	(-2.22)	(0.64)	(-1.36)	(-2.93)	(0.44)	(-1.56)
RMRF	1.44***	1.40***	1.39***	1.35***	1.26***	1.39***
	(17.16)	(14.32)	(19.01)	(20.07)	(11.30)	(14.11)
SMB	0.93***	0.70***	0.98***	0.60***	0.94***	0.85***
	(8.77)	(5.67)	(10.67)	(7.10)	(6.70)	(6.84)
HML	-0.74***	-1.14***	-0.59***	-0.77***	-0.39**	-0.21
	(-5.83)	(-7.69)	(-5.34)	(-7.60)	(-2.32)	(-1.43)
Number of monthly observations	300	300	300	300	300	300
Adjusted R^2	0.73	0.69	0.77	0.78	0.52	0.58
Panel B: VC-backed IPOs with Patents						
Alpha	0.39	0.97**	0.59*	0.73**	0.58	-0.15
	(1.18)	(2.07)	(1.92)	(2.01)	(1.21)	(-0.33)
RMRF	1.37***	1.45***	1.38***	1.49***	1.21***	1.31***
	(16.11)	(12.18)	(17.63)	(16.14)	(10.00)	(11.77)
SMB	1.17***	0.71***	1.26***	1.06***	1.41***	1.13***
	(10.99)	(4.77)	(12.84)	(9.17)	(9.28)	(8.10)
HML	-1.01***	-1.57***	-0.93***	-1.19***	-0.70***	-0.74***
	(-7.87)	(-8.71)	(-7.86)	(-8.53)	(-3.82)	(-4.37)
Number of monthly observations	300	300	300	300	300	300
Adjusted R^2	0.77	0.66	0.80	0.76	0.58	0.61

Table1 13
Multivariate Regression analyses of VC-backed IPOs

The sample consists of 2213 venture capital (VCs) backed initial public offerings (IPOs) between January 1981 and December 2004. When we include independent variables from COMPUSTAT database, the sample size falls to 1865. The dependent variable for (1) and (2) is 3-year buy-and-hold excess returns adjusted by the value-weighted (VW) NYSE/Amex/Nasdaq market index. The dependent variable for (3) and (4) is Fama and French alpha estimated by running firm-specific time-series regressions of monthly firm excess returns on the value-weighted NYSE/Amex/Nasdaq excess returns for 36 months after the IPO. The dependent variable for (5) and (6) is the delisting dummy, which is one if a firm delists within 36 months after IPO, zero otherwise. The independent variables include the logarithm of sales after the IPO, Tobin's Q after the IPO, underpricing, the debt-to-total assets ratio after the IPO, and research and development expenses-to-sales ratio. All variables are computed using data at the end of the quarter of the IPO. All the regressions have industry and year fixed effects. Absolute robust t-statistics are in parentheses. *, **, and *** indicate significance at the 10%, 5%, and 1% confidence level, respectively.

	Buy-and-hold excess return		FF alpha	
	(1)	(2)	（3）	（4）
Patent(s) dummy	0.359***	0.387***	0.009***	0.010***
	(3.39)	(2.94)	(5.72)	(5.44)
Logarithm of sales at IPO		0.163***		0.002*
		(3.18)		(2.17)
Tobin's Q		-0.002		0.000
		(-0.10)		(0.07)
Underpricing		0.126		0.002
		(0.62)		(0.62)
Total debt-to-assets ratio		-0.375		-0.004
		(-0.95)		(-0.81)
R&D/sales		0.060		0.000
		(0.95)		(0.07)
Observations	2194	1727	2194	1727
R^2	0.05	0.07	0.09	0.11
Year fixed effects	Yes	Yes	Yes	Yes
Industry fixed effects	Yes	Yes	Yes	Yes

Table1 14
Decisions on Patents and Its Effect on Performance

This table presents the results of the regressions of long-run performance on patent(s) using Heckman's selection approach. Estimations are based on the following:

First Step: Probit (*Patent Dummy*) $=\alpha_0 + \alpha_1 * Control\ Variables + \varepsilon$

Second Step: *Performance* $= \alpha_0 + \alpha_1 * Patent\ Dummy + \alpha_2 * Control\ Variables + \alpha_3 * Lambda + \varepsilon$

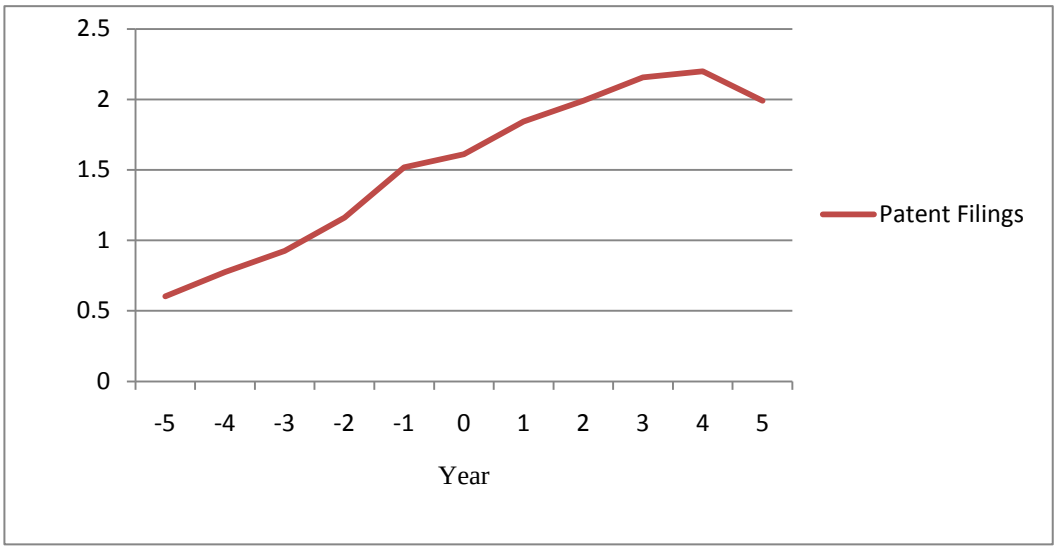
Column 2 gives the first-step probit regression results for patent dummy; Columns 3, 4, and 5 present the second-step OLS regression. The probit regression in Column 3 uses a delisting dummy; the OLS regression in Column 4 uses the buy-and-hold return, and the OLS regression in Column 5 uses the Fama and French alpha. The delisting dummy is set to 1 if a firm is delisted from the market within a three-year window post-IPO. The buy-and-hold return is measured three years following IPO and adjusted by the value-weighted market benchmark. The Fama and French alpha is estimated by running firm-specific time-series regressions of monthly firm excess returns on the value-weighted NYSE/Amex/Nasdaq excess returns for 36 months after the IPO. Lambda is the inverse Mills ratio calculated from the first-step selection regression. Absolute robust t-statistics are in parentheses. *, **, and *** indicate significance at the 10%, 5%, and 1% confidence level, respectively.

	First Step Selection	Second Step Selection		
	Patent dummy	Delisting dummy	Buy-and-hold excess return	FF alpha
Constant		0.52**	-2.42***	-0.02*
		(2.01)	(-4.19)	(-1.92)
Patent dummy		-2.04***	0.29	0.00
		(-25.32)	(0.82)	(0.19)
IPO underpricing		0.02	-0.08	0.00*
		(0.77)	(-0.91)	(1.85)
Logarithm of sales at IPO		-0.04***	0.13***	0.00***
		(-2.61)	(4.55)	(3.02)
R&D/sales at IPO	0.03***			
	(4.52)			
Operating income/sales at IPO	0.00			
	(0.35)			
Logarithm of assets at IPO	-0.03			
	(-1.24)			
Lambda		0.10***	1.96***	0.03***
		(184.41)	(60.69)	(42.84)
Number of Observations	1845	1845	1845	1845

Figure 1
Year Average of Patent Counts Before and After initial public offerings (IPOs)

The sample consists of 2213 venture capital (VCs) backed IPOs between January 1981 and December 2004. Panel A reports the average patent counts from [-5, +5] year centered in the year of IPOs for all VC-backed firms; Panel B reports the average patent counts from [-5, +5] year centered in the year of IPOs for VC-backed firms with patent records prior to IPOs.

Panel A: Full sample



Panel B: Subsample of firms with successful patent application(s) before IPOs