Venture Capital Backing and Overvaluation: Evidence from the High-Tech Bubble*

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Abstract: This paper investigates the association between venture capital (VC) backing and the likelihood of firm overvaluation in and around the high-tech bubble period. We make use of a large sample of 14,364 firm-year observations for firms listed on NASDAQ during the pre-bubble (1994–1997), bubble (1998–2000) and post-bubble (2001–2004) periods. After controlling for endogeneity and many other factors, we find strong evidence that a VC-backed firm is more likely than a non-VC-backed firm to be overvalued during the bubble period. But outside of the bubble period, all the differences in overvaluation between VC-backed and non-VC-backed firms disappear. Further evidence suggests that such association is only relevant if the firms are recently went public and VCs have high ownership or control. Our findings provide additional evidence supporting VC opportunism in a boom period and contribute to the literature on the behavior of financial institutions over the business cycle.

Keywords: Venture Capital, Overvaluation, Bubble

JEL Codes: G14, G24, G31, G32

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1. Introduction

Venture capital (VC) plays a dominant role in financing startups in high-tech industries (Sahlman, 1990; Kaplan and Stromberg, 2003; Gompers *et al.*, 2008). The literature indicates that, besides financing, venture capitalists (VCs) are extensively involved in a number of value-adding activities. For example, they sit on the boards of directors, hire key executives, formulate strategies and modernize firms (Barry *et al.*, 1990; Hellmann and Puri, 2002; Baker and Gompers, 2003; Bottazzi *et al.*, 2008; Campbell and Frye, 2009). VCs' active involvement in their chosen portfolios has been shown in theory to reduce information asymmetry and agency problems (Admati and Pfleiderer, 1994; Bergemann and Hege, 1998; Neher, 1999; Casamatta, 2003; Wang and Zhou, 2004; Dessi, 2005) and in empirical analysis to create public companies (Barry *et al.*, 1990), spur innovations (Kortum and Lerner, 2000), improve information quality (Morsfield and Tan, 2006) and enhance performance (Hochberg *et al.*, 2007; Gompers *et al.*, 2008; Bottazzi *et al.*, 2008; Nahata, 2008).

However, the value-added role of VCs is dependent on market conditions (Kortum and Lerner, 2000; Cumming and MacIntosh, 2001; Gompers and Lerner, 2002; Kanniainen and Keuschnigg, 2003; Cumming and MacIntosh, 2004; Cumming *et al.*, 2005; Cumming, 2006). Moreover, venture capitalists have been shown to be opportunistic during asset bubbles. Lerner (1994) document that VC-backed firms go public when equity valuations are high and conduct private financings when equity valuations are low. Gompers and Lerner (1998) find that VC distributions occur after substantial increases in share value, which leads to a substantial price reaction immediately before and after the sales event. Gompers *et al.* (2008) suggest that VCs react positively to public market signals as proxied by industry Tobin-Q or IPO activity, and such a reaction is much stronger for VCs with more industry experience. As suggested by Cumming and MacIntosh (2004), many immature firms are taking to the market during the boom period with the run-ups of IPO exits and IPO valuations. Also, in the boom period, VCs switch their investing behavior away from early-stage to later-stage firms, employ less due diligence, engage in sub-optimal contracting, provide less monitoring and strategic advice, and perform fewer and less-effective staged financings. Gompers (1996) finds that IPOs backed by young VCs are younger and more underpriced than those of established VCs. Lee and Wahal (2004) extend the study of Gompers (1996) and find that VC-backed IPOs experience larger IPO underpricing than non-VC-backed counterparts, after controlling for the endogeneity problem in receiving VC financing. Such a difference in first-day returns is much larger during the bubble period than during a normal period. Loughran and Ritter (2004) find that VCs tolerate high underpricing if the underwriter's analyst is expected to be bullish. And, underwriters make use of future hot IPOs to reward

VCs who tolerate underpricing, which creates incentives for even more underpricing. Hoberg and Seyhun (2009) indicate that a potential collaboration between VCs and underwriters hurts the firm's valuation. On the one hand, VCs who tolerate larger underpricing today may receive long-term marketing support and favorable analyst reports from collaborating underwriters, allowing them to exit at relatively high prices later. On the other hand, collaborating underwriters may receive repeat business and more profits from distributing underpriced shares. However, exits by these VCs are typically followed by large negative abnormal returns, leading to an inverse-U-shaped price pattern centered on the lockup expiration date. The bubble period of 1998–2000 explains the majority of this effect.

We are interested in VC opportunism during a boom period. We investigate this opportunism by identifying an association between VC backing and firm overvaluation in different periods. Given the fact that VCs' profitability is highly related to equity market conditions (Ljungqvist and Richardson, 2003; Cumming and MacIntosh, 2004; Cochrane, 2005; Kaplan and Schoar, 2005), VCs have incentives to take advantage of a bubble. We expect a VC-backed firm to be more likely to be overvalued during a bubble period than during a normal period, especially for a firm that recently went public during a bubble. Further, this opportunistic behavior should be more prominent for VCs with high ownership and control over their portfolio firms. The high-tech bubble during 1998–2000 provides a good setting to investigate such a problem. The NASDAQ index rose rapidly during the late 1990s and peaked in March 2000. Another reason to investigate high-tech bubble during 1998-2000 is that such bubble closely related to high-tech firms which are the focus of VC investments, providing a good chance to investigate VC opportunism. During this so-called internet or high-tech bubble period, many early-stage high-tech firms achieved extraordinary market valuation with little or no earnings. This study investigates the association between VC backing and firm overvaluation in and around this internet bubble period.

We make use of a large sample of 14,364 firm-year observations of NASDAQ from the databases of COMPUSTAT, SDC global new issues, Jay Ritter's IPO data, SDC VentureXpert and SEC EDGAR. We consider three periods: the pre-bubble period of 1994–1997, the bubble period of 1998–2000, and the post-bubble period of 2001–2004. We focus on the question of whether or not VC-backed firms are more likely to be overvalued during the bubble period comparing with other periods. From our regression analysis, we find that a VC-backed firm is more likely than a non-VC-backed firm to be overvalued in the bubble period after controlling for market- and firm-level characteristics, as well as the year and industry fixed effects. However, this relationship is only significant in the bubble period (1998–2000) and is generally insignificant in the pre- and post-bubble periods. By decomposing our sample into two subsamples with one containing recently public firms and the other containing seasoned public firms based on the time since IPO, we further find that the association between VC backing and the likelihood of overvaluation during the bubble

period only presents in the recently public firms, consistent with the evidence that VCs gradually exit from the IPOs they back after several years. Further analysis on VCs' ownership and control provides evidence that VCs are more likely to ride the bubble if they have more ownership and control over their backed recently public IPOs. Our analysis deals with endogeneity problem arising from omitted variables using a two-stage probit model.

Our main contribution to the literature is that we provide further firm-level evidence on the changes of VC behavior in different market conditions. Although prior literature suggests that the extent to which VC behavior changes over the business cycle depends on the extent to which IPOs are overvalued during boom periods, there is still no direct evidence on the difference in the likelihood of being overvalued stocks between VC-backed and non-VC-backed firms. Our study tries to address the gap in the literature. Our study also contributes to the literature on the behavior of financial institutions in the bubble period, as suggested by Brunnermeier and Nagel (2004), Sharma *et al.* (2006), Gonzalez and James (2007), Dass *et al.* (2008), Bradley *et al.* (2008) and Greenwood and Nagel (2009).

The remainder of this paper is organized as follows. Section 2 develops hypotheses. Section 3 describes research design. Sections 4 and 5 respectively provide empirical analyses and robustness checks. Section 6 concludes the paper.

2. Hypothesis Development

VC investment activity fluctuates dramatically over time and appears to be closely tied to valuation in public markets (Cumming and MacIntosh, 2004; Gompers *et al.*, 2008). During the bubble period, decisions about what stocks to buy may not be based on what investors think they are worth, but on what investors think other investors think they are worth. Valuations become divorced from fundamentals. Profit-driving incentives make it rational for VCs to ride the bubble. In addition, as short-term owners, VCs benefit from overvaluation but bear little cost from it. Since VC investments are usually not compensated by dividends, the bulk of a VCs' profits comes from IPOs. As expected, the returns of VC funds appear to be highly correlated with the returns from the stock market. Cumming and MacIntosh (2004) indicate that the average return on VC investments in the U.S. is approximately 20% in 1998, 150% in 1999, 35% in 2000, and -10% in 2001. Further, there is also a rapid increase in VC fund inflows, which is no doubt driven by the increase in VC profitability. The capital under the management of VC funds has grown from $2 billion in 1978 to $200 billion in 1998. Due to "too much money chasing too few deals", the competition for a limited number of attractive investments is responsible for rising stock prices. Gompers and Lerner (2000) provide strong evidence that increasing capital inflows have led to higher security prices. This effect is robust to firm characteristics and public market valuations using first differences and instrumental variables.

We are interested in the difference in the likelihood of overvaluation between VC-backed and non-VC-backed firms, and further, whether such a difference is dependent on market conditions. We consider three time periods: the pre-bubble period of 1994–1997, the bubble period of 1998–2000 and the post-bubble of 2001–2004. Based on the prior discussion of VCs' taking advantage of overvalued stocks for profits, we develop our first hypothesis:

Hypothesis 1. *A VC-backed firm is more likely than a non-VC-backed firm to be overvalued in the bubble period; this difference does not exist in the pre- and post-bubble periods.*

VC funds have short lifecycles of about ten years in general. They usually make investments in the first half of their lives and try to cash out in the second half. The most successful channel for VCs to exit is to take their portfolio firms public and to sell the shares gradually on stock markets or to distribute the shares directly to investors. VCs are typically actively involved in their portfolio firms before exiting within three to four years after IPOs. Campbell and Frye (2009) provide consistent evidence that differences in governance and monitoring between VC-backed and non-VC-backed firms disappear four years after IPOs. Since VCs exit from their portfolio firms within a few years, the association between VC backing and the likelihood of being overvalued stocks should be quite different between recently and seasoned public firms. We expect this association to be driven by recently public firms instead of their seasoned counterparts. Hence, our second hypothesis is stated as:

Hypothesis 2. *The association between VC backing and the likelihood of overvaluation is stronger for recently public firms than for seasoned public firms.*

VCs usually are block shareholders and have powerful control rights over their backed firms, including the rights to put their shares to managers (Sahlman, 1990), fire managers (Hellmann, 1998), etc. If our prior predictions are correct, that is, VCs take advantage of overvalued stocks that recently went public during a bubble. We further predict that such behavior is more prominent for VCs with high ownership and control over their backed firms. If so, we should find a statistical relationship between VCs' ownership or control and overvaluation during the bubble period. As a result, we develop our third hypothesis as following

Hypothesis 3. *VC-backed recently public firms are more likely to be overvalued in the bubble period if VCs have higher ownership or control over them.*

3. Research Design

3.1. The Sample

We investigate the association between VC backing and the likelihood of overvaluation. We are also interested in how such associations differ between the high-tech bubble period, 1998-2000, and the pre- and post-bubble periods. Our sample period is chosen as 1994–2004, with the bubble occurring in the middle. We decompose the time period into three sub-periods: the pre-bubble period of 1994–1997, the bubble period of 1998–2000, and the post-bubble period of 2001–2004.[1]

Our primary sample is gathered from the COMPUSTAT database for U.S. firms listed on NASDAQ during 1994–2004 with 36,468 firm-year observations. We employ the following selection procedure to obtain the final sample: (1) exclude the financial sectors with the SIC code between 6000–6999; (2) exclude those observations with missing values for overvaluation measurement; (3) drop those firms without the IPO information in the SDC global new issues database and Jay Ritter's IPO data (http://bear.warrington.ufl.edu/ritter/) needed to perform the first-stage regression of the likelihood of receiving VC funding; (4) exclude those observations with missing control variables. This selection procedure gives us a final sample of 14,364 firm-year observations over the period of 1994–2004. Those firms that have VC financing before IPOs are regarded as VC-backed firms. To obtain a final sample of VC-backed firms, we merge the sample with data from the SDC VentureXpert database. SDC VentureXpert covers more than 90% of all VC investments in the U.S. market (Gompers and Lerner, 2004).

[Insert Table 1 here]

Panels A and B of Table 1 present the distributions of our sample by year and by industry, respectively. In each panel, the numbers of observations and corresponding percentages are listed for the whole sample, the VC-backed subsample and the non-VC-backed subsample. In Panel A, we can see that the yearly distributions are quite even across three time periods, and there are no structural differences between the VC-backed subsample and the non-VC-backed subsample. In Panel B, the industry classification is based on the 3-digit SIC code. In total, we have 196 industry sectors. To save space, we only report the sample distribution of the 20 largest sectors. Observations from the other 176 sectors constitute 30.88% of the whole sample. It is shown that industry types vary greatly. The four biggest industries—computer and data processing services, drugs, electronic components and accessories, and medical instruments and supplies—make up respectively 19.33%, 8.79%, 5.84% and 5.40% of the sample, consistent with the characteristics of NASDAQ. The VC-backed subsample presents more industry clustering than the non-VC-backed subsample, in line with the focus of VC investments. There are more VC-backed firms than

non-VC-backed firms in high technology sectors, such as computer and data processing services, drugs, electronic components and accessories, medical instruments and supplies, computer and office equipment, etc. However, there are more non-VC-backed firms than VC-backed firms in traditional sectors, such as eating and drinking places, trucking and courier services (except air mail), professional and commercial equipment, motor vehicles and equipment, etc.

3.2. Variables

Our dependent variable is named *Overvalued Stock*, a dummy variable indicating whether or not a firm's stock is overvalued. Following the literature, we use *Price-to-Sales Ratio* or *Valuation Error* to measure the extent of overvaluation. The price-to-sales ratio has traditionally been used to identify overvalued securities; see, for example, Brunnermeier and Nagel (2004), Dass *et al.* (2008), and Greenwood and Nagel (2009). The valuation error is defined in Rhodes-Kropf *et al.* (2005),[2] which is a more precise measure of misvaluation and used widely in the recent literature (Campello and Graham, 2007; Elliott *et al.*, 2008; Chi and Gupta, 2009; Hertzel and Li, 2010; Hoberg and Phillips, 2010). Specifically, for each year, we rank all stocks on the basis of *Price-to-Sales Ratio* or *Valuation Error*, and call the stocks in the top quartile the overvalued stocks. Hence, we have two measures of the dependent variable *Overvalued Stock* in our baseline regressions.

To test Hypotheses 1 and 2 investigating the difference in the likelihood of overvaluation between VC-backed and non-VC-backed firms, we adopt a test variable named *VC-Back*, which is a dummy variable indicating whether or not a firm has received VC funding before its IPO. To address Hypothesis 3 documenting the association between VCs' ownership or control and the likelihood of overvaluation of VC-backed recently public firms, we make use of four variables proxing VCs' ownership and control as the test variables. Specifically, VCs' ownership is proxied by the variables *Ownership* and *Block Owner*. *Ownership* is defined as the percentage shares owned by VCs, and *Block Owner* is measured as the number of VCs who hold over 5% of the equity shares. We use two variables *Chairman* and *Board Ratio* to represent VCs' control over the firm. Specifically, *Chairman* is a dummy variable indicating whether the VC holds the chairman position in the board of directors. *Board Ratio* indicates VCs' participation in the board of directors as measured by the ratio of the number of VC directors to the board size. We measure these four variables, *Ownership*, *Block Owner*, *Chairman* and *Board Ratio*, just after IPOs as proxies for VCs' ownership and control over a VC-backed recently public firm. The information on ownership structure and board distribution just after IPOs is hand-collected from firms' IPO prospectuses in the section of Management and Principal Shareholders from the SEC EDGAR database.[3] We obtain information on ownership structure and board distribution from the SEC EDGAR database for 671 VC-backed recently public firms corresponding to 2,464 firm-year observations.

We control for the industry median of Tobin-Q (named *Tobin-Q*), representing a market signal of the industry's attractiveness.[4] The industry classification is based on the 3-digit SIC code. We use the standard definition of Tobin-Q, which is the ratio of the firm's market value to the book value of assets, where the market value is the value of the firm's common stock plus the redemption value of the preferred stock and the net value of debt.

We also include variables representing firm-level fundamental characteristics, such as the logarithm of the time since IPO (*Years Since IPO*) to control for maturity, the leverage ratio (*Leverage*) to take the capital structure into account, the ratio of earnings before interest and taxes (EBIT) to sales (*EBIT*) to represent the firm's operational performance, the ratio of EBIT to sales in the past one year (*EBIT_1*) to take into account a lagged effect, the standard deviation of returns on assets (ROA) (*StdROA*) to control for performance volatility, the ratio of capital expenditures to sales (*Capital Expenditure*) and sales growth (*Growth*) to control for growth opportunities, the logarithm of total assets (*Size*) to represent firm size, and whether or not the firm is audited by a big-4 accounting auditor (*Big4*) to indicate accounting information quality. All these variables follow standard definitions in the literature.

We further include year dummies to control for time-series effects and industry dummies based on the 3-digit SIC code to control for industry characteristics.[5]

To rule out the possible influence of outliers, we winsorize the top and the bottom one percentiles for each continuous variable in all our regressions.

We present the definitions, measures and sources of the dependent, independent and control variables, and some terminologies in Table 2.

[Insert Table 2 here]

3.3. Methodology

When investigating the association between VC backing and the likelihood of overvaluation, a major concern is the endogeneity that stems from omitted variables influencing the likelihood of obtaining VC funding. To address this problem, we perform a two-stage procedure, in which the first stage is a probit regression that estimates the likelihood of receiving VC financing, and the second stage uses predictions from the first stage to provide a consistent probit analysis of the likelihood of overvaluation. To implement this procedure, we need instruments to act as predictive variables in the first-stage regressions. Unfortunately, the ex ante instruments are unobservable. Following the literature (Lee and Wahal, 2004; Morsfield and Tan, 2006), we use the underwriter rank (*Underwriter Rank*), logarithm of proceeds (*Proceeds*), logarithm of years since founding at the time of IPO (*Age*), sales per share in the year prior to IPO scaled by the offering price (*Sales per Share*), total assets per share in the year prior to IPO scaled by the offering price

(*Assets per Share*), book value of equity per share in the year prior to IPO scaled by the offering price (*Equity per Share*) and headquarters-state dummies as exclusion instruments in the first-stage regression.[6] The underwriter rank and proceeds are known only at the time of IPO, which is made after receiving VC funding. We use these variables with the belief that they are likely to be correlated with the ex ante unobservable variables, such as the firm's funding requirements.

To address Hypothesis 1, the second-stage probit regression can be written as the following: [7]

$$\begin{aligned} \textit{Overvalued Stock}_{it} = {} & \beta_0 + \beta_1 \textit{VC-Back}_i + \beta_2 \textit{Tobin-Q}_{ct} + \beta_3 \textit{Years Since IPO}_{it} + \beta_4 \textit{Leverage}_{it} \\ & + \beta_5 \textit{EBIT}_{it} + \beta_6 \textit{EBIT\_1}_{it} + \beta_7 \textit{StdROA}_{it} + \beta_8 \textit{Capital Expenditure}_{it} \\ & + \beta_9 \textit{Growth}_{it} + \beta_{10} \textit{Size}_{it} + \beta_{11} \textit{Big4}_{it} + \textit{Industry Dummies} + \textit{Year Dummies} + \varepsilon_{it}. \end{aligned} \quad (1)$$

where *i* refers to firm, *t* refers to year, and *c* refers to industry sector. The coefficient of interest is β_1, which captures the association between VC backing and the likelihood of overvaluation. To see how this association differs between the bubble period and other periods, we separately conduct regressions in the pre-bubble, bubble and post-bubble periods. Hypothesis 1 predicts a positive and significant β_1 during the bubble period, and an insignificant β_1 during the pre- and post-bubble periods.

To test Hypothesis 2, we employ the same two-stage probit model on the recently and seasoned public subsamples. Hypothesis 2 predicts that the positive and significant coefficient β_1 in the second-stage regression is driven by the recently public subsample instead of the seasoned public subsample.

To address Hypothesis 3, we apply a probit analysis from regressing *Overvalued Stock* on VCs' ownership or control, as proxied by *Ownership*, *Block Owner*, *Chairman* and *Board Ratio*, and other control factors. The regression model is:

$$\begin{aligned} \textit{Overvalued Stock}_{it} = {} & \gamma_0 + \gamma_1 \textit{VC Factor}_{it} + \gamma_2 \textit{Tobin-Q}_{ct} + \gamma_3 \textit{Years Since IPO}_{it} + \gamma_4 \textit{Leverage}_{it} \\ & + \gamma_5 \textit{EBIT}_{it} + \gamma_6 \textit{EBIT\_1}_{it} + \gamma_7 \textit{StdROA}_{it} + \gamma_8 \textit{Capital Expenditure}_{it} \\ & + \gamma_9 \textit{Growth}_{it} + \gamma_{10} \textit{Size}_{it} + \gamma_{11} \textit{Big4}_{it} + \textit{Industry Dummies} + \textit{Year Dummies} + \zeta_{it}. \end{aligned} \quad (2)$$

Here, "*VC Factor*" indicates either *Ownership*, *Block Owner*, *Chairman* or *Board Ratio*. We predict a positive and significant γ_1 during the bubble period, and an insignificant γ_1 during the pre- and post-bubble periods.

3.4. Summary Statistics, Univariate Analysis and Correlation Matrix

Table 3 presents summary statistics of all the variables. The number of observations, means, quartiles, standard deviations, minimums and maximums are presented. As shown, the means and medians of the control and test variables are similar and the standard

deviations are all within an acceptable range, suggesting that the distributions of these variables are not severely skewed.

[Insert Table 3 here]

Since *Overvalued Stock* is a dummy variable indicating whether or not the firm's stock belongs to the top quartile of *Price-to-Sales Ratio* or *Valuation Error*, both definitions of *Overvalued Stock* have the same mean of 0.25. Around 45.1% of the whole sample is backed by VC. In the VC-backed recently public subsample, VCs on average own 28.2% shares (with a median of 25.8%), 2.55 VCs (with a median of 2) are block owners owning more than 5% of the shares, 13.5% of the board chairmen are VCs, and VCs on average hold 31.0% of board seats (with a median of 28.6%) just after IPOs. These statistics are highly consistent with existing studies (Barry *et al.*, 1990; Sahlman, 1990; Baker and Gompers, 2003; Kaplan and Stromberg, 2003). All control variables show similar trends as the distribution of firms listed in NASDAQ during 1994–2004.

We also report the results of the univariate analysis in Table 3, which are the *t*-tests for equality of means and Wilcoxon tests for equality of medians between the overvalued and non-overvalued subsamples.[8] As shown, those firms backed by VCs are more likely to be overvalued at the 1% significance level. And, positive associations are found between overvaluation and variables *Ownership*, *Block Owner*, *Chairman* and *Board Ratio*. As suggested by the univariate tests, there are strong relationships between all the control variables and the likelihood of overvaluation, suggesting a need to control for these factors.

As indicated in unreported correlation coefficients, the likelihood of overvaluation is positively correlated with the test variables *VC-Back*, *Ownership*, *Block Owner*, *Chairman* and *Board Ratio*. Also, the likelihood of overvaluation is positively correlate with the control variables *Tobin-Q*, *StdROA*, *Capital Expenditure*, *Growth*, *Size* and *Big4*, and is negatively correlated with the control variables *Years Since IPO*, *Leverage*, *EBIT* and *EBIT_1*, suggesting the need to control for these variables. Moreover, excepting between *EBIT* and *EBIT_1*, there is no serious correlation between any two control variables or between the test and control variables, suggesting that our regression model does not suffer from severe multicollearity.

4. Empirical Analysis

In this section, we provide empirical evidence supporting Hypotheses 1-3. We run regressions separately over the three time periods: the pre-bubble period (1994–1997), the bubble period (1998–2000) and the post-bubble period (2001–2004). The industry dummies, defined by the 3-digit SIC code, and year dummies are included in all the

regressions to control for industry and year fixed effects. All the *z-statistic*s are adjusted for heteroskedasticity (White, 1980) and firm-level clustering (Petersen, 2009).

4.1. Association between VC Backing and Overvaluation

Panels A and B of Table 4 respectively present our baseline regression results without and with the consideration of endogeneity using the two-stage probit model. In panel A, we conduct probit regressions of *Overvalued Stock* on the variable *VC-Back* and other control variables directly. The dependent variable *Overvalued Stock* is defined respectively based on *Price-to-Sales Ratio* and *Valuation Error* in models 1–3 and models 4–6. As indicated in models 1–3, the coefficients on *VC-Back* are positive in all three periods, but it is significant only in the bubble period. Similarly, models 4–6 predict a larger and more significant association between *VC-Back* and *Overvalued Stock* in the bubble period than in the pre- and post-bubble periods.

[Insert Table 4 here]

However, as explained in section 3.3, there may be endogeneity problem because of omitted variables determining the likelihood of obtaining VC fund. Panel B presents the results from the two-stage probit model after taking endogeneity into account, which makes our analysis more convincing. Models 1–3 report the first-stage probit results from regressing *VC-Back* on instrumental variables *Underwriter Rank*, *Proceeds*, *Age*, *Sales per Share*, *Assets per Share*, *Equity per Share*, headquarters-state dummies and other control variables. Models 4–9 report the second-stage probit results from regressing *Overvalued Stock* on *VC-Back* obtained from the first-stage probit analysis and other control variables. The dependent variable *Overvalued Stock* in models 4–6 and 7–9 is defined respectively based on *Price-to-Sales Ratio* and *Valuation Error*.

The first-stage regression in models 1–3 has a high pseudo-R^2 of over 0.22, suggesting that the model fits the data well. Sargan's (1958) and Basmann's (1960) tests reject the null hypothesis that the equation is underidentified (i.e., the exclusion instruments are not valid at the 0.1% significance level). Cragg and Donald's (1993) test also strongly rejects the null hypothesis that the exclusion instruments are weak instruments (with an F-statistic greater than 50 and a p-value less than 0.01%). Also, the coefficients are quite similar across the three time periods, suggesting the equation is identified well. Our results indicate that the instrumental variables *Underwriter Rank*, *Age* and *Sales per Share* are strongly related to the likelihood of receiving VC funding. The unreported coefficients for the headquarters-state dummies indicate that VC financing is highly biased towards the states of California and Massachusetts. These findings are consistent with the literature (Barry *et al.*, 1990; Sahlman, 1990; Kaplan and Stromberg, 2003; Lee and Wahal, 2004; Nahata, 2008).

The second-stage regression results in models 4–9 suggest that a VC-backed firm is more likely to be overvalued during the bubble period, after controlling for endogeneity and other control factors. Specifically, the likelihood of overvaluation for a VC-backed firm is 6.66 percentages higher than for a non-VC-backed firm in the bubble period (with a *z-statistic* of 2.65) if a bubble stock is defined based on *Price-to-Sales Ratio*; it is 5.65 percentages higher (with a *z-statistic* of 2.78) if a bubble stock is defined based on *Valuation Error*. By contrast, *VC-Back* is not significantly associated with *Overvalued Stock* in the pre- and post-bubble periods. These findings support Hypothesis 1.

The signs of the estimated coefficients of the control variables are generally consistent with our expectations. For example, in models 4–6 when *Overvalued Stock* is defined by *Price-to-Sales Ratio*, *Tobin-Q* is positively related to the likelihood of overvaluation, suggesting that a firm in a fast-growing industry is more likely to be overvalued. The coefficients of *Years Since IPO* are in general negative, indicating that a newly public firm is more likely to be overvalued, probably due to high expectations and large asymmetric information between outsiders and insiders. The coefficients of *Leverage* are negative suggesting that a firm with more debt is less likely to be overvalued probably due to much limitation from debt covenants. *EBIT* is negatively related to *Overvalued Stock*, indicating that operational performance helps to reduce the likelihood of overvaluation. Also, the coefficients of *StdROA*, *Capital Expenditure*, *Growth* and *Size* are positive, suggesting that the more volatile the ROA, the better growth opportunities, and that the higher the growth rate, the larger the firm size, and so the more likely the firm will be overvalued. Further, the coefficients of *Big4* and *EBIT_1* are overall insignificant. Models 7–9 give findings that are generally consistent with those in models 4–6.

4.2. Subsample Analysis for Recently Public Firms and Seasoned Public Firms

Next, we turn to Hypothesis 2, that is, whether the association between VC backing and the likelihood of overvaluation differs between recently and seasoned public firms. We decompose our sample into two subsamples based on *Years Since IPO*, with one containing recently public firms and the other containing seasoned public firms. The dividing point is the median of *Years Since IPO*, i.e., 1.792. Specifically, for each year, those firms with *Years Since IPO* less than or equal to the median go to the recently public subsample, while those firms with *Years Since IPO* greater than the median go to the seasoned public subsample. With this division, the recently public subsample consists of 7,752 firm-year observations (3,856 VC-backed and 3,896 non-VC-backed), and the seasoned public subsample consists of 6,612 firm-year observations (2,616 VC-backed and 3,996 non-VC-backed). We apply the two-stage probit model to both subsamples. There is no need to include the variable *Years Since IPO* since the sample partition is based on the variable. To save space, we only report

the second-stage probit results from regressing *Overvalued Stock* on the estimated *VC-Back* derived from the first-stage regression and other control variables in Table 5. Panels A and B present the results with the dependent variable *Overvalued Stock* being defined by *Price-to-Sales Ratio* and *Valuation Error*, respectively.

[Insert Table 5 here]

As suggested by Panel A of Table 5, for recently public firms, the coefficients of *VC-Back* are significantly positive in both the bubble and post-bubble periods when *Overvalued Stock* is defined by *Price-to-Sales Ratio*, and the coefficient of *VC-Back* in the bubble period is much larger and more significant than that in the post-bubble period. Panel B indicates that, for recently public firms, the coefficients of *VC-Back* are only significantly positive in the bubble period when *Overvalued Stock* is defined by *Valuation Error*. While for seasoned public firms, both Panels A and B show that the coefficients of *VC-Back* are completely insignificant in all three periods with either definition of *Overvalued Stock*, that is, the likelihood of overvaluation is statistically the same between VC-backed and non-VC-backed firms, after controlling for endogeneity and other factors. In general, the difference in the likelihood of overvaluation between VC-backed and non-VC-backed firms is mainly concentrated in the recently public subsample and in the bubble period. By contrast, the likelihood of overvaluation for a VC-backed firm that is recently public is 14.32 percentages higher than that for a non-VC-backed firm that is also recently public in the bubble period (with a *z-statistic* of 3.92) if a bubble stock is defined by *Price-to-Sales Ratio*; it is 11.63 percentages higher (with a *z-statistic* of 4.06) if a bubble stock is defined by *Valuation Error*. These findings are highly consistent with Hypothesis 2.

4.3. Analysis on VCs' Ownership and Control

In Table 6, we provide evidence on the association between VCs' ownership (control) and the likelihood of overvaluation in the subsample of VC-backed recently public firms. Panels A-B and C-D present the results with the dependent variable *Overvalued Stock* defined by *Price-to-Sales Ratio* and *Valuation Error*, respectively. To save space, the coefficients of control variables are not reported.

[Insert Table 6 here]

We find a significantly positive relationship between *Overvalued Stock* and VCs' ownership and control as proxied by *Ownership*, *Block Owner*, *Chairman* and *Board Ratio* in the bubble period. This relationship generally disappears in the pre- and post-bubble periods. On the marginal effects, for a VC-backed recently public firm, a one standard deviation increase in *Ownership* (about 17.46 percentages) at the mean level increases the likelihood of overvaluation by 4.90 percentages (with a *z-statistic* of 2.03) when *Overvalued Stock* is defined by *Price-to-Sales Ratio*, and by 5.40 percentages (with a *z-statistic* of 2.08)

when *Overvalued Stock* is defined by *Valuation Error* in the bubble period. And, a one standard deviation increase in *Block Owner* (about 1.69) at the mean level increases the likelihood of overvaluation by 4.22 percentages (with a *z-statistic* of 1.69) when *Overvalued Stock* is defined by *Price-to-Sales Ratio,* and by 6.71 percentages (with a *z-statistic* of 2.85) when *Overvalued Stock* is defined by *Valuation Error* in the bubble period. If the board chairman position is held by a VC, the likelihood of overvaluation for a VC-backed recently public firm is increased by 13.63 percentages (with a *z-statistic* of 2.12) when *Overvalued Stock* is defined by *Price-to-Sales Ratio,* and by 10.66 percentages (with a *z-statistic* of 3.76) when *Overvalued Stock* is defined by *Valuation Error* in the bubble period. A one standard deviation increase in *Board Ratio* (about 18.99 percentages) at the mean level increases the likelihood of overvaluation for a VC-backed recently public firm by 3.50 percentages (with a *z-statistic* of 2.38) when *Overvalued Stock* is defined by *Price-to-Sales Ratio,* and by 4.06 percentages (with a *z-statistic* of 1.75) when *Overvalued Stock* is defined by *Valuation Error* in the bubble period. These findings support the prediction that VCs' opportunistic behavior during the boom environment is more prominent for VCs with high ownership and control over the firms they back.

Our empirical analysis provides interesting findings. VC-backed firms are more likely to be overvalued during the bubble period, and such association only occurs in recently public firms. Further, those firms with VCs containing higher ownership and control are more likely to be overvalued during the bubble period. All these findings are consistent with our Hypotheses 1-3, suggesting VC opportunism during a boom period.

5. Robustness Checks

In this section, we conduct many robustness tests to ensure reliability of our results. For brevity, we haven't reported the results, which are available upon request.

5.1. Alternative Measures of Overvaluation

To show that our findings are robust, we consider several alternative measures of overvaluation. First, we try two alternative traditional measures of overvaluation: *Market-to-Book Ratio* and *Price-to-Earnings Ratio.* The definition method is the same as that used in Tables 4–6, that is, for each year, we rank all the stocks on the basis of *Market-to-Book Ratio* or *Price-to-Earnings Ratio,* and call the stocks in the top quartile the overvalued stocks. We find similar results as those in Table 4. VC backing is positively associated with the likelihood of being overvalued stocks in the bubble period after controlling for endogeneity and other factors. On the marginal effects, the likelihood of overvaluation for a VC-backed firm is 6.14 percentages higher than that for a non-VC-backed

firm in the bubble period (with a *z-statistic* of 2.69) if *Overvalued Stock* is defined by *Market-to-Book ratio*; it is 0.97 percentages higher (with a *z-statistic* of 1.83) if *Overvalued Stock* is defined by *Price-to-Earnings Ratio*. By contrast, *VC-Back* has no statistically significant association with *Overvalued Stock* in the pre-bubble and post-bubble periods.

Second, considering the possible loss of information by converting continuous variables to binary variables, we run OLS regressions on overvaluation directly using the raw values of *Valuation Error* and *Market-to-Book Ratio*,[9] instead of nonlinear probit regressions on *Overvalued Stock* using the second-stage regression model. Consistent with the earlier regression results, we find a positive and significant coefficient of *VC-Back* in the bubble period after controlling for endogeneity and other factors; this coefficient is insignificant in the pre- and post-bubble periods. Specifically, *Valuation Error* and *Market-to-Book Ratio* of a VC-backed firm are respectively 0.09 (with a *t*-statistic of 2.49) and 0.40 (with a *t*-statistic of 3.04) greater than those of a non-VC-backed firm.

5.2. Alternative Explanations

To ensure reliability, we further consider some other possible explanations.

Experience of Mutual Fund Managers

As shown by Greenwood and Nagel (2009), inexperienced mutual fund managers are more likely to ride a bubble. Using age as a proxy for a manager's experience, they find that young mutual fund managers are more likely to choose overvalued stocks in their investment portfolios than their older colleagues in the bubble period. Therefore, inexperienced investors play a role in the formation of asset price bubbles. To rule out the effect of mutual fund managers' experience on the likelihood of overvaluation during the bubble period, we further control for the net percentage change in shares held by experienced mutual fund managers (*Mutual*) for each firm i in year t, where *Mutual* is measured by the percentage change of shares in mutual funds held by older portfolio managers minus the percentage change of shares in mutual funds held by young portfolio managers. Data for share trading changes in mutual funds is obtained from the CDA Spectrum database. The number of years since a portfolio manager's first appearance in this database is used as a proxy for the investment experience of the manager, which is similar to the measure used in Greenwood and Nagel (2009). After merging the CDA Spectrum database with our sample, we have 8,905 firm-year observations of *Mutual* with a mean of -0.46, a median of -0.12 and a standard deviation of 5.31. The univariate analysis suggests a negative association between *Mutual* and *Overvalued Stock*, which is consistent with Greenwood and Nagel's (2009) findings.

After adding *Mutual* to our regression model, we find a strong negative effect of mutual fund managers' experience on the likelihood of overvaluation in the bubble period. On the marginal effects, with a one standard deviation increase in outstanding shares held by experienced mutual fund managers relative to inexperienced mutual fund managers in the bubble period (about 5.56), a firm will be 4.61 percentages (with a *z-statistic* of 3.48) and 3.04 percentages (with a *z-statistic* of 2.45) less likely to be a bubble stock if *Overvalued Stock* is defined by *Price-to-Sales Ratio* and *Valuation Error*, respectively. This effect does not exist in the pre- and post-bubble periods. This evidence is highly consistent with Greenwood and Nagel's (2009) prediction of a negative relationship between overvaluation and the experience of mutual fund managers in the bubble period. In our model, for either definition of *Overvalued Stock*, the coefficient of *VC-Back* remains significantly positive during the bubble period after controlling for mutual fund managers' experience. The regression results for other coefficients and their significance levels in each period are very similar to the earlier ones when *Mutual* was not included, except for a reduced sample size.

Institutional Buy-Side Herding

Griffin *et al.* (2011) examine trading behaviors of various investor groups at daily frequency and find evidence that institutional investors drive and burst the technology bubble. Sharma *et al.* (2006) and Puckett and Yan (2008) find further evidence that institutional herding, especially buy-side herding, has an impact on stock prices. Hence, we should investigate a possible relationship between overvaluation and institutional buy-side herding. We add a variable, named *Buy Herding*, into our regression model to represent institutional buy-side herding.[10] The trading data of institutions is again obtained from the CDA Spectrum database. For firm i, we measure *Buy Herding* in year t by the mean of the quarterly buy-side herding in year t. Specifically, let $B(i,q)$ be the number of institutional investors who are net buyers of stock i in quarter q, $S(i,q)$ be the number of institutional investors who are net sellers of stock i in quarter q, and N_{iq} be the number of traded shares of stock i by institutional investors in quarter q. Using the herding model in Lakonishok *et al.* (1992) and Sharma *et al.* (2006), we measure quarterly institutional herding by:

$$H(i,q) = \left| p(i,q) - p(q) \right| - AF(i,q), \tag{3}$$

where[11]

$$p(i,q) = \frac{B(i,q)}{B(i,q) + S(i,q)}, \quad p(q) = \frac{\sum_{i=1}^{i=N_{iq}} B(i,q)}{\sum_{i=1}^{i=N_{iq}} B(i,q) + \sum_{i=1}^{i=N_{iq}} S(i,q)}, \quad AF(i,q) = E\left\{ \left| p(i,q) - p(q) \right| \right\}.$$

Then, the buy-side herding of firm i in quarter q is defined as:

$$BH(i,q) = \begin{cases} H(i,q) & \text{if } p(i,q) > p(q), \\ 0 & \text{otherwise.} \end{cases} \quad (4)$$

Finally, the buy-side herding of firm i in year t (*Buy Herding*) is defined as the mean of $BH(i,q)$ in year t.

After merging the CDA Spectrum database with our sample, we have 10,671 firm-year observations for *Buy Herding* with a mean of 0.04, a median of 0.04 and a standard deviation of 0.08, which are similar to the calculations by Lakonishok *et al.* (1992) and Sharma *et al.* (2006), etc. The univariate tests suggest a consistent association between *Buy Herding* and overvaluation as in the literature. That is, there is a positive association between institutional buy-side herding and the likelihood of overvaluation.

The results of *Buy Herding* are quite consistent with our expectations. As expected, when *Overvalued Stock* is defined by *Price-to-Sales Ratio,* institutional buy-side herding is found to be positively related to the likelihood of overvaluation. The coefficient of *Buy Herding* is significant in the bubble period and insignificant in the pre- and post-bubble periods. A one standard deviation increase in *Buy Herding* during the bubble period (about 0.08) raises the likelihood of overvaluation by 8.45 percentages (with a *z-statistic* of 4.99). When *Overvalued Stock* is defined by *Valuation Error,* we find significantly positive coefficients of *Buy Herding* in all three periods, while the coefficient of *Buy Herding* is larger and more significant during the bubble period than during the pre- and post-bubble periods. Specifically, a one standard deviation increase in *Buy Herding* during the pre-bubble, bubble and post-bubble periods (about 0.08, 0.08 and 0.07) raises the likelihood of overvaluation by 4.12 percentages (with a *z-statistic* of 2.86), 10.34 percentages (with a *z-statistic* of 6.85) and 5.26 percentages (with a *z-statistic* of 4.80), respectively. Further, our regressions continue to show that even after controlling for mutual fund managers' experience and institutional buy-side herding, the coefficient of *VC-Back* is significantly positive in the bubble period, and generally insignificant in the pre- and post-bubble periods. In other words, the positive association between VC backing and overvaluation is not due to mutual fund managers' experience or institutional buy-side herding.

6. Conclusion

This paper focuses on the association between VC backing and overvaluation in and around the high-tech bubble period. We make use of 14,364 firm-year observations of firms listed on NASDAQ, including firms with or without VC support. We consider three periods: the normal period of 1994–1997, the bubble period of 1998–2000, and the post-bubble period of 2001–2004. After controlling for endogeneity and other market- and firm-level

characteristics, the main findings are as follows. First, a VC-backed firm is significantly more likely to become an overvalued stock in the bubble period. Second, the association between VC backing and overvaluation is limited to recently public firms (in terms of time since IPO). Third, VCs' ownership and control over the recently public firms they back have a positive relationship with the likelihood of overvaluation in the bubble period.

Our findings enrich the understanding of VC opportunism during a boom environment and provide more evidence on the behavior of financial institutions over the business cycle. We pose two questions for future research. Can strategic interactions between VCs and entrepreneurs affect overvaluation? And, have VCs learned from this bubble experience and changed certain behaviors?

References

1. Abreu, D. and M. Brunnermeier, 2003. Bubbles and crashes. *Econometrica* 71(1), 173–204.
2. Admati, A. and P. Pfleiderer, 1994. Robust financial contracting and the role of venture capitalists. *Journal of Finance* 49(2), 371–402.
3. Baker, M. and P. Gompers, 2003. The determinants of board structure at the initial public offering. *Journal of Law and Economics* 46(2), 569–598.
4. Barry, C., C. Muscarella, J. Peavy and M. Vetsuypens, 1990. The role of venture capital in the creation of public companies: evidence from the going-public process. *Journal of Financial Economics* 27(2), 447–471.
5. Basmann, R., 1960. On finite sample distributions of generalized classical linear identifiability test statistics. *Journal of the American Statistical Association* 55(292), 650–659.
6. Bergemann, D. and U. Hege, 1998. Venture capital financing, moral hazard, and learning. *Journal of Banking and Finance* 22(5), 703–735.
7. Bottazzi, L., M. Rin and T. Hellmann, 2008. Who are the active investors? Evidence from venture capital. *Journal of Financial Economics* 89(3), 488–512.
8. Bradley, D., B. Jordan and J. Ritter, 2008. Analyst behavior following IPOs: the "bubble period" evidence. *Review of Financial Studies* 21(1), 101-133.
9. Brunnermeier, M. and S. Nagel, 2004. Hedge funds and the technology bubble. *Journal of Finance* 59(5), 2013-2040.
10. Campbell, T. and M. Frye, 2009. Venture capitalist monitoring: evidence form governance structures. *Quarterly Review of Economics and Finance* 49(2), 265–282.
11. Campello, M. and J. Graham, 2007. Do stock prices influence corporate decisions? Evidence from the technology bubble. NBER Working Paper.

12. Casamatta, C., 2003. Financing and advising: optimal financial contracts with venture capitalists. *Journal of Finance* 58(52), 2059–2085.

13. Chi, J. and M. Gupta, 2009. Overvaluation and earnings management. *Journal of Banking and Finance* 33(9), 1652–1663.

14. Cochrane, J., 2005. The risk and return of venture capital. *Journal of Financial Economics* 75(1), 3–52.

15. Cragg, J. and S. Donald, 1993. Testing identifiability and specification in instrumental variables models. *Econometric Theory* 9(2), 222–240.

16. Cumming D., G. Fleming and A. Schwienbacher, 2005. Liquidity risk and venture capital finance. *Financial Management* 34(4), 77-105.

17. Cumming, D., 2006. The determinants of venture capital portfolio size: empirical evidence. *Journal of Business* 79(3), 1083-1126.

18. Cumming, D. and J. MacIntosh, 2001. Venture capital investment duration in Canada and the United States. *Journal of Multinational Financial Management* 11(4-5), 445-463.

19. Cumming, D. and J. MacIntosh, 2004. Boom, bust, and litigation in venture capital finance. *Willamette Law Review* 40(4), 867-906.

20. Dass, N., M. Massa and R. Patgiri, 2008. Mutual funds and bubbles: the surprising role of contractual incentives. *Review of Financial Studies* 21(1), 51–99.

21. Dessi, R., 2005. Start-up finance, monitoring and collusion. *RAND Journal of Economics* 36(2), 255-274.

22. Elliott, W., J. Koëter-Kant and R. Warr, 2008. Market timing and the debt-equity choice. *Journal of Financial Intermediation* 17(2), 175–197.

23. Flood, R. and R. Garber, 1994. Speculative bubbles, speculative attacks, and policy switching. The MIT Press. Cambridge, MA.

24. Gompers, P., 1996. Grandstanding in the venture capital industry. *Journal of Financial Economics* 42(1), 133-156.

25. Gompers, P., A. Kovner, J. Lerner and D. Scharfstein, 2008. Venture capital investment cycles: the impact of public markets. *Journal of Financial Economics* 87(1), 1-23.

26. Gompers, P. and J. Lerner, 1998. Venture capital distributions: short-run and long-run reactions. *Journal of Finance* 53(6), 2161–2183.

27. Gompers, P. and J. Lerner, 2000. Money chasing deals? The impact of fund inflows on private equity valuations. *Journal of Financial Economics* 55(2), 281-325.

28. Gompers, P. and J. Lerner, 2002. Short-term America revisited? Boom and bust in the venture capital industry and the impact on innovation? In *Innovation Policy and the Economy*. Vol. 3, edited by Adam B. Jaffe, Josh Lerner and Scott Stern. MIT Press. London.

29. Gompers, P. and J. Lerner, 2004. The venture capital cycle. The MIT Press. London.

30. Gonzalez, L. and C. James, 2007. Banks and bubbles: how good are bankers at spotting winners? *Journal of Financial Economics* 86(1), 40–70.

31. Greenwood, R. and S. Nagel, 2009. Inexperienced investors and bubbles. *Journal of Financial Economics* 93(2), 239-258.

32. Griffin, J., J. Harris and S. Topaloglu, 2011. Who drove and burst the tech bubble? *Journal of Finance*, Forthcoming.

33. Hellmann, T., 1998. The allocation of control rights in venture capital contracts. *Rand Journal of Economics* 29(1), 57–76.

34. Hellmann, T. and M. Puri, 2000. The interaction between product market and financing strategy: The role of venture capital. *Review of Financial Studies* 13(4), 959-984.

35. Hellmann, T. and M. Puri, 2002. Venture capital and the professionalization of start-up firms: empirical evidence. *Journal of Finance* 57(1), 169-197.

36. Hertzel, M. and Z. Li, 2010. Behavioral and rational explanations of stock price performance around SEOs: evidence from a decomposition of market-to-book ratios. *Journal of Financial and Quantitative Analysis* 45(4), 935-958.

37. Hoberg, G. and G. Phillips, 2010. Real and financial industry booms and busts. *Journal of Finance* 65(1), 45–86.

38. Hoberg. G. and N. Seyhun, 2009. Do underwriters collaborate with venture capitalists in IPOs? Implications and evidence. Working Paper, University of Maryland.

39. Hochberg, Y., A. Ljungqvist and Y. Lu, 2007. Whom you know matters: venture capital networks and investment performance. *Journal of Finance* 62(1), 251–301.

40. Kanniainen, V. and C. Keuschnigg, 2003. The optimal portfolio of start-up firms in venture capital finance, *Journal of Corporate Finance* 9(5), 521–534.

41. Kaplan, S. and P. Stromberg, 2003. Financial contracting theory meets the real world: an empirical analysis of venture capital contracts. *Review of Economic Studies* 70(2), 281–315.

42. Kaplan, S. and A. Schoar, 2005. Private equity performance: returns, persistence and capital flows. *Journal of Finance* 60(4), 1791–1823.

43. Kortum, S. and J. Lerner, 2000. Assessing the contribution of venture capital to innovation. *Rand Journal of Economics* 31(4), 674–692.

44. Lakonishok, J., A. Shleifer and R. Vishny, 1992. The impact of institutional trading on stock prices. *Journal of Financial Economics* 32(1), 23–43.

45. Lee, P. and S. Wahal, 2004. Grandstanding, certification and the underpricing of venture capital backed IPOs. *Journal of Financial Economics* 73(2), 375–407.

46. Lerner, J., 1994. Venture capitalists and the decision to go public. *Journal of Financial Economics* 35(3), 293–316.

47. Ljungqvist, A. and M. Richardson, 2003. The cash flow, return and risk characteristics of private equity, Working Paper, New York University.

48. Loughran, T. and J. Ritter, 2004. Why has IPO underpricing changed over time? *Financial Management* 33(2), 5-37.

49. Morsfield S. and C. Tan, 2006. Do venture capitalists influence the decision to manage earnings in initial public offerings? *Accounting Review* 81(5), 1119-1150.

50. Nahata, R., 2008. Venture capital reputation and investment performance. *Journal of Financial Economics* 90(2), 127-151.

51. Neher, D., V. 1999. Staged financing: an agency prospective. *Review of Economic Studies* 66(2), 255–274.

52. Pagano, M., F. Panetta and L. Zingales, 1998. Why do companies go public? An empirical analysis. *Journal of Finance* 53(1), 27-64.

53. Peterson, M., 2009. Estimating standard errors in finance panel data sets: comparing approaches. *Review of Financial Studies* 22(1), 435–480.

54. Puchett, A. and X. Yan, 2008. Short-term institutional herding and its impact on stock prices. Working Paper, University of Tennessee.

55. Rhodes-Kropf, M., D. Robinson and S. Viswanathan, 2005. Valuation waves and merger activity: the empirical evidence. *Journal of Financial Economics* 77(3), 561–603.

56. Ritter, J. and I. Welch, 2002. A review of IPO activity, pricing, and allocations. *Journal of Finance* 57(4), 1795-1828.

57. Sahlman, W., 1990. The structure and governance of venture capital organizations. *Journal of Financial Economics* 27(2), 473–521.

58. Sargan, J., 1958. The estimation of economic relationships using instrumental variables. *Econometrica* 26(3), 393–415.

59. Sharma, V., J. Easterwood and R. Kumar, 2006, Institutional herding and internet bubble. Working Paper, University of Michigan-Dearborn.

60. Wang, S. and H. Zhou, 2004. Staged financing in venture capital: moral hazard and risks. *Journal of Corporate Finance* 10(1), 131–155.

61. White, H., 1980. A heteroskedasticity-consistent covariance matrix estimator and a direct test for heteroskedasticity. *Econometrica* 48(4), 817–838.

Tables

Table 1. Sample Distribution

This table presents sample distributions by year and by industry in Panels A and B, respectively. The sample consists of 14,364 firm-year observations from COMPUSTAT, SDC global new issues, Jay Ritter's website and SDC VentureXpert for the period 1994–2004. Percentages and numbers of observations are reported for the whole sample, the VC-backed sample and non-VC-backed sample. The industry classification is based on the 3-digit SIC code. The time period is divided into three periods: the pre-bubble period of 1994–1997, the bubble period of 1998–2000, and the post-bubble period of 2001–2004.

Panel A. The Sample Distribution by Year

Year		Whole		VC-backed		Non-VC-backed	
		Obs.	%	Obs.	%	Obs.	%
Pre-bubble period	1994	984	6.850	433	6.690	551	6.982
	1995	1060	7.380	456	7.046	604	7.653
	1996	1196	8.326	522	8.066	674	8.540
	1997	1463	10.185	640	9.889	823	10.428
Subtotal		4703	32.742	2051	31.690	2652	33.604
Bubble period	1998	1458	10.150	634	9.796	824	10.441
	1999	1348	9.385	577	8.915	771	9.769
	2000	1519	10.575	703	10.862	816	10.340
Subtotal		4325	30.110	1914	29.574	2411	30.550
Post-bubble period	2001	1452	10.109	684	10.569	768	9.731
	2002	1426	9.928	671	10.368	755	9.567
	2003	1369	9.531	643	9.935	726	9.199
	2004	1089	7.581	509	7.865	580	7.349
Subtotal		5336	37.148	2507	38.736	2829	35.846
Total		14364	100	6472	100	7892	100

Panel B. The Sample Distribution by Industry

3-digit SIC code	Industry	Whole		VC-backed		Non-VC-backed	
		Obs.	%	Obs.	%	Obs.	%
737	Computer and Data Processing Services	2777	19.333	1622	25.062	1155	14.635
283	Drugs	1262	8.786	822	12.701	440	5.575
367	Electronic Components and Accessories	839	5.841	532	8.220	307	3.890
384	Medical Instruments and Supplies	775	5.395	460	7.108	315	3.991
357	Computer and Office Equipment	612	4.261	341	5.269	271	3.434
366	Communications Equipment	609	4.240	287	4.434	322	4.080
382	Measuring and Controlling Devices	557	3.878	306	4.728	251	3.180
581	Eating and Drinking Places	329	2.290	101	1.561	228	2.889
355	Special Industry Machinery	295	2.054	181	2.797	114	1.445
421	Trucking and Courier Services (Except Air)	228	1.587	47	0.726	181	2.293
504	Professional and Commercial Equipment	201	1.399	44	0.680	157	1.989
481	Telephone Communications	179	1.246	99	1.530	80	1.014
596	Non-store Retailers	173	1.204	72	1.112	101	1.280
738	Miscellaneous Business Services	169	1.177	74	1.143	95	1.204
873	Research, Development, and Testing Services	153	1.065	97	1.499	56	0.710
874	Management and Public Relations Services	131	0.912	48	0.742	83	1.052
369	Miscellaneous Electrical Equipment and Supplies	116	0.808	25	0.386	91	1.153
394	Toys and Sporting Goods	108	0.752	11	0.170	97	1.229
371	Motor Vehicles and Equipment	106	0.738	18	0.278	88	1.115
495	Sanitary Services	104	0.724	52	0.803	52	0.659
Other		4436	30.883	1233	19.051	3408	43.183
Total		14364	100	6472	100	7892	100

Table 2. Variable Definition

This table lists the definitions, measures and data sources of all the variables.

Variable	Definition and Measure	Data Source
Dependent Variable:		
Overvalued Stock	A dummy variable indicating whether or not a firm's stock value belongs to the top quartile of *Price-to-Sales Ratio* or *Valuation Error* in a year.	COMPUSTAT
Independent Variable:		
VC-Back	A dummy variable that equals 1 if a firm is financed by VCs before its IPO.	SDC VentureXpert
Ownership	The ratio of VCs' stock ownership as a group just after the IPO.	SEC EDGER
Block Owner	The number of VCs who are block stock owners after IPOs, as measured by the number of VCs who hold over 5% of stocks just after IPO.	SEC EDGER
Chairman	Whether the VC holds the chairman position in the board of directors just after the IPO.	SEC EDGER
Board Ratio	The ratio of VCs' participation in the board of directors, as measured by the ratio of the number of VC seats to board size just after the IPO.	SEC EDGER
Control Variables:		
Tobin-Q	Industry median of Tobin-Q (COMPUSTAT: (PRCC_F*CSHO+PSTKRV+DLTT+DLC)/AT) based on the 3-digit SIC code.	COMPUSTAT
Years Since IPO	The logarithm of the number of years since the IPO.	SDC global new issues; Jay Ritter's website
Leverage	The ratio of short-term and long-term debt to total assets (COMPUSTAT: (DLTT+DLC)/AT).	COMPUSTAT
EBIT	The ratio of EBIT to sales (COMPUSTAT: EBIT/SALE).	COMPUSTAT
EBIT_1	The ratio of EBIT to sales (COMPUSTAT: EBIT/SALE) in the previous year.	COMPUSTAT
StdROA	The historical standard deviation of ROA (COMPUSTAT: IB/AT) in the past five years. For those firms with less than five years' worth of ROA information in COMPUSTATA, we use as much as possible the historical ROA in the past five years to calculate the standard deviation.	COMPUSTAT
Capital Expenditure	The ratio of capital expenditure to sales (COMPUSTAT: CAPX/SALE).	COMPUSTAT
Growth	The sales (COMPUSTAT: SALE) growth in the previous year.	COMPUSTAT
Size	Firm size (COMPUSTAT: ln(1+AT)).	COMPUSTAT
Big4	A dummy variable, which is equal to 1 if the firm is audited by one of the big four auditors and 0 otherwise.	COMPUSTAT
Variables Used in the First-Stage Regression		
Underwriter Rank	The rank of the book underwriter in IPOs, as defined by the Carter-Manaster ranking	SDC global new issues; Jay Ritter's website
Proceeds	The natural logarithm of IPO proceeds.	SDC global new issues

Age	The firm's age at its IPO, as measured by the logarithm of the number of years since founding.	SDC global new issues; Jay Ritter's website
Sales per Share	The sales per share (COMPUSTAT: SALE/CSHO) in the year prior to the IPO scaled by the offering price.	COMPUSTAT
Assets per Share	The total assets per share (COMPUSTAT: AT/CSHO) in the year prior to the IPO scaled by offering price.	COMPUSTAT
Equity per Share	The book value of equity per share (COMPUSTAT: CEQ/CSHO) in the year prior to the IPO scaled by the offering price.	COMPUSTAT
Misc.		
Price-to-Sales Ratio	The ratio of price to sales (COMPUSTAT: PRCC_F*CSHO/SALE).	COMPUSTAT
Valuation Error	The residual of the model in Rhodes-Kropf *et al.* (2005), which regresses market value on financial leverage (COMPUSTAT: 1-CEQ/AT), book value of assets (COMPUSTAT: AT) and net income (COMPUSTAT: NI) for the twelve Fama-French sectors of the economy. *Valuation Error* equals *Firm-Specific Valuation Error* plus *Industry-Specific Valuation Error*.	COMPUSTAT
Firm-Specific Valuation Error	The difference between market valuation and the valuation implied by contemporaneous industry-level valuation multiples, as measured by the $m_{it} - v(q_{it};a_{jt})$ component in Rhodes-Kropf *et al.*'s (2005) model.	COMPUSTAT
Industry-Specific Valuation Error	The difference between the valuation implied by contemporaneous industry-level valuation multiples and the valuation implied by long-run industry-level valuation multiples, as measured by the $v(q_{it};a_{jt}) - v(q_{it};a_j)$ component in Rhodes-Kropf *et al.*'s (2005) model.	COMPUSTAT
Recently Public Sample	The subsample covers observations with *Years Since IPO* less than the median in a year.	COMPUSTAT
Seasoned Public Sample	The subsample covers observations with *Years Since IPO* greater than the median in a year.	COMPUSTAT
Market-to-Book Ratio	The ratio of market value to the book value of assets (COMPUSTAT: (PRCC_F*CSHO+AT-CEQ-TXDB)/AT).	COMPUSTAT
Price-to-Earnings Ratio	The ratio of price to earnings per share (COMPUSTAT: PRCC_F/EPSPX).	COMPUSTAT
Mutual	Net percentage change of shares held by experienced mutual fund managers, as measured by the percentage change of shares held by older mutual fund managers minus the percentage change of shares held by young mutual fund managers.	CDA Spectrum
Buy Herding	Buy-side institutional herding, as defined in Lakonishok *et al.* (1992).	CDA Spectrum

Table 3. Summary Statistics and Univariate Analysis

This table presents summary statistics of the dependent, independent and control variables, as well as other variables used in estimating VC backing (the first-stage regression), in measuring overvaluation and in robustness tests. The definitions and data sources for these variables are described in Table 2. The means, quartiles, standard deviations, minimums and maximums are presented. *Overvalued Stock* is defined by *Price-to-Sales Ratio* and *Valuation Error* in rows (1) and (2), respectively. The results of *t*-tests for equality of the means and the Wilcoxon tests for equality of the medians between overvalued and non-overvalued samples are also reported, where the overvalued stocks are defined by *Price-to-Sales Ratio*. The significance levels at the 1%, 5% and 10% are identified by ***, ** and *, respectively.

Variable	Obs	Mean	0.25	Median	0.75	Std. Dev	Min	Max	Overvalued		Non Overvalued	
									Mean	Median	Mean	Median
Overvalued Stock	14,364	0.250	0	0	1	0.433	0	1				
Overvalued Stock	14,364	0.250	0	0	1	0.433	0	1				
VC-Back	14,364	0.451	0	0	1	0.498	0	1	0.598***	1***	0.401	0
Ownership	2,464	0.282	0.152	0.258	0.404	0.180	0	0.717	0.291**	0.283**	0.277	0.249
Block Owner	2,464	2.551	1	2	4	1.700	0	8	2.834***	2.5***	2.393	2
Chairman	2,464	0.135	0	0	0	0.341	0	1	0.198***	0***	0.100	0
Board Ratio	2,464	0.310	0.167	0.286	0.429	0.187	0	0.750	0.318**	0.333**	0.305	0.286
Tobin-Q	14,364	1.669	1.120	1.514	2.045	0.737	0.677	3.949	2.140***	2.009***	1.511	1.389
Years Since IPO	14,364	1.771	1.099	1.792	2.398	0.754	0	3.178	1.629***	1.609***	1.818	1.946
Leverage	14,364	0.152	0.000	0.061	0.251	0.195	0	0.876	0.097***	0.011***	0.170	0.096
EBIT	14,364	-0.527	-0.108	0.042	0.109	2.426	-18.900	0.370	-1.847***	-0.027***	-0.086	0.045
EBIT_1	14,364	-0.643	-0.122	0.043	0.111	2.914	-22.642	0.368	-2.098***	-0.075***	-0.157	0.048
StdROA	14,364	0.164	0.032	0.075	0.180	0.261	0.004	1.706	0.234***	0.120***	0.141	0.065
Capital Expenditure	14,364	0.119	0.022	0.045	0.097	0.272	0.002	2.094	0.246***	0.085***	0.077	0.037
Growth	14,364	0.344	0.001	0.156	0.390	0.843	-0.690	5.793	0.649***	0.323***	0.243	0.122
Size	14,364	4.715	3.812	4.635	5.538	1.311	1.817	8.294	4.889***	4.770***	4.657	4.600
Big4	14,364	0.779	1	1	1	0.415	0	1	0.840***	1***	0.759	1
Underwriter Rank	14,364	6.769	5.500	8.001	8.875	2.471	1.001	9.001	7.246***	8.001***	6.609	8.000
Proceeds	14,364	3.123	2.518	3.219	3.728	0.900	1.065	5.252	3.253***	3.353***	3.080	3.176
Age	14,364	2.206	1.609	2.197	2.708	0.874	0	4.489	1.958***	1.946***	2.289	2.303
Sales per Share	14,364	0.812	0.183	0.491	1.012	1.005	0.003	5.894	0.302***	0.148***	0.983	0.643
Assets per Share	14,364	7.655	0.753	2.269	6.632	16.572	0.006	107.745	1.792***	0.619***	9.611	3.125
Equity per Share	14,364	0.393	0.232	0.363	0.509	0.224	-0.025	1.201	0.331***	0.292***	0.414	0.394
Price-to-Sales Ratio	14,364	7.552	0.611	1.650	4.667	22.291	0.036	176.586	25.929***	10.482***	1.419	1.034
Valuation Error	14,364	0.014	-0.420	-0.061	0.399	0.637	-1.412	1.869	0.579***	0.567***	-0.174	-0.207

Table 4. Analysis With and Without Controlling for Endogeneity

Panel A reports regression results without controlling for the endogeneity of VC backing. Panel B reports regression results using a two-stage regression model to control for endogeneity, where the first-stage regression is a probit regression that estimates the likelihood of receiving VC backing before IPO with *VC-Back* as the dependent variable, and the second-stage regression is also a probit regression that estimates the likelihood of overvaluation using *VC-Back* estimated from the first stage as the explanatory variable. The instrumental variables used in the first-stage regression include *Underwriter Rank, Proceeds, Age, Sales per Share, Assets per Share, Equity per Share* and the Headquarters-State dummies. The dependent variable in Panel A and in the second stage of Panel B is *Overvalued Stock*, which is defined by *Price-to-Sales Ratio* or *Valuation Error*. The control variables include *Tobin-Q, Years Since IPO, Leverage, EBIT, EBIT_1, StdROA, Capital Expenditure, Growth, Size* and *Big4*. The definitions and data sources for these variables are described in Table 2. The industry fixed effects as defined by the 3-digit SIC code and the year fixed effects are included, but their coefficients are not reported. The *z-statistic*s based on the standard error adjusted for heteroskedasticity (White 1980) and clustering at the firm level (Petersen 2009) are printed in parentheses. The significance levels at 1%, 5% and 10% are identified by ***, ** and *, respectively.

Panel A. Probit Analysis without Controlling for Endogeneity

Variable	*Price-to-Sales Ratio*			*Valuation Error*		
	1	2	3	4	5	6
	Pre-bubble	Bubble	Post-bubble	Pre-bubble	Bubble	Post-bubble
VC-Back	0.129	0.170**	0.007	0.156***	0.162***	0.070
	(1.61)	(2.46)	(0.09)	(2.62)	(2.64)	(1.15)
Tobin-Q	0.354***	0.326***	0.493***	0.488***	0.438***	0.518***
	(2.69)	(6.78)	(4.97)	(3.71)	(8.91)	(5.83)
Years Since IPO	-0.084	-0.165***	-0.026	-0.113***	-0.129***	0.030
	(-1.59)	(-3.44)	(-0.47)	(-2.73)	(-3.30)	(0.66)
Leverage	-2.262***	-1.555***	-1.590***	-0.947***	-0.739***	-0.390**
	(-8.80)	(-6.49)	(-7.50)	(-4.95)	(-4.02)	(-2.39)
EBIT	-0.151***	-0.159***	-0.207***	-0.063***	-0.020	-0.030*
	(-3.05)	(-5.10)	(-4.83)	(-3.11)	(-1.17)	(-1.88)
EBIT_1	0.068***	0.023	0.029	0.089***	0.010	0.057***
	(3.17)	(1.38)	(1.30)	(6.09)	(0.81)	(3.52)
StdROA	0.406**	0.290**	0.239**	0.294**	0.308***	0.374***
	(2.25)	(2.07)	(2.29)	(2.16)	(2.61)	(4.57)
Capital Expenditure	1.023***	0.362**	1.087***	0.057	-0.183	0.007
	(5.51)	(2.23)	(3.73)	(0.46)	(-1.44)	(0.06)
Growth	0.322***	0.137***	0.247***	0.361***	0.119***	0.365***
	(6.00)	(4.00)	(4.21)	(7.87)	(3.99)	(7.60)
Size	0.276***	0.327***	0.244***	0.103***	0.172***	0.078***
	(6.88)	(9.86)	(8.24)	(3.32)	(6.43)	(3.31)
Big4	0.058	0.084	0.109	-0.007	0.035	0.213***
	(0.62)	(1.04)	(1.11)	(-0.10)	(0.54)	(2.84)
Constant	-2.493***	-2.675***	-1.956***	-1.420***	-0.436***	-1.903***
	(-4.21)	(-6.78)	(-6.51)	(-5.06)	(-2.75)	(-7.27)
Industry and Year	Yes	Yes	Yes	Yes	Yes	Yes
Clustering	Yes	Yes	Yes	Yes	Yes	Yes
Obs.	3,849	3,596	4,528	4,131	3,617	4,864
Pseudo-R^2	0.265	0.274	0.284	0.142	0.131	0.107

Panel B. Analysis after Controlling for Endogeneity using a Two-Stage Probit Model

Variable	First-Stage			Second-Stage					
	VC-Back			*Price-to-Sales Ratio*			*Valuation Error*		
	1	2	3	4	5	6	7	8	9
	Pre-bubble	Bubble	Post-bubble	Pre-bubble	Bubble	Post-bubble	Pre-bubble	Bubble	Post-bubble
Underwriter Rank	0.123***	0.151***	0.152***						
	(5.17)	(6.27)	(5.68)						
Proceeds	-0.058	-0.035	-0.069						
	(-0.63)	(-0.42)	(-0.77)						
Age	-0.118**	-0.145***	-0.144**						
	(-2.20)	(-2.85)	(-2.55)						
Sales per Share	-0.129	-0.170**	-0.191**						
	(-1.56)	(-2.08)	(-2.17)						
Assets per Share	0.008*	0.003	0.005						
	(1.78)	(0.82)	(1.27)						
Equity per Share	-0.222	-0.164	-0.143						
	(-0.94)	(-0.82)	(-0.65)						
VC-Back				0.021	0.214***	0.134	0.048	0.184***	0.097
				(0.23)	(2.65)	(1.51)	(0.64)	(2.78)	(1.38)
Tobin-Q	-0.040	-0.037**	0.054*	0.354***	0.334***	0.492***	0.489***	0.442***	0.518***
	(-0.60)	(-2.12)	(1.83)	(2.71)	(6.90)	(4.95)	(3.74)	(8.97)	(5.84)
Years Since IPO	-0.080	-0.143**	-0.160***	-0.088*	-0.152***	-0.002	-0.117***	-0.118***	0.039
	(-1.20)	(-2.26)	(-2.95)	(-1.66)	(-3.16)	(-0.04)	(-2.80)	(-3.01)	(0.85)
Leverage	-0.585**	-0.286	0.030	-2.291***	-1.530***	-1.573***	-0.971***	-0.721***	-0.383**
	(-2.47)	(-1.37)	(0.14)	(-8.77)	(-6.34)	(-7.40)	(-5.05)	(-3.91)	(-2.35)
EBIT	-0.009	0.001	0.021	-0.153***	-0.159***	-0.207***	-0.063***	-0.020	-0.030*
	(-0.47)	(0.08)	(1.39)	(-3.01)	(-5.01)	(-4.86)	(-3.08)	(-1.19)	(-1.88)
EBIT_1	0.016	-0.005	-0.019	0.069***	0.023	0.031	0.089***	0.010	0.057***
	(1.18)	(-0.37)	(-1.62)	(3.16)	(1.40)	(1.39)	(6.07)	(0.79)	(3.52)
StdROA	0.179	-0.028	-0.108	0.421**	0.281**	0.233**	0.298**	0.296**	0.373***
	(1.07)	(-0.20)	(-0.88)	(2.33)	(2.03)	(2.24)	(2.18)	(2.51)	(4.55)
Capital Expenditure	0.020	-0.002	0.048	1.015***	0.373**	1.078***	0.056	-0.183	0.005
	(0.14)	(-0.02)	(0.34)	(5.45)	(2.28)	(3.75)	(0.45)	(-1.42)	(0.04)
Growth	0.053	0.010	-0.059*	0.322***	0.139***	0.252***	0.360***	0.120***	0.366***

	(1.28)	(0.29)	(-1.69)	(5.97)	(4.06)	(4.31)	(7.84)	(4.00)	(7.62)
Size	0.116**	0.102**	0.075**	0.284***	0.315***	0.234***	0.109***	0.161***	0.074***
	(2.24)	(2.55)	(2.00)	(6.80)	(9.24)	(7.79)	(3.37)	(5.75)	(3.10)
Big4	0.203**	0.219***	0.302***	0.068	0.063	0.079	0.002	0.017	0.199***
	(2.19)	(2.61)	(3.53)	(0.72)	(0.77)	(0.79)	(0.02)	(0.26)	(2.58)
Constant	-0.032	-5.849***	-6.416***	-2.420***	-1.579***	-2.116***	-1.330***	-2.538***	-1.917***
	(-0.02)	(-5.27)	(-6.02)	(-4.08)	(-3.59)	(-6.67)	(-4.77)	(-2.77)	(-7.34)
Headquarters-State	Yes	Yes	Yes						
Industry and Year	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Clustering				Yes	Yes	Yes	Yes	Yes	Yes
Obs.	4,102	3,851	4,676	3,579	3,419	4,151	3,816	3,449	4,508
Pseudo-R^2	0.231	0.221	0.220	0.365	0.335	0.341	0.134	0.129	0.102

Table 5. Analysis on the Recently Public and Seasoned Public Subsamples

This table presents the second-stage probit regression results on the recently public and seasoned public subsamples. The dependent variable *Overvalued Stock* is defined by *Price-to-Sales Ratio* and *Valuation Error* in Panels A and B, respectively. The test variable is *VC-Back* estimated from the first-stage probit regression with *Underwriter Rank*, *Proceeds*, *Age*, *Sales per Share*, *Assets per Share*, *Equity per Share* and the Headquarters-State dummies as instrumental variables. The control variables include *Tobin-Q, Leverage, EBIT, EBIT_1, StdROA, Capital Expenditure, Growth, Size* and *Big4*. The definitions and data sources for the variables are described in Table 2. The industry fixed effects defined by the 3-digit SIC code and the year fixed effects are included in all the regressions, but their coefficients are not reported. The *z-statistic*s based on the standard error adjusted for heteroskedasticity (White 1980) and clustering at the firm level (Petersen 2009) are printed in parentheses. The significance levels at 1%, 5% and 10% are identified by ***, ** and *, respectively.

Panel A. The Second-Stage Probit Analysis on the Recently Public and Seasoned Public Subsamples with the Dependent Variable *Overvalued Stock* Defined By *Price-to-Sales Ratio*

Variable	*Recently Public*			*Seasoned Public*		
	1	2	3	4	5	6
	Pre-bubble	Bubble	Post-bubble	Pre-bubble	Bubble	Post-bubble
VC-Back	0.032	0.410***	0.206*	-0.042	0.078	0.037
	(0.29)	(3.92)	(1.70)	(-0.27)	(0.57)	(0.27)
Tobin-Q	0.348**	0.336***	0.458***	0.520*	0.261***	0.486***
	(2.05)	(5.41)	(3.19)	(1.91)	(2.75)	(2.94)
Leverage	-2.518***	-1.554***	-1.761***	-2.135***	-1.738***	-1.677***
	(-7.81)	(-5.03)	(-6.29)	(-4.87)	(-4.51)	(-4.90)
EBIT	-0.149***	-0.110***	-0.145***	-0.199	-0.345***	-0.666***
	(-2.69)	(-3.77)	(-4.46)	(-1.54)	(-4.19)	(-4.27)
EBIT_1	0.066***	0.024	0.020	0.071	0.078**	0.143**
	(2.93)	(1.40)	(1.00)	(1.35)	(2.25)	(2.20)
StdROA	0.508***	0.169	0.215*	0.152	0.812*	0.113
	(2.68)	(1.19)	(1.83)	(0.28)	(1.86)	(0.46)
Capital Expenditure	0.912***	0.390**	0.652***	1.904***	0.514	2.821***
	(5.24)	(2.22)	(2.59)	(2.93)	(1.16)	(4.08)
Growth	0.332***	0.146***	0.176***	0.320***	0.337***	0.557***
	(5.45)	(4.07)	(2.91)	(2.90)	(3.83)	(3.59)
Size	0.301***	0.311***	0.226***	0.305***	0.376***	0.295***
	(5.93)	(6.63)	(5.15)	(4.69)	(7.97)	(6.47)
Big4	0.072	0.077	-0.029	0.067	0.017	0.048
	(0.64)	(0.73)	(-0.23)	(0.43)	(0.12)	(0.29)
Constant	-1.636	-3.018***	-2.756***	-2.939***	-2.480***	-2.772***
	(-1.40)	(-6.50)	(-8.52)	(-3.99)	(-2.67)	(-4.83)
Industry and Year	Yes	Yes	Yes	Yes	Yes	Yes
Clustering	Yes	Yes	Yes	Yes	Yes	Yes
Obs.	1,968	1,816	2,198	1,343	1,336	1,659
Pseudo-R^2	0.380	0.321	0.294	0.332	0.345	0.426

Panel B. The Second-Stage Probit Analysis on the Recently Public and Seasoned Public Subsamples with the Dependent Variable *Overvalued Stock* Defined By *Valuation Error*

Variable	*Recently Public*			*Seasoned Public*		
	1	2	3	4	5	6
	Pre-bubble	Bubble	Post-bubble	Pre-bubble	Bubble	Post-bubble
VC-Back	0.101	0.346***	0.027	0.010	0.039	0.151
	(1.06)	(4.06)	(0.28)	(0.08)	(0.36)	(1.56)
Tobin-Q	0.534***	0.509***	0.511***	0.418*	0.255***	0.517***
	(3.08)	(8.01)	(3.92)	(1.68)	(2.80)	(3.93)
Leverage	-1.470***	-0.962***	-0.455**	-0.604**	-0.536**	-0.337
	(-5.35)	(-3.83)	(-2.02)	(-2.13)	(-1.96)	(-1.37)
EBIT	-0.053**	0.009	-0.012	-0.080*	-0.068**	-0.052*
	(-2.14)	(0.42)	(-0.67)	(-1.92)	(-2.23)	(-1.94)
EBIT_1	0.084***	0.008	0.057***	0.083***	0.028	0.045*
	(4.62)	(0.52)	(2.78)	(2.69)	(1.17)	(1.89)
StdROA	0.256*	0.201	0.193**	0.684**	0.840***	0.913***
	(1.70)	(1.54)	(2.00)	(1.97)	(2.84)	(4.76)
Capital Expenditure	0.077	-0.083	0.078	0.114	-0.286	-0.147
	(0.55)	(-0.53)	(0.61)	(0.42)	(-1.14)	(-0.68)
Growth	0.328***	0.123***	0.328***	0.462***	0.214***	0.431***
	(6.52)	(3.77)	(5.65)	(4.17)	(3.00)	(4.91)
Size	0.108***	0.162***	0.059*	0.136***	0.193***	0.119***
	(2.60)	(4.11)	(1.72)	(2.81)	(4.71)	(3.34)
Big4	-0.002	-0.092	0.075	0.022	0.178	0.247**
	(-0.03)	(-1.08)	(0.69)	(0.18)	(1.60)	(2.10)
Constant	-1.278	-1.969**	-1.113***	-1.705***	-0.465**	-1.072***
	(-1.19)	(-2.03)	(-4.21)	(-4.19)	(-2.45)	(-5.64)
Industry and Year	Yes	Yes	Yes	Yes	Yes	Yes
Clustering	Yes	Yes	Yes	Yes	Yes	Yes
Obs.	2,105	1,902	2,372	1,492	1,391	1,973
Pseudo-R^2	0.133	0.115	0.0818	0.144	0.134	0.138

Table 6. Analysis on VCs' Ownership and Control

This table reports the results of regressing *Overvalued Stock* on VCs' Ownership and control. The sample consists of VC-backed firms that have recently gone public. The dependent variable is *Overvalued Stock*, which is defined by *Price-to-Sales Ratio* (Panels A and C) or *Valuation Error* (Panels B and D). The test variables are *Ownership*, *Block Owner*, *Chairman* or *Board Ratio*. The control variables include *Tobin-Q, Years Since IPO, Leverage, EBIT, EBIT_1, StdROA, Capital Expenditure, Growth, Size,* and *Big4*. The definitions and data sources for the variables are described in Table 2. The industry fixed effects defined by the 3-digit SIC code and the year fixed effects are included in all the regressions. The coefficients of control variables, industry dummies and year dummies are not reported. The *z-statistic*s based on the standard error adjusted for heteroskedasticity (White 1980) and clustering at the firm level (Petersen 2009) are printed in parentheses. The significance levels at 1%, 5% and 10% are identified by ***, ** and *, respectively.

Panel A. Probit Analysis on VC's Ownership with the Dependent Variable *Overvalued Stock* Defined By *Price-to-Sales Ratio*

Variable	1	2	3	4	5	6
	Pre-bubble	Bubble	Post-bubble	Pre-bubble	Bubble	Post-bubble
Ownership	-1.642	0.951**	0.241			
	(-0.98)	(2.03)	(0.77)			
Block Owner				-0.080	0.065*	0.020
				(-0.92)	(1.69)	(0.60)
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Industry and Year	Yes	Yes	Yes	Yes	Yes	Yes
Clustering	Yes	Yes	Yes	Yes	Yes	Yes
Obs.	134	712	1,455	128	797	1,372
Pseudo-R^2	0.381	0.212	0.175	0.272	0.234	0.241

Panel B. Probit Analysis on VC's Ownership with the Dependent Variable *Overvalued Stock* Defined By *Valuation Error*

Variable	1	2	3	4	5	6
	Pre-bubble	Bubble	Post-bubble	Pre-bubble	Bubble	Post-bubble
Ownership	1.460	0.870**	-0.256			
	(1.21)	(2.08)	(-0.90)			
Block Owner				0.206	0.104***	-0.007
				(1.59)	(2.85)	(-0.26)
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Industry and Year	Yes	Yes	Yes	Yes	Yes	Yes
Clustering	Yes	Yes	Yes	Yes	Yes	Yes
Obs.	139	714	1,549	137	715	1,576
Pseudo-R^2	0.385	0.292	0.234	0.381	0.265	0.238

Panel C. Probit Analysis on VC's Control with the Dependent Variable *Overvalued Stock* Defined By *Price-to-Sales Ratio*

Variable	1	2	3	4	5	6
	Pre-bubble	Bubble	Post-bubble	Pre-bubble	Bubble	Post-bubble
Chairman	0.188	0.344**	0.159			

	(0.52)	(2.12)	(1.26)			
Board Ratio				1.080	0.464**	0.135
				(1.17)	(2.38)	(0.46)
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Industry and Year	Yes	Yes	Yes	Yes	Yes	Yes
Clustering	Yes	Yes	Yes	Yes	Yes	Yes
Obs.	130	689	1,348	126	669	1,377
Pseudo-R^2	0.265	0.211	0.272	0.275	0.233	0.240

Panel D. Probit Analysis on VC's Control with the Dependent Variable *Overvalued Stock* Defined By *Valuation Error*

Variable	1	2	3	4	5	6
	Pre-bubble	Bubble	Post-bubble	Pre-bubble	Bubble	Post-bubble
Chairman	0.512	0.269***	0.142**			
	(1.19)	(3.76)	(2.05)			
Board Ratio				-0.174	0.561*	-0.210
				(-0.18)	(1.75)	(-0.81)
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Industry and Year	Yes	Yes	Yes	Yes	Yes	Yes
Clustering	Yes	Yes	Yes	Yes	Yes	Yes
Obs.	135	714	1407	129	713	1581
Pseudo-R^2	0.177	0.156	0.160	0.338	0.258	0.239

[1] We have also tried other sample periods. For example, we selected the sample period of 1995-2003 and also tried the sample period excluding the bubble bursting year 2000. All the results are similar.

[2] As Rhodes-Kropf *et al.* (2005) indicate, if there exists a perfect measure of the firm's true value, V, then, the market-to-book value M/B can be written as: $M/B = (M/V) \cdot (V/B)$, which can be rewritten in the logarithmic form: $m - b = (m - v) + (v - b)$. The valuation error $(m - v)$ is the deviation of the firm's market value from its true value, which implies overvaluation if positive and undervaluation if negative. This term can be further divided into two parts: firm-specific misvaluation and industry-specific misvaluation, that is,

$$m_{it} - b_{it} = \underbrace{m_{it} - v(q; a_{it})}_{\text{firm-specific error}} + \underbrace{v(q; a_{it}) - v(q; a_{jt})}_{\text{industry-specific error}} + \underbrace{v(q; a_{jt}) - b_{it}}_{\text{long-run valuation}}.$$

To measure overvaluation using this model, we need to estimate the long-run valuation. Again, we follow Rhodes-Kropf *et al.* (2005) and estimate the long-run valuation as a function of the book value, absolute net income, negative net income indicator and financial leverage. A detailed description of the estimation is available upon request.

[3] Information on ownership structure and board distribution is only available for those firms going public after 1995 due to limitations in the SEC EDGAR database. This leads to nearly 50% of the observations being unavailable. Since we make use of the VC-backed recently public subsample in this section, this data limitation does not affect estimations for the bubble and post-bubble periods substantially, but it may greatly affect the estimations for the pre-bubble period. This is the reason why the numbers of observations in the pre-bubble period in Table 7 are all quite small.

[4] We have also tried an alternative market factor, *IPO Activity*, in place of *Tobin-Q*, and the results are very similar. *IPO Activity* is the number of IPOs within the range of the 3-digit SIC code. The connection between *IPO Activity* and market valuation has been investigated in the literature, including studies by Pagano *et al.* (1998), Ritter and Welch (2002) and Gompers *et al.* (2008).

[5] If we classify industries based on the 4-digit SIC code, all our findings remain qualitatively similar albeit with a less effective sample size but better model fit.

[6] Lee and Wahal (2004) investigate IPO underpricing and Morsfield and Tan (2006) focus on earnings management in IPOs. Both studies make use of the propensity score method in their univariate analyses and adopt a two-stage procedure similar to ours in the multivariate regression analyses. Lee and Wahal (2004) suggest that underwriter rank, net proceeds, firm age, total assets, book value of equity, sales and headquarter-state dummies are good predictors of VC backing. To avoid a look-ahead bias, they do not include underwriter rank and net proceeds as instruments in multivariate analyses, since most of the information of the variables are only known at the time of IPO. Further, adding firm age reduces their sample size substantially. For the same reason, Morsfield and Tan (2006) use only total assets, book value of equity, sales and headquarter-state dummies as instruments in the first-stage regression. Since our study analyzes overvaluation of public firms rather than IPOs only, we prefer to keep underwriter rank and net proceeds in addition to firm age, total assets, book value of equity, sales and headquarter-state dummies as instruments in the first-stage regression. If we only include total assets, book value of equity, sales and headquarter-state dummies as instruments, the Pseudo R-squared of the first-stage regression will be reduced to about 0.19, which is quite similar to those reported in Lee and Wahal (2004) and Morsfield and Tan (2006), and the results are also similar.

[7] All the regression results remain unchanged if we use a logit model.

[8] In Tables 3, we only report the univariate tests and correlations using *Price-to-Sales Ratio* to define overvalued stocks. But the results are quite similar if we define overvalued stocks using *Valuation Error*.

[9] However, *Price-to-Sales Ratio* has close relationships with many control variables, such as *EBIT*, *EBIT_1* and *Capital Expenditure*. And, *Price-to-Earnings Ratio* often shows a negative sign. Hence, it is inappropriate to use the raw values of *Price-to-Sales Ratio* and *Price-to-Earnings* for overvaluation.

[10] We do not consider sell-side herding due to its much lower frequency of occurrence than buy-side herding, as indicated by existing studies as well as our own calculations.

[11] Here, $p(i,q)$ is the fraction of active managers who buy stock i in quarter q, $p(q)$ is the total number of institutional investors who buy in quarter q relative to the total number of active institutional investors in quarter q aggregated across all stocks, and $|p(i,q) - p(q)|$ measures the excess buying or selling of stock i adjusted by the average stock bought or sold by institutional investors in quarter q. Accounting for the fact that under the null hypothesis of no herding the expected value of $|p(i,q) - p(q)|$ will be greater than zero, an adjustment factor $AF(i,q)$ is used. As the number of active traders increases in stock-quarter q, we expect that the fraction of traders who are buyers and sellers will tend to become equal in the absence of herding. Thus, in the absence of herding, $p(i,q)$ will approach $p(q)$, and $AF(i,q)$ will approach zero as the number of traders increases.