The Rise of Venture Capital and IPO Quality

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September 2, 2023

Abstract

We show that an increase in the supply of venture capital (VC) leads to a decline in the quality of firms going public. We argue that due to VC selectivity, private capital flows disproportionately to the most promising firms causing them to hold back from public issuance. Post-IPO abnormal returns indicate that the stock market does not fully incorporate this decline in quality at the time of the IPO. Our research adds to recent evidence on the negative impact of fast-growing private markets on Main Street investors.

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Abstract

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"*Investors and corporate boards stepped back from the IPO market, wary that the stock market would value their companies at less than prior fundraising rounds. And together with cheap funding that's widely available for private companies, it helps explain why many richly valued startups and others aren't rushing to go public. Indeed, some investors and underwriters say there's concern that the public markets are being used as a last resort."*
Wall Street Journal article[1]

1. Introduction

Private capital markets have grown significantly in recent years. According to the National Venture Capital Association, total U.S. venture capital (VC) deal value increased almost fivefold from $32 billion in 2010 to $156 billion in 2020. The Wall Street Journal estimates that more money has been raised through private placements than via public debt and equity markets since 2011.[2] The shrinking of the public capital markets, and more specifically, the decline in the number of initial public offerings (IPOs) is well documented in academic research (Gao, Ritter, and Zhu, 2013; Doidge, Karolyi, and Stulz, 2013, 2017; Eckbo and Lithell, 2020).

Recent studies suggest that the decline in IPO activity is attributable to the rise of private capital markets (Kwon, Lowry, and Qian, 2020; Ewens and Farre-Mensa, 2020). These papers offer a few reasons why firms' preferences may have tilted in favor of private capital relative to public issuance. First, private capital markets can now support larger fundraising rounds thereby permitting mature startups to delay the cost and scrutiny of public issuance and achieve greater scale before going public, the latter being an important consideration highlighted by Gao et al (2013). Second, with more institutional investors such as mutual funds participating in private fund-raising rounds, private markets now offer more dispersed ownership and greater liquidity

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[1] As IPOs pick up, big startups hold out" *Wall Street Journal*, May 8, 2017
[2] For example, in 2017 $2.4 trillion was raised in private capital markets as compared with $2.1 trillion in public debt and equity markets. See "The fuel powering corporate America: $2.4 trillion in private fund raising" *The Wall Street Journal*, April 3, 2018

than before (Kwon et al, 2020). Third, earlier evidence in Gompers and Lerner (2000) suggests that valuations could also play a role. They show that larger inflows into VC funds increase the valuation received by the funds' new investments. Indeed, recent discussions in the business press suggest that higher valuations received in the private market have contributed to the decline in IPO activity (see the opening quote above).

While prior literature focuses on the impact of private capital on IPO volume, we propose that the growth in private capital also affects the quality of firms issuing public equity. Our hypothesis is motivated by prior evidence that venture capitalists identify and invest in better quality firms (Hellman and Puri, 2000; Sørensen, 2007; Chemmanur, Krishnan, and Nandy, 2011). Due to this selectivity of venture capitalists, we hypothesize that when more private capital pursues a limited set of attractive investment opportunities, the better-performing private firms will step back from public issuance due to higher valuations received in the private market. Thus, an increase in the supply of private capital will be accompanied by a decline in the average quality of IPOs. While concerns about the negative effect of private capital on IPO quality have been raised in the business media, there has been no rigorous empirical study of this issue.[3] Such a study is needed especially considering the policy debate on the negative impact of private capital on the investment opportunity set of 'main street' investors.[4]

Using a sample of 8,182 IPOs between 1980 and 2021, we examine the change in the quality of issuing firms in a U.S. state when the supply of venture capital to that state increases. The quality of issuing firms is difficult to measure because most of their value is tied up in future growth. Therefore, we use different measures of quality. Our two primary proxies of IPO quality

[3] See "Today's Tech IPOs Offer Lower Growth for Top Dollar" Wall Street Journal Aug 17, 2019.
[4] See "SEC chairman wants to let more main street investors in on private deals" *Wall Street Journal*, Aug 30, 2018 and "SEC gives more investors access to private equity, hedge funds" *Wall Street Journal*, Aug 26, 2020.

are industry-adjusted operating profit margin and industry-adjusted sales growth over the three years following issue year. Our secondary measure of IPO quality is post-IPO survival as a publicly listed firm. We also examine post-IPO abnormal stock returns.

To address endogeneity of venture capital investment, we use shifts in national VC fundraising to construct a Bartik-style, shift-share instrument. Exposure of a state to shifts in national VC fundraising over a specific decade is based on the state's share of total VC investments during a fixed window preceding the decade. This shift share instrument serves as our estimate of the annual supply of venture capital to a state. Controlling for industry- and year-fixed effects as well as several firm-level characteristics, we find that an increase in the supply of venture capital to a state is accompanied by a contemporaneous decline in the quality of issuing firms headquartered in that state. Our estimates indicate that a one-standard-deviation increase in the supply of venture capital is associated with a 0.5 percentage point decline in post-IPO operating profit margins and a 1 percentage point decline in post-IPO sales growth. These findings are robust to dropping specific periods such as the dotcom bubble period (1997-2000), or the subprime crisis period (2008-2009), or the COVID crisis period and SPAC phenomenon (2020 and later).

Investor preferences have changed over time. In the early part of our sample, the average IPO, both VC-backed and non-VC-backed, was profitable. In recent decades, investors have encouraged growth over profitability. The average IPO in the latter part of our sample has negative operating profit margins but high sales growth.[5] We show that the sensitivity of IPO quality to the supply of venture capital reflects this change in VC preferences. In the pre-dotcom period (which we define as years prior to 1995) an increase in the supply of venture capital to a state-year is accompanied by a contemporaneous decline in the average profitability of firms going public in

[5] Prior research documents an increase in the percentage of high-growth firms that go public while unprofitable (see Doidge et al, 2017; Fama and French, 2004; Gao et al, 2013; Ritter and Welch, 2002).

that state-year but is unrelated to average growth rate of the issuing firms. This finding is consistent with the hypothesis that in the pre-dotcom period, venture capitalists screened on profitability, i.e., the most profitable private firms received VC financing and held back from public issuance. In the post-dotcom period (defined as 1995 and later) an increase in the supply of venture capital to a state-year is accompanied by a contemporaneous decline in the average sales growth of firms going public in that state-year but is unrelated to the profitability of issuing firms. This finding is consistent with the hypothesis that, in the post-dotcom period, venture capitalists screened primarily on growth, i.e., firms with higher growth potential received VC funding and held back from public issuance.

We show that this negative relation between the supply of VC capital and IPO quality is robust to alternative proxies for IPO quality such as IPO survival. We find that firms going public when their state is experiencing an increase in VC supply are more likely to delist due to failure within two years and three years of going public. Specifically, a one-standard-deviation increase in the supply of venture capital to an issuing firm's state during the year of issue leads to a 10.3% (14.2%) increase in the likelihood of delisting within 2 years (3 years).

Does it matter that high-quality firms hold back from public issuance when the supply of venture capital rises? We argue that it does. At best, these high-quality firms only delay public issuance and go public later when they are older and more mature firms. This possibility changes the investment opportunity set available for public investors - they miss out on the opportunity to invest in promising young firms during their high-risk, high-return phase.[6] Our findings help explain the Securities and Exchange Commission's (SEC) decision in 2020 to expand the

[6] Concerns that startups coming to public market later deprives public investors from owning companies during their high growth phase are discussed in "Today's Tech IPOs Offer Lower Growth for Top Dollar" Wall Street Journal Aug 17, 2019.

definition of accredited investor and enable more individual investors to invest in private companies.[7]

The second potentially negative implication for public investors depends on the efficiency of capital markets. Under the efficient capital market assumption, the issuing firm's quality would be factored into the offer price and post-IPO returns earned by public investors would not be significantly related to the supply of venture capital. However, if a firm's true quality is only gradually revealed after IPO, abnormal returns would be negatively related with the supply of VC capital. To assess the post-IPO investor experience, we examine calendar-time abnormal returns (CTARs) following the method in Mitchell and Stafford (2000) for different horizons ranging from 6 months to 24 months following the IPO. We find that, at several horizons, the post-IPO abnormal returns are lower for IPOs from state-years experiencing a sharp increase in the supply of venture capital as compared with state-years that do not experience a sharp increase. For example, over the 12-month period, abnormal returns for IPOs in the high VC-supply portfolio underperform the benchmark by -9.84%, while abnormal returns of the low VC-supply portfolio are statistically insignificant. Our returns analysis suggests that at the time of IPO, public capital markets do not fully account for the lower average quality of firms issuing public equity during periods of high VC supply.

Our preferred hypothesis is that IPO quality declines when the supply of venture capital rises because VC firms provide funding to the highest quality firms causing such firms to pull back from the public markets. The question arises why public markets do not attract these high-quality firms with competitive valuations. We believe the answer lies in information asymmetry. VC investors may have an information advantage due to their active involvement in screening and

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[7] SEC gives more investors access to private equity, hedge funds" *Wall Street Journal*, Aug 26, 2020

monitoring. If so, public investors would compensate for this information disadvantage by offering lower valuations. We find that our results are indeed conditional on information asymmetry. Using different proxies for information asymmetry, we show that in the subsample of firms that face high information asymmetry, IPO quality declines when the supply of venture capital goes up. In contrast, in the subsample of firms with low information asymmetry, the relation between the supply of venture capital and IPO quality is largely insignificant.

For our preferred hypothesis to be credible, it must be that venture capitalists invest selectively even when there is an abundance of private capital by offering disproportionately more funding and higher valuations to high-quality firms. This is not a foregone conclusion. If the set of private firms that meet the minimum quality threshold for external financing is limited, a sharp increase in the supply of venture capital can lead to more capital and higher valuations for all firms above the minimum threshold, thereby causing medium-quality firms to also pull back from public markets.[8] In this case, an increase in the supply of venture capital may not cause a decline in the average quality of IPOs. Although it is already well established in prior literature that venture capitalists engage in screening, our hypothesis requires that we document evidence of VC selectivity even when the supply of private capital is high. We do so using data provided by PrivCo on VC funding amounts and valuations received by a sample of start-ups during the period 2007 through 2021. Of our two measures of quality - sales growth and operating profit margins - we can only calculate sales growth for this subsample of private firms. We show that when the supply of venture capital rises, funding amounts and valuations received by both low-growth and high-growth firms increase. However, the increase in funding amounts and valuations is significantly greater for high-growth firms. These findings suggest that VC firms expend effort on screening

[8] We assume that firms below a minimum quality threshold will not receive any external financing, private or public.

and identifying high-quality firms even when the supply of private capital is high. The relative increase in VC funding amounts and valuations received by the higher-quality firms helps explain our finding that IPO quality declines when the supply of venture capital goes up.

We consider potential threats to the exclusion restriction of the Bartik-style instrument. Could a state's supply of venture capital over the fixed window (i.e., the window over which the state's VC investment share is calculated) predict the quality of firms going public over the subsequent decade for reasons other than the persistence in the state's supply of venture capital? One possibility is that firms funded by venture capitalists in the earlier period (i.e., over the fixed window) performed persistently poorly and went public in the subsequent decade. We use data on VC-funded private firms obtained from PrivCo and compare employment growth and sales growth of firms receiving VC funding during one of the fixed windows. We find no evidence that these are poor-performing firms. Since we cannot rule out all possible channels through which the exclusion restriction can be violated, we show that our results relating to post-IPO profitability and post-IPO abnormal returns are robust to an alternative instrument that relies on shifts in states' pension assets and the home bias inherent in the VC commitments of state pension funds.

Our paper is most closely related to recent studies showing that the growth of private capital markets has led to a decline in the number of IPOs (Ewens and Farre-Mensa, 2020 and Kwon et al, 2020). We add to this literature by showing that an increase in the supply of private capital also leads to significantly lower average quality of firms issuing public equity and lower investment returns for public investors. Our results contribute to the ongoing policy debate on the investment opportunity set available to public investors and offer an explanation for recent moves by the SEC to increase access to private capital markets.[9] Our paper is also related to Gompers and Lerner (2000) who find that inflows of capital into venture funds increases the valuations of new investments by these funds. We show that the increase in VC valuations is more pronounced for higher-quality firms, and this contributes to a contemporaneous decline in the quality of firms going public. More broadly, our findings are related to other studies about IPO quality such as Helwege and Liang (2004) and Yung, Çolak and Wang (2008), who examine issuing firm quality across hot and cold IPO markets.[10]

The paper is organized as follows. Section 2 discusses related literature and presents our hypothesis. Section 3 describes the data. Section 4 and 5 present the main results. Section 6 presents robustness to other instruments for the supply of venture capital. Section 7 concludes.

2. Related literature and hypothesis development

Numerous theoretical papers explore the going public decision to understand what type of firms go public and when in its life cycle a firm goes public. A central theme in most models is that insiders have private information about the quality of a firm's projects while outside investors must acquire this information at a cost. In Chemmanur and Fulghieri (1999), issuing public equity involves duplication of information production costs (which, in equilibrium, are borne by the firm through a lower share price) while raising capital privately involves paying a higher risk premium due to the venture capitalists undiversified holdings. A key prediction of Chemmanur and Fulghieri (1999) is that firms are more likely to go public when information production costs for public

[9] The amendments made by the SEC in August 2020 revise Rule 501(a), Rule 215, and Rule 144A of the Securities Act to expand the list of entities that qualify as "accredited investors". See https://www.sec.gov/news/press-release/2020-191

[10] Other papers that address changes in IPO quality across hot and cold markets are Allen and Faulhaber (1989), Grinblatt and Hwang (1989), and Welch (1989) Loughran and Ritter (1995), and Lerner (1994).

investors are low – i.e., when information asymmetry surrounding the firm is low. In Maksimovic and Pichler (2001), firms trade off the risk of disclosing sensitive product information to competitors when going public against the higher cost of raising private financing. Their model predicts that the timing of public issuance depends on product development costs, product market competition (i.e., the risk of displacement) and the value of proprietary information. Other models such as Bhattacharya and Ritter (1983) and Spiegel and Tookes (2007) involve a similar tradeoff – public equity financing is cheaper than private equity but carries the risk of disclosing product information to rivals.

While models of the going-public decision commonly assume that private equity is more expensive than public equity, existing theory does not address how the type of issuing firms might change when the cost of private equity declines (which is likely when the supply of private capital is high). Existing empirical evidence shows that the volume of initial public offerings declines when the supply of private capital goes up (Ewens and Farre-Mensa, 2020; Kwon et al, 2020). To understand what type of firm holds back from public markets when the supply of venture capital rises, we draw on empirical evidence that VC valuations rise when the supply of venture capital increases (Gompers and Lerner, 2000). We use this prior evidence, along with the well-established role of information asymmetry to set up the conceptual framework of our tests.

Consider a continuum of private firms in the economy. Each firm *i* has a project with probability of success π_i where success probability is uniformly distributed on [0,1]. Both public and private investors gather information about the firms prior to making an investment decision. Firms with success probability below π_{min} receive no external financing, public or private. We assume that venture capitalists receive more precise signals about the firm's quality than public investors and only pursue a subset of high-quality firms with success probabilities in the interval

[π_q,1], where $\pi_{min} < \pi_q < 1$. The ability of venture capitalists to screen and identify better-quality firms is well established in the literature (Barry, Muscarella, Peavy, and Vetsuypens,1990; Hellman and Puri, 2000; Sørensen, 2007, Chemmanur et al, 2011; Krishnan, Ivanov, Masulis, and Singh, 2011). The information advantage of venture capitalists may also arise from their monitoring role, which is also recognized in the literature (Gompers, 1995; Lerner, 1995; Bernstein, Giroud, and Townsend, 2016).

We propose that when the supply of private capital increases, venture capital firms continue to be selective and offer disproportionately more capital and higher valuations to firms in the interval [π_q,1]. Public investors are at a disadvantage due to the superior information set of venture capitalists which enables VCs to better identify and compete for high-quality firms. Due to this adverse selection problem, public markets offer lower valuations than private investors causing more firms in the interval [π_q,1] to opt for private financing. The negative impact of adverse selection on the price investors are willing to pay is well established in the literature (Rock, 1986; Fishman and Parker, 2015).[11]

These arguments lead us to hypothesize that when the supply of venture capital rises, the average IPO quality declines. Moreover, the decline in IPO quality will be driven by firms that suffer from information asymmetry, as this is the setting where public markets face an information disadvantage. In addition to testing this hypothesis, we provide support for the critical assumption that VC firms are selective even when the supply of private capital is high. This is important to document empirically for the following reason. If the increase in supply of private capital leads to

[11] Information asymmetry plays an important role in IPO pricing. See Welch (1989), Allen and Faulhaber (1989), Benveniste and Spindt (1989), Benveniste and Wilhelm (1990), and Spatt and Srivastava (1991), Chemmanur (1993), Chemmanur, Hu, and Huang (2010), Lowry, Officer, and Schwert (2010)

more funding and higher valuations for all firms, then medium-quality firms in the interval [π_{min}, π_q] are also likely to pull back from public markets. In this scenario, the average quality of issuing firms will not be affected by the increase in supply of private capital.

3. Data and method

3.1. IPO Sample and measures of IPO quality

We obtain initial public offerings (IPO) data from Refinitiv's SDC Platinum database from the period 1980 through 2021. As in prior studies, we exclude unit offerings, foreign issues, ADRs, and IPOs with offer price below $5. Next, we match the IPOs with CRSP and COMPUSTAT databases and retain only IPOs with non-missing sales and total assets as of the first fiscal year end following issue date. This leads to our final sample of 8,182 IPOs. Figure 1 shows the distribution of our IPO sample over time. The well-recognized peaks and troughs of the IPO market are evident in this figure. Characteristics of the sample of IPOs are presented in Table 1. The IPOs in our sample raise $112 million on average with average offer price of $13. About 37% of the firms going public have venture capital backing. The majority of IPOs occur during hot IPO markets. We classify a quarter as a hot IPO market if the three-quarter moving average of IPO volume centered on that quarter is in the top quartile of our sample. Table 1 (Panel C) shows that 55% of the IPOs occur during hot markets.

In our primary tests, we assess the quality of an IPO using industry-adjusted, post-IPO profit margins and post-IPO growth. In supplementary tests, we also examine IPO survival and post-IPO abnormal stock returns. Industry-adjusted operating profit is calculated as operating income before depreciation divided by total assets of the issuing firm less the median value for all public firms in the same 2-digit SIC code. We calculate this measure for up to three years after

IPO and take the average to obtain the post-IPO operating profit (OPER3). Industry-adjusted sales-growth (SG3) is calculated as the annual growth in sales of the issuing firm less the median value for all public firms in the same industry, averaged up to three years after IPO. Panel A of Table 1 summarizes these variables for our sample of IPO firms. We see that industry-adjusted operating profit is negative for the average and median issuing firm. The average (median) firm grows at 35% (14%) during the three years following issue year.

Prior research shows that the profile of IPO firms has changed over time. In the period preceding the mid 1990s, most issuing firms were profitable at the time of IPO. In recent decades, investors have encouraged growth over profitability with majority of issuing firms being unprofitable at the time of IPO (Fama and French, 2004).[12] These patterns are evident in our data as well. Panel B of Table 1 summarizes OPER3 and SG3 in the years prior to 1995 (which we refer to as the pre-dotcom period) and over the years after 1995 (post-dotcom period). The median issuing firm in the pre-dotcom period had positive OPER3, while in the post-dotcom period the median firm had negative operating profits. The decline in both the average and median profitability in the post-dotcom period is statistically significant at the 99% confidence level. In contrast, SG3 of issuing firms is significantly higher in the post-dotcom period than in the pre-dotcom period. A similar pattern exists if we focus on VC backed IPO firms only (not tabulated). This change in investor preference offers an opportunity for us to refine our hypothesis further, which we discuss in Section 4.1 below.

3.2. Venture capital data

We download historical venture capital investments from Refinitiv's Eikon Private Equity and Venture Capital database (previously maintained by Thomson Reuters as VentureXpert)

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[12] Also see "Initial Public Offerings: Updated Statistics", Jay Ritter, 2023.

during the period of 1980 through 2021. We identify VC deals by requiring the primary security type to be either "Common Stock" or "Venture Capital Equity Investment", or contain the keyword "Preferred". In addition, we exclude the deals whose investment stage is not "Early Stage", "Later Stage", "Seed", or "VC Partnership". Observations with zero or negative values for the amount invested are dropped. Figure 2A (2B) shows the total nominal (inflation-adjusted) dollar value by year of VC deals in our data. We also trace the states in which the VC-funded companies are located. The five states with the largest amount of VC investments are California, Massachusetts, New York, Texas, and Washington, respectively.

We also collect annual VC fundraising data from the Eikon database. These data are at the national level and include all venture capital funds based in the United States. Figure 3A (3B) plots the distribution of nominal (real) VC fundraising over our sample period. The data on state-level VC investments and national VC fundraising are combined to create a shift-share instrument as follows. We multiply state-level shares of VC investment calculated over fixed windows with national level shifts in venture capital fundraising. Given the length of our sample (spanning more than four decades), we use three different fixed windows to estimate states' share of total VC investment: (i) Fixed Window 1: Jan 1980 through Dec 1981, (ii) Fixed Window 2: Jan 1994 to Dec 1995 and (iii) Fixed Window 3: Jan 2009 to Dec 2010. A state's share of VC investment in each window is assumed to persist for the next 10 to 12 years. Specifically, for each year t between 1982 to 1993 (inclusive), the annual supply of venture capital in state s is estimated as the state's investment share over Fixed Window 1 times the average national VC fundraising in years $t-1$ and $t-2$. Similarly, the annual supply of venture capital in a state during each year t between 1996 and 2008 is estimated as the state's investment share over Fixed Window 2 times the average national VC fundraising in years $t-1$ and $t-2$. The same process is used to estimate the annual supply of venture capital over the period 2011 to 2021, with the state's investment share calculated over Fixed Window 3. The distribution of this Bartik-style instrument for the supply of venture capital is presented in Figure 4. Note that the three fixed windows over which the investment shares are calculated are excluded from the estimation.

In Table 1 Panel D, we present summary statistics of both inflation-adjusted actual VC investments by state-year and of our estimated VC supply measure. The average value of estimated VC supply to a state-year in inflation-adjusted terms is $0.098 billion, i.e., $98 million. This is quite comparable to the average level of actual VC investment to a state-year (shown in the same table). The correlation between actual VC investments and our estimated supply of venture capital is 0.82.

Next, we discuss possible weaknesses of this shift-share instrument in achieving identification. In an ideal setting, states' VC investment shares during the fixed windows would be randomly assigned. In practice, however, the amount of VC investment a state receives during the fixed window may depend on state characteristics that also affect the going-public decision. To address this, we show that our findings are robust to the inclusion of state-fixed effects. All our regressions include year-fixed effects, which absorb shifts in fundraising at the national level. To provide reassurance that our results are not overly sensitive to the choice of shares, or the choice of the shift variable used, in Section 6, we show that our results are robust to an alternative shift-share instrument. Section 6 also presents robustness tests in which the home bias inherent in VC commitments of state pension funds is used as a proxy for the change in supply of venture capital.

4. Main results

4.1 Baseline specification

We regress the quality of an IPO on the supply of venture capital using the following ordinary least squares regression:

$$Y_i = \alpha_0 + \alpha_1 V_{st} + \alpha \boldsymbol{Z_i} + \varphi_j + \tau_t + \epsilon_i \quad (1)$$

In the regression above, there is one observation per IPO. The subscript *i* indicates the issuing firm and *t* indicates issue year. Y_i is one of our two industry-adjusted measures of IPO quality, OPER3 or SG3 (described above in Section 3) calculated as of the first fiscal year-end following issue date. V_{st} is the supply of venture capital in the issuing firm's headquarter state during the issue year *t*. $\boldsymbol{Z}$ is a vector of control variables including firm size (market capitalization), book-to-market, leverage, IPO underpricing, a dummy variable for venture capital backed firms, and a dummy variable if the firm went public during an IPO hot market. All control variables are described in Appendix A. τ_t are year fixed effects. φ_j are industry fixed effects. IPOs tend to occur in waves. To account for correlation across different firms going public in the same year, we cluster standard errors by year.[13] Correlations between all variables used in equation 1 are presented in Table 2.

Controlling for industry is important because recent decades have seen an increase in public offerings by hi-tech and biotech firms with negative earnings at the time of IPO. While using industry-adjusted dependent variables is common practice in empirical corporate finance, Gormley and Matsa (2014) point out that industry-adjusting only the dependent variable can lead to inconsistent estimates. We take two steps to address this concern. First, as per Gormley and Matsa (2014), we include industry fixed effects, which address unobserved heterogeneity in both the

[13] Our results are robust to alternate clustering of standard errors, such as clustering by state or double clustering by state and year.

dependent and independent variables. Second, we show that our results are similar if the dependent variable is not de-medianed and only industry-fixed effects are used.

In columns 1 and 2 of Table 3, we show estimates of equation 1 with V_{st} set equal to the actual VC investments to a firm's state in the year of issue. Since VC investments are endogenous to a state's economic conditions, the results in columns 1 and 2 are presented as correlations only with no causal interpretation. For OPER3, the coefficient on VC investment is negative and statistically significant at the 95% confidence, while for SG3, the coefficient on VC is negative but only weakly significant at the 90% confidence level. These findings suggest a negative relation between the availability of venture capital and the quality of firms going public.

Next, we estimate equation 1 using the Bartik-style, shift-share instrument described above in Section 3 as an estimate of the supply of venture capital in state *s* in issue year *t*. Estimates of equation 1 with V_{st} set equal to the shift-share instrument are shown in columns 3 and 4 of Table 3. The sample size is smaller in these regressions than in columns 1 and 2 because, due to concerns about endogeneity of VC investments, we do not estimate the supply of venture capital over the three fixed windows (see Section 3.2). We see that the coefficient on VC supply is negative and statistically significant at the 95% confidence for both OPER3 (column 3) and SG3 (column 4). The coefficient on VC supply in column 3 (column 4) indicates that a one-standard-deviation increase in the supply of venture capital leads to a 0.5 percentage point (1 percentage point) drop in OPER3 (SG3).[14] The point estimates and t-statistics are similar if we do not subtract the industry

[14] For OPER3, multiplying the coefficient on VC supply in column 3 of Table 3 (-0.013) with the standard deviation of VC supply (0.395, as show in Panel D of Table 1) gives -0.005 or -0.5 percentage points. Since the mean and median values of OPER3 are -6% and -2% respectively (see Panel A of Table 1), a decline of 0.5 percentage points is economically meaningful. For SG3, multiplying the coefficient on VC supply in column 4 of Table 3 (-0.026) with the standard deviation of VC supply (0.395, as show in Panel D of Table 1) gives -0.010 or -1 percentage point decline in growth.

median when calculating OPER3 and SG3 (columns 7 and 8). In the rest of the paper, we use the industry-adjusted versions of OPER3 and SG3.

These results provide support for our main hypothesis - an increase in the supply of venture capital in a state is accompanied by a decline in the quality of IPOs from that state, both in terms of post-IPO operating profits and post-IPO growth. These findings hold if we drop specific periods such as (i) dotcom years from 1997-2000 (ii) mortgage crisis years from 2008 to 2010 and (iii) COVID crisis and the SPAC phenomenon of 2020-2021 (shown in Appendix B). We note that the baseline results presented in Table 3 use the current state recorded in Compustat. Doing so risks introducing noise in the data if firms relocate during our sample period. To address this concern, we obtain historical headquarter state from Mingze Gao's website and find that our results are robust to using the historical state instead of current state obtained from Compustat (see Appendix B).[15]

We address two potential issues with the shift-share instrument. First, the only cross-sectional variation in the instrument comes from the states' share of VC investment during the fixed windows, which leads to concerns that our results are driven by unobserved state characteristics. In columns 5 and 6 of Table 3, we include state-fixed effects and find that our results still hold. Second, we discuss threats to the exclusion restriction. The main threat is that the share of a state's VC investments calculated over the three fixed windows is associated with lower IPO quality over the subsequent decade through some mechanism other than the persistence in the state's share of venture capital. One possibility is that startups that were funded by venture capital during the fixed windows were of lower quality, and that these lower quality firms gradually went public over the subsequent decade. While we cannot completely rule out this possibility, we use

[15] For more information on historical state data see Gao, Leung, Qiu (2021).

data on VC-funded firms obtained from PrivCo to compare the quality of startups receiving VC funding during one of the fixed windows with that of startups receiving VC funding outside the fixed window. PrivCo covers startups that had revenue of at least $1 million and received VC funding of at least $1 million. Coverage begins in early 2000s, but funding data are patchy prior to 2007. Therefore, we can only compare startup characteristics for one of our three fixed windows, namely Jan 2009 to Dec 2010. We have funding data on more than sixty thousand funding rounds received by twenty thousand unique startups. Sales data are available for over eleven thousand funding rounds received by about 5,400 startups. Since earnings data are not available for these startups, we focus on sales growth. In untabulated results, we find that the sales growth at the time of VC funding of startups financed during the Jan 2009 to Dec 2010 window is not significantly different from sales growth of the rest of VC-funded startups. This is inconsistent with the alternative explanation that startups funded by VCs during the fixed windows were of lower quality.

Next, we run our analysis within two subperiods. As discussed in Section 3.1, the majority of firms going public in the pre-dotcom period were profitable firms. In recent decades, however, investors have encouraged growth over profitability and most IPO firms in the post-dotcom period have negative earnings. This change in investor preference has implications for our preferred hypothesis. We argue that IPO quality declines when the supply of venture capital rises because venture capitalists selectively pursue high-quality firms and offer attractive valuations, thus causing these high-quality firms to opt out of public markets. Since our argument relies on the screening behavior of venture capitalists, we would expect the relation between the supply of private capital and our two measures of IPO quality to be different in the two subperiods, depending on which quality characteristic venture capitalists are screening upon. Specifically, we expect the negative link between the supply of venture capital and OPER3 to be driven by the pre-dotcom period because VCs pursued profitable firms in the pre-dotcom period. Similarly, we expect the negative link between the supply of venture capital and SG3 to be a feature of the post-dotcom period because VCs preferred high growth firms in the post dotcom period. In Table 4, we present estimates of equation 1 in the pre-dotcom and post-dotcom periods separately. In columns 1 and 2 of Table 4 the dependent variable is OPER3. We see that the coefficient on VC supply is negative and statistically significant at the 99% confidence level in the pre-dotcom period (column 1). In column 2, which is restricted to the post dotcom period, we find no relation between VC supply and the operating profit margins of IPO firms. This finding is consistent with the hypothesis that in the pre-dotcom period, when profitability was the sought-after measure of quality, the most profitable firms receive private funding and held back from public issuance

In columns 3 and 4, we use SG3 as the measure of IPO quality. We see that in the pre-dotcom period, there is no relation between VC supply and SG3. In the post-dotcom period, however, an increase in the supply of venture capital is associated with a significant decline in post-IPO sales growth. This finding is consistent with the hypothesis that in the post-dotcom period, when sales growth was the sought-after measure of quality, firms with the highest growth potential receive VC funding and opted out of public issuance.

4.2 IPO survival

In this section, we consider survival as a publicly listed firm to be an alternate proxy of IPO quality. Prior research indicates that the majority of failed IPOs delist within the first few years after going public (Bhattacharya, Borisov, and Yu (2015). As in prior research we classify IPO firms as having failed as public firms if they delist involuntarily from an exchange. Specifically, we follow Yung et al (2008) and define a firm as having failed as a public firm if the

CRSP delist code lies between 400 and 599 excluding 501, 502, 503, and 573. Panel A of Table 5 shows delisting statistics of IPO firms in our sample. We do not consider delisting due to mergers or acquisitions (CRSP delist code lies between 200 and 399) as failures. While these firms do not survive as independent public firms, acquisitions are often a means for venture capitalists and other private equity investors to successfully exit an investment.

Of the initial samples of 8,182 IPOs in our sample, only 17 delist due to failure within the first 12 months. There are 224 delistings due to failure within 24 months (2.7% of sample) and 490 delistings within 36 months (6% of sample). The three-year failure rate in our sample is comparable to the 6.5% failure rate in Yung et al (2008). Due to the small sample of failures in the first year, we focus on failures over the 2-year and 3-year horizon only.[16] In Panel B of Table 5, we present logit regressions of the likelihood of delisting due to failure. In columns 1 to 3, the dependent variable takes the value 1 if the issuing firm delists due to failure within 24 months of issue date and 0 otherwise. Since less than 3% of issuing firms delist within 2 years, some of the industry- and year- fixed effects predict failure perfectly, leading to a loss of sample size. For this reason, we present three variations of the regression, one with no fixed effects (column 1), one with industry-fixed effects only (column 2), and a third with both industry- and year-fixed effects (column 3). In all three regressions, the coefficient on VC supply is positive and statistically significant, indicating that two-year delisting rates are higher for firms that went public when the supply of venture capital to their state was higher during the issue year. In columns 4 to 6, the dependent variable takes the value 1 if the issuing firm delists due to failure within 36 months of issue date and 0 otherwise. In all specifications, the coefficient on VC supply is positive and

[16] However, in unreported tests focusing on the 1-year horizon, we find that despite the small number of delistings, the results are qualitatively similar.

statistically significant, indicating that IPO firms issuing during periods of high VC supply are more likely to delist within three years.

Exponentiating the coefficients in column 3 and column 6 gives odds ratio of 1.26 and 1.37 respectively, implying that a one-unit increase in the supply of VC capital to a state leads to a 26% (37%) increase in the odds that an IPO from that state delists within 2 years (3 years). In our data, a one-unit increase means a $1 billion increase in inflation-adjusted venture capital. To get more practical economic magnitudes, we turn to Table 1 Panel D, which shows the inflation-adjusted supply of venture capital for an average state-year is just under $100 million with standard deviation of $395 million. A one-standard-deviation increase in the supply of venture capital to an issuing firm's state during the year of issue leads to a 10% (15%) increase in the likelihood of delisting within 2 years (3 years).[17]

4.3 Abnormal returns

In this section, we explore the public investor experience by examining post-IPO abnormal returns over various time horizons. We use calendar time abnormal returns (CTAR) which help address the cross-sectional correlation of event firm abnormal returns (Mitchell and Stafford, 2000). An equal-weighted event portfolio is formed at the beginning of each month that includes companies that completed an IPO within the prior *n* months. By forming these monthly IPO event portfolios, any cross-sectional correlations of the individual event firms will be automatically accounted for in the portfolio variance at each point in calendar time.

For a given horizon *n* (ranging from 6 to 24 months), we implement the following procedure. For each month from January 1980 to December 2021, we create a high-VC-supply event portfolio and a low-VC-supply event portfolio. An IPO firm is included in the high-VC-

[17] Adjusting the odds ratio proportionally: 26% x ($ 395/$1000) = 10.27% and 37% x ($395/$1000) = 14.6%

supply event portfolio if it went public within the previous *n* months and VC supply during the issue year to the firm's state was in the top quartile of the sample. An IPO firm is included in the low-VC-supply event portfolio if it went public in the previous *n* months, but VC supply during the issue year to the firm's state was not in the top quartile. Both portfolios are rebalanced monthly to keep equal weights. Firms that reach the end of the horizon *n* are dropped and firms that have just announced an IPO that meets the event criterion are added. The portfolio excess returns are regressed on the Fama-French (1993) factors and the Carhart (1997) momentum factor as follows

$$R_{pt} - R_{ft} = \alpha_p + \beta_p(R_{mt} - R_{ft}) + s_p SMB_t + h_p HML_t + u_p UMD_t + \varepsilon_{pt} \quad (2)$$

The intercept alpha in equation 2 is the CTAR capturing the event portfolio excess return. In Figure 5, we plot the CTARs for the high-VC-supply portfolio and the low-VC-supply portfolio estimated over different horizons (with *n* ranging from 6 months to 24 months). The grey solid bar is the alpha of the high-VC-supply event portfolio and the bar with the horizontal lines is the alpha of the low-VC-supply event portfolio. A triangle placed at the end of the bar indicates whether the alpha is statistically significant. We see that the high-VC-supply alphas consistently lie below zero and are statistically significant from the 10-month to 12- month horizons. Over the 12-month horizon, the CTAR estimation shows the high VC-supply portfolio has significant abnormal returns of -0.82% per month, which implies an underperformance of -9.84% over a 12-month period. Alphas of the low-VC-supply portfolio are statistically indistinguishable from zero at all horizons.

We also form a long-short, self-financing portfolio by long holding the high-VC-supply portfolio and short selling the low-VC-supply portfolio. The alpha of the long-short portfolio is presented in the same graph as a dashed line (labeled 'L-S diff') and the t-statistic of the long-short portfolio's alpha is reported as a dotted line. The dotted line lies below the 95% critical value at the 10- to 12- month horizons and again around the 28- to 29-month horizon indicating that the high-VC-supply portfolio significantly underperforms the low-VC-supply portfolio over several horizons. Thus, firms going public during periods of high VC supply experience poorer post-IPO abnormal returns than firms that go public when VC supply is low. This finding is in line with evidence above that IPO quality is lower when VC supply increases. It also suggests that the market does not fully incorporate the decline in IPO quality into the pricing of the IPO.

5. Evidence to support the main hypothesis

5.1 Information asymmetry

We propose that IPO quality declines when the supply of venture capital is high because the best-quality firms receive higher valuations in the private market and forego public issuance. The question arises why public markets do not attract these high-quality firms with competitive valuation. We believe the answer lies in information asymmetry. Outside investors are at an information disadvantage relative to the firm's management, and this disadvantage is likely greater for public investors than for venture capitalists. VC firms may have insider knowledge of the private firm due to participation in prior fundraising rounds and active monitoring of the firm (Gompers, 1995; Lerner, 1995; Chemmanur et al, 2011). VC firms are also known to have expertise that enables them to screen and select better-quality firms and offer certification about an issuing firm's quality (Megginson and Weiss, 1991). We argue that public markets, cognizant of their information disadvantage, lower their estimate of firm value when facing better-informed and well-funded venture capitalists.

If our explanation is valid, our main results should be driven by firms with greater valuation uncertainty. We use four proxies to capture valuation uncertainty. First, the value of high-tech firms is harder to estimate precisely. We identify hi-tech firms as firms in the computer equipment, electronics, and biotech industries.[18] The second variable we use to capture valuation uncertainty is innovativeness of the firm's industry. It is harder to accurately value firms in innovative industries since it is often difficult to predict which of the competing new products will be successful. We classify industries as innovative if the truncation-bias adjusted number of successful patents by firms in that industry is above the sample median. Our third variable captures whether the firm listed on the NASDAQ exchange. NASDAQ firms tend to be smaller, younger, and from the hi-tech industry, all of which are characteristics that make it harder for an underwriter to accurately value a firm. Since young firms have a shorter track record, our fourth variable to capture information asymmetry is the firm's age at the time of IPO, calculated as the number of years since the firm was founded. We use the Field-Ritter data set of founding dates (see Field and Karpoff (2002) and Loughran and Ritter (2004)). Firms with age below the sample median are classified as young firms.

Panel A of Table 6 presents estimates of equation 1 in subsamples of high information asymmetry based on all four measures – columns 1 and 2 are restricted to the subsample of hi-tech firms, columns 3 and 4 are restricted to firms in innovative industries, columns 5 and 6 are restricted to firms that listed on NASDAQ, while columns 7 and 8 are restricted to the subsample of young firms. We see that the coefficient on VC supply is negative and statistically significant in all regressions. That is, we find robust evidence that in subsamples of high information asymmetry, both post-IPO operating profits and post-IPO sales growth are lower when the supply of VC capital is high. In Panel B of Table 6, we present estimates of equation 1 in subsamples of low information asymmetry. Columns 1 and 2 are restricted to the subsample of non-hi-tech firms,

[18] Firms in SIC codes 283, 357, 366, 367, 382, 384, 737 are classified as hi-tech firms.

columns 3 and 4 are restricted to firms in non-innovative industries, columns 5 and 6 are restricted to firms that did not list on NASDAQ, while columns 7 and 8 are restricted to the subsample of older firms. We see that the coefficient on VC supply is insignificant in 7 of the 8 specifications presented.

Overall, the results in Table 6 indicate that the negative relation between VC supply and IPO quality is observed primarily when information asymmetry is high. These findings support our conjecture that when adverse selection costs are high, VC firms with deep pockets are able to offer better valuations than public markets for the best-quality firms.

5.2 VC funding and valuations

Our hypothesis relies on the assumption that VC firms are selective even when the supply of private capital is high. Although it is well established that venture capitalists engage in screening (Hellman and Puri, 2000; Chemmanur et al, 2011), prior research does not examine whether screening and selectivity persists even when the supply of venture capital is high. This is an important consideration for the interpretation of our findings. If an increase in the supply of venture capital caused a proportional increase in funding for all private firms, not just high-quality firms, medium-quality firms in the interval [π_{min} , π_q] may also pull back from public markets. In this scenario, the observed decline in average IPO quality could not be attributed to the rise in venture capital.

In this section, we examine whether VCs screen and invest selectively even when the supply of venture capital is high and offer higher valuations to better-quality firms. Specifically, we examine whether higher quality startups receive disproportionately more VC investments and higher valuations than lower quality startups when the supply of venture capital increases. The venture capital data we obtain from Refinitiv's Eikon database do not have information on startup financials or on valuations received by startups. Therefore, we turn to VC funding data provided by PrivCo for the period 2007 to 2021. These data include the funding amount received by the startup, funding valuations at each round, the firm's revenue, and the firm's age as of funding date. The PrivCo sample contains funding amount information for more than 60,000 funding rounds received by over twenty thousand startups. However, data on the startup firm's revenue are available for only subset of the firms. We calculate annualized revenue growth using the most recent revenue data available prior to each funding round, provided the revenue data are not more than 4 years before the funding round. If no revenue data are available in the four years preceding a funding round, we drop the funding round from the sample. We are able to calculate revenue growth for more than 11,000 funding rounds received by about 5,400 startups. Since earnings data are not available for private firms, we use only revenue growth as a proxy for quality. We classify a startup as a high-quality (low-quality) startup if its revenue growth is above (below) the median growth of firms in the PrivCo sample. Summary statistics are provided in Panel A of Table 7. The average (median) startup receives \$66 million (\$18 million) in VC funding at a post-money valuation (PMV) of \$950 million (\$185 million) and a PMV-to-Revenue multiple of 19.5 (9). Given the high skewness of the data, we check the robustness of our results to median regressions (untabulated) and find qualitatively similar results.

We estimate the following regression separately for the sub-sample of high-growth startups and low-growth startups:

$$X_{ift} = \beta_0 + \beta_1 V_{st} + \beta_2 F_{it} + \varphi_j + \tau_t + \varepsilon_{ift} \tag{3}$$

In this equation, *i* indicates the firm, *f* indicates funding round, and *t* indicates funding year. *X* is one of the following three dependent variables (i) funding amount (in logs), (ii) PMV (in logs) and (iii) PMV-to-Revenue multiple. F represents two firm-level control variables, namely age and revenue. φ_j are industry fixed effects, and τ_t are year-fixed effects.

To examine the differential impact of VC supply on the funding amounts and valuations received by high-growth firms relative to low-growth firms, we pool the sample of high-growth and low-growth firms together and estimate the following model:

$$X_{ift} = \delta_0 + \delta_1 V_{st} \times High\,Growth_{it} + \delta_2 V_{st} + \delta_3 High\,Growth_i + \delta_4\, F_{it} + \varphi_j + \tau_t + \varepsilon_{ift} \quad (4)$$

In equation 4, *High Growth* is a dummy variable that takes the value of one for firms with above-median growth and zero otherwise. The coefficient of interest is $\delta_1$which captures whether high-growth firms receive relatively more funding or higher valuations than low-growth firms when the supply of venture capital increases. Results are presented in Panel B of Table 7. In columns 1 to 3, the dependent variable is the funding amount received. Columns 1 and 2 present estimates of equation 3 for the sub-sample of low-growth and high-growth firms respectively. The coefficient on VC Supply, β_1, is positive and statistically significant for both, indicating that the funding amounts received are significantly greater for both high- and low-growth firms when the supply of venture capital is higher. Column 3 presents the estimates of equation of 4. The coefficient, δ_1, on the interaction of VC Supply and the high-growth indicator variable is positive and statistically significant, which means that when the supply of venture capital rises, the increase in funding amounts is larger for high-growth firms than for low-growth firms.

In columns 4 to 6, the dependent variable is the post-money valuation (in logs). In columns 4 and 5, which present estimates of equation 3 for low-growth firms and high-growth firms respectively, we see that valuations are higher for both low-growth firms and high-growth firms when the supply of venture capital increases. However, estimates of equation 4 in column 6 show that the coefficient δ_1 is positive and significant, indicating that valuations go up more for high-growth firms than for low-growth firms. In columns 7 through 9, we use the PMV-to-Revenue multiple as an alternative measure of valuation. In column 7, we see that low-growth firms do not experience an increase in valuation multiples when the supply of venture capital is high. However, the coefficient on VC Supply in column 8 is positive and statistically significant, implying that high-growth firms receive higher valuation multiples when the supply of venture capital is higher. The pooled sample estimation in column 9 shows δ_1 is positive and significant, indicating that valuation multiples increase more for high-growth firms than for low-growth firms. These findings indicate that VC selectivity persists when the supply of venture capital is high. The additional venture capital chases high-quality firms more aggressively, offering more funding and higher valuations to high-growth firms. The results in this section offer an explanation for the decline in IPO quality when VC supply is high – the most promising firms opt for private financing.

6. Alternate instruments for VC investment

6.1. An alternate shift-share instrument

In this subsection, we use a different shift and different share variable than the instrument used in our main analysis. We present this instrument (referred to as the employment-share instrument for convenience) as reassurance that our findings are not highly sensitive to the shift or share variable. The employment-share instrument exploits shifts in total industry-level venture capital investments rather than national-level VC fundraising. A state's exposure to shifts in an industry's VC investments depends on the share of the state's employment in that industry. We use the US Census Bureau's County Business Patterns (CBP) data from the year 1986 to calculate a state's share of employment in each industry. This employment share determines how total VC investment received by industry *j* in year *t* is allocated to state *s* over the years 1987 to 2021.

Exposure of a state to venture capital investment in year *t* is calculated by multiplying the share of the state's employment in industry *j* with shifts in total venture capital investment in industry *j* in year *t* and then summing across all industries as follows

$$Employment\ Share\ Instrument_{st} = \sum_j Employment\ share_{sj} \times VC\ Investment_{jt} \quad (5)$$

The exclusion restriction for this instrument is that a state's share of industry employment is not related to IPO quality through channels other than the share predicting future allocation of venture capital investment to that state. One possible threat to the exclusion restriction is that firms in some industries tend to go public while still unprofitable and these industries may be geographically clustered in specific states. All our regressions include industry-fixed effects to account for this possibility. We estimate equation 1 using this employment share instrument as a proxy for the supply of venture capital to a state-year. Results for operating profits, OPER3, are presented in columns 1 to 5 of Table 8 and for SG3 in columns 6 to 10 of Table 8. We present estimates of equation 1 in the full sample and, to highlight the importance of information asymmetry, we also present estimates in subsamples of information asymmetry. In the interest of space, we focus on two proxies of information asymmetry – the indicator variable for hi-tech industries and the indicator variable for innovative industries. In column 1, the coefficient on the employment share instrument is negative but statistically insignificant when the dependent variable is OPER3. However, when we focus on the subsamples with high information asymmetry (hi-tech firms in column 2 and innovative firms in column 3), we see that OPER3 is significantly lower when the supply of venture capital as captured by the employment share instrument is high. In the subsamples with low information asymmetry (columns 4 and 5), the coefficient on the employment share instrument is insignificantly different from zero. Moving to sales growth, SG3, we see in column 6 that the coefficient on the employment share instrument is significantly negative, indicating that post-IPO growth is lower for firms that go public when the supply of venture capital in their state is high. Again, this significant negative relation is driven by industries with high information asymmetry (columns 7 and 8). The coefficient on the employment share instrument is insignificant in subsamples of low information asymmetry (columns 9 and 10). In summary, this alternate construction of a shift-share instrument supports the adverse-selection explanation for the negative relation between the supply of venture capital and IPO quality.

6.2. States' pension assets as an instrument for supply of venture capital

Hochberg and Rauh (2013) show that public pension funds exhibit substantial home bias in private equity investments. The overweighting in home-state investments by public pension funds is especially strong for venture capital funds. We use annual public pension fund asset data combined with the home bias of pension funds' venture capital commitments to capture changes in the supply of venture capital. This instrument is available only for a limited sample period, but despite the smaller sample size, it provides some evidence supportive of our main hypothesis.

To calculate the home bias of public pension funds, we obtain data on VC commitments from Preqin. Public pension fund commitment data is sparse prior to 1993. Therefore, we restrict the sample period of this test to 1993 to 2021. For this period, we have data on public pension fund commitment to general partners (GP) in 23 states. For each state, we calculate *Overall State Share* as total VC commitments made to general partners located in that state divided by total VC commitments made to all general partners located in the United States. *Overall State Share,* which captures a state's share of overall VC commitments, serves as the benchmark against which we measure the state's share of VC commitments by public pension funds. For example, *Overall State Share* for Massachusetts is 14.5%, meaning that 14.5% of sample VC commitments are allocated to funds located in Massachusetts. If Massachusetts public pension funds allocated the same portfolio share to Massachusetts GPs as the average limited partner (LP) in the United States, only 14.5% of Massachusetts' public pension fund VC commitments would be made to Massachusetts-based GPs.

Next, we calculate *Pension Fund State Share* for each state as the state's public pension fund VC commitments to GPs located in the same state divided by total VC commitments by the state's pension funds across all GPs in the country. The *Pension Fund State Share* for Massachusetts is 31%, which means that public pension funds in Massachusetts are overweight in Massachusetts-based VC funds as compared with the average LP in the United States. The home bias of a state's pension funds is calculated as *Overweight = Pension Fund State Share - Overall State Share*. In our sample, Massachusetts' public pension funds are 31%- 14.5% = 16.5% overweight in Massachusetts-based VC funds.

Finally, we obtain public pension fund asset data from the Census Bureau's Annual Survey of Public Pensions. These data are available from year 1993 to 2021. The average (median) nominal public pension fund asset over our sample period is $142.9 (72.9) billion. We estimate the change in supply of venture capital to a state-year as the state's total inflation-adjusted pension assets (in billions) in the state-year times *Overweight*. This instrument, which we call the pension assets instrument has a statistically significant correlation coefficient of 51% with total venture capital investments. Our identification assumption is that the home bias of pension funds and shifts in state-level pension fund assets are not endogenous to IPO decisions of firms in that state.

In Table 9, we present estimate equation 1 using the pension assets instrument as a proxy for the supply of venture capital to a state-year. Results for operating profits, OPER3, are presented in columns 1 to 5 of Table 9 and for SG3 in columns 6 to 10 of Table 9. We present estimates of equation 1 in the full sample and, to highlight the importance of information asymmetry, we also present estimates in subsamples of information asymmetry. In the interest of space, we focus on two proxies of information asymmetry – the indicator variable for hi-tech industries and the indicator variable for innovative industries. The sample size in Table 9 is noticeably smaller because public pension fund asset data is available only after 1993. In column 1, the coefficient on the employment share instrument is negative and statistically significant when the dependent variable is OPER3. When we focus on the subsamples with high information asymmetry (hi-tech firms in column 2 and innovative firms in column 3), we see that OPER3 is significantly lower when the supply of venture capital as captured by the pension asset instrument is high. In the subsamples with low information asymmetry (columns 4 and 5), the coefficient on the pension asset instrument is insignificantly different from zero. Thus, when focusing on profit margins, the pension-asset instrument delivers support for our hypothesis that an increase in the supply of venture capital leads to lower IPO quality.

Moving to columns 6 through 10, however, we see that sales growth, SG3, does not have a significant relation with the pension asset instrument in any of the regression specifications. Since results using the pension assets instrument are mixed, we examine post-IPO abnormal returns as a tiebreaker. Following the method described in Section 4.3 we examine calendar-time abnormal returns (CTARs) for a high-VC-supply event portfolio and a low-VC-supply event portfolio. An IPO firm is included in the high-VC-supply (low-VC-supply) event portfolio if it went public within the previous *n* months and the pension asset instrument during the issue year to the firm's state was (not) in the top quartile of the sample.

The portfolio excess returns based on equation 2 are plotted in Figure 6. The grey solid bar is the alpha of the high-VC-supply event portfolio and the bar with the horizontal lines is the alpha of the low-VC-supply event portfolio. A triangle placed at the end of the bar indicates whether the alpha is statistically significant. We see that the high-VC-supply alphas consistently lie below zero and are statistically significant from the 14-month to 16- month horizons. We also form a long-short, self-financing portfolio by long holding the high-VC-supply portfolio and short selling the low-VC-supply portfolio. The alpha of the long-short portfolio is presented in the same graph as a dashed line (labeled 'L-S diff') and the t-statistic of the long-short portfolio's alpha is reported as a dotted line. The dotted line lies below the 95% critical value at the 14- to 16- month horizons indicating that firms going public when the pension-asset-based VC supply is high experience poorer post-IPO abnormal returns than firms that go public when it is low. Overall, using the pension asset instrument, two of the three measures examined provide evidence supportive of our hypothesis.

7. Conclusion

The rise of private capital markets has been accompanied by a shrinking public market. The number of public companies fell by more than half between 1996 and 2021. This phenomenon has led to concerns about declining investment opportunities for "main street" investors. Recent studies such as Kwon et al (2020) and Ewens and Farre-Mensa (2020) argue that the decline in IPO activity since the early 2000s is attributable to the rise of private capital markets. We add to this stream of literature by showing that the supply of venture capital also affects the type of firm going public. Specifically, we show that an increase in the flow of venture capital investment to a state leads to a decline in the average quality of IPOs from that state.

To address endogeneity of venture capital investment, we use shifts in national VC fundraising to construct a shift-share instrument. Exposure of a state to shifts in national VC fundraising over a specific decade is based on the state's share of total VC investments during a fixed window preceding the decade. This Bartik-style shift share instrument serves as our estimate of the supply of venture capital to a state. We find that an increase in the supply of venture capital to a state is accompanied by a contemporaneous decline in the quality of issuing firms headquartered in that state. This finding is driven by the subsample of firms that suffer from high information asymmetry.

We argue that when the supply of venture capital goes up, it flows selectively to higher-quality startups enabling such firms to delay public issuance. In support of this screening explanation, we use a sample of VC-funded startups and show that when the supply of venture capital in a state increases sharply, higher-quality startups experience a bigger increase in both VC funding amounts and VC valuations than lower-quality startups. Finally, we ask whether the decline in IPO quality matters for returns earned by public investors. Under the efficient market's hypothesis, public investors pay a fair price for the IPO, and therefore, the supply of private capital should be unrelated to post-IPO returns. However, we find evidence of a negative relation between the supply of venture capital and post-IPO abnormal returns, which suggests that the stock market does not fully price in the decline in IPO quality associated with high supply of venture capital.

Our research adds to recent evidence on the negative impact of fast-growing private markets on the investment opportunities for public investors. It also helps understand recent moves by the SEC to change the 'accredited investor' definition in order to make private capital markets more accessible to smaller investors.

Appendix A: Variable descriptions

Variable	Definition
Age	The number of years between the IPO year and the founding year. Founding year is obtained from Dr. Jay Ritter's website.
Book-to-market	Book value of equity as of first fiscal year end following issue date divided by market capitalization as of calendar year end following issue date. Book value of equity is shareholder's equity plus deferred taxes and investment tax credits plus the redemption value of preferred stock. If redemption value is not available, liquidation value of preferred stock is used. If liquidation value is not available, par value is used.
Employment share instrument	Exposure of a state-year to inflation-adjusted venture capital investment (in $ billions) in year *t* is calculated by multiplying the share of the state's employment in industry *j* with shifts in total venture capital investment in industry *j* in year *t* and then summing across all industries. See definition of VC investment for the inflation-adjustment procedure.
IPO hot market	A dummy variable equal to one if IPO occurs in a calendar quarter classified as a hot IPO market and zero otherwise. Quarters are classified as hot IPO markets if the three-quarter moving average of IPO volume centered on that quarter is in the top quartile of our sample and zero otherwise.
IPO proceeds	Total dollar amount raised from the IPO (in $ millions)
Leverage	The sum of short- and long-term debts divided by total assets subtracting common equity and adding market capitalization. All book items are as of the first fiscal year end following issue date. Market capitalization is calculated as of calendar year end following issue date
Market capitalization	The product of common shares outstanding and stock close price at the calendar year end following issue date.
Offer price	Price per share at which the IPO is issued
OPER3	Post-IPO industry-adjusted operating profit margin of issuing firm, calculated as operating income before depreciation divided by total assets less the median value for all public firms in the same 2-digit SIC code, averaged up to three years after IPO.
Pension assets instrument	Calculated for each state-year as the state's total inflation-adjusted pension assets (in $ billions) in the state-year times *Overweight*, where Overweight captures how much public pension funds commitments in a state are overweight in own-state VC funds as compared to the average limited partner in the United States.
Sales	Issuing firm's sales in $ millions as of the first fiscal year end after issue date.
SG3	Post-IPO industry-adjusted sales-growth, calculated as the annual growth in sales of the issuing firm less the median value for all public firms in the same 2-digit SIC code, averaged up to three years after IPO.
Underpricing	Share price 21 days after IPO minus the offer price divided by the offer price
VC backed	Dummy variable equal to one for IPOs that received venture capital backing prior to IPO
VC investment	Inflation-adjusted venture capital (VC) investments aggregated by state and year. VC are identified as the deals from Refinitiv's Eikon Private Equity and Venture Capital database, whose primary security type is Common Stock, Venture Capital Equity Investment, or includes the key word of "Preferred," and whose investment stage is Early Stage, Later Stage, Seed, or VC Partnership. Inflation adjustment is made by dividing the nominal dollar amount by the

	quarterly inflation rate, which is calculated as the Implicit Price Deflator (GDPDEF from Federal Research Bank of St Louis) of the quarter divided by the Implicit Price Deflator of the first quarter of 1958.
VC supply	The supply of venture capital to a state estimated by multiplying state-level shares of VC investment over fixed windows with national level shifts in inflation-adjusted venture capital fundraising. Three different fixed windows are used to estimate states' share of VC investment: (i) Fixed Window 1: Jan 1980 through Dec 1981, (ii) Fixed Window 2: Jan 1994 to Dec 1995 and (iii) Fixed Window 3: Jan 2009 to Dec 2010. For each year *t* between 1982 to 1993 (inclusive), the annual supply of venture capital in state *s* is estimated as the state's share of VC investment during Fixed Window 1 times the average national VC fundraising in years *t-1* and *t-2*. The annual supply of venture capital in state *s* in each year *t* between 1996 and 2008 is estimated as the state's investment share over Fixed Window 2 times the average national VC fundraising in years *t-1* and *t-2*. The same process is used to estimate the annual supply of venture capital over the period 2011 to 2021, with the states' share calculated Fixed Window 3. Note that the three fixed windows over which the investment shares are calculated are excluded from the analysis. See definition of VC investment for the inflation-adjustment procedure.

Appendix B: Robustness tests

Regression of IPO quality on the supply of venture capital on a sample of firms that went public between 1980 and 2021. Measures of IPO quality are (i) OPER3 calculated as operating income before depreciation divided by total assets of the issuing firm less the median value for all public firms in the same industry, averaged up to three years after IPO. (ii) SG3 calculated as the annual sales growth of the issuing firm less the median growth rate of public firms in the same industry, averaged up to three years after IPO. VC Supply is the inflation-adjusted estimated supply of venture capital based on a shift-share instrument summarized in Table 1. In columns 1 and 2, the sample period is the same as in the baseline specification of Table 3, but a firm's headquarter state is based on historical state data from Gao, Leung, Qiu (2021). In all remaining columns of this table, a firm's headquarter state is obtained from Compustat (as in the baseline specification of Table 3) but the sample period varies. In columns 3 and 4, the dotcom bubble period from 1997 to 2000 is excluded. In columns 5 and 6, the subprime crisis period from 2008 through 2010 is excluded. In columns 7 and 8, COVID crises and the SPAC phenomenon are excluded by dropping the years 2020 and 2021. All control variables are described in Appendix A. *t*-statistics reported in parentheses are estimated based on standard errors clustered by year. Statistical significance at the 10%, 5% and 1% levels is highlighted by *, **, and ***, respectively.

	Using historic state		Drop 1997-2000		Drop 2008-2010		Drop 2020-2021	
	OPER 3	SG3	OPER 3	SG3	OPER 3	SG3	OPER 3	SG3
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
VC Supply	-0.014**	-0.034***	-0.009**	-0.032**	-0.013**	-0.025**	-0.023***	-0.028**
	(-2.257)	(-3.155)	(-2.040)	(-2.187)	(-2.103)	(-2.198)	(-3.909)	(-2.154)
Market cap (logs)	0.059***	-0.047***	0.059***	-0.062***	0.059***	-0.047***	0.060***	-0.047***
	(15.933)	(-4.496)	(16.715)	(-7.486)	(15.973)	(-4.528)	(15.115)	(-4.267)
Underpricing	-0.000	0.153***	0.021*	0.077**	-0.000	0.151***	-0.002	0.163***
	(-0.002)	(3.277)	(1.823)	(2.148)	(-0.037)	(3.314)	(-0.158)	(3.511)
Book-to-market	0.046***	-0.188***	0.036***	-0.210***	0.048***	-0.192***	0.045***	-0.181***
	(3.235)	(-4.019)	(3.104)	(-4.889)	(3.319)	(-3.989)	(2.972)	(-3.830)
Leverage	0.057**	-0.271***	0.042**	-0.315***	0.060**	-0.275***	0.047**	-0.279***
	(2.580)	(-2.939)	(2.040)	(-3.029)	(2.717)	(-2.924)	(2.225)	(-2.953)
VC backed	-0.086***	0.147***	-0.072***	0.123***	-0.086***	0.143***	-0.088***	0.147***
	(-8.170)	(5.487)	(-7.734)	(4.340)	(-8.200)	(5.361)	(-8.059)	(5.474)
Hot market	-0.002	0.011	0.007	-0.010	-0.002	0.013	-0.006	0.007
	(-0.064)	(0.149)	(0.319)	(-0.215)	(-0.076)	(0.172)	(-0.220)	(0.089)
Constant	-0.355***	0.626***	-0.344***	0.719***	-0.356***	0.627***	-0.344***	0.617***
	(-10.775)	(7.507)	(-14.184)	(14.322)	(-10.894)	(7.493)	(-10.020)	(7.020)
Observations	6,444	6,041	5,047	4,757	6,412	6,010	6,082	5,866
R-squared	0.277	0.106	0.277	0.109	0.277	0.105	0.292	0.107

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Figure 1: Distribution of IPOs over time

The distribution in calendar time of 8,182 initial public offerings (IPOs) occurring between 1980 and 2021. IPOs are obtained from Refinitiv's SDC Platinum database. The following IPOs are excluded - unit offerings, foreign issues, ADRs, IPOs with offer price below $5, and IPOs with missing sales or total assets data as of the first fiscal year end following issue date. The five states with the largest total number of IPOs in the sample period are highlighted.

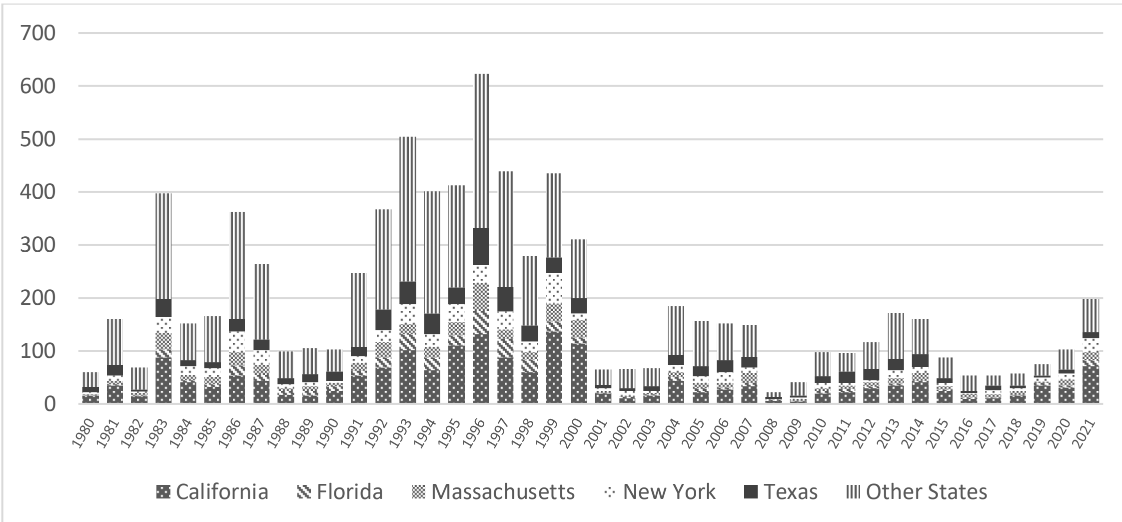
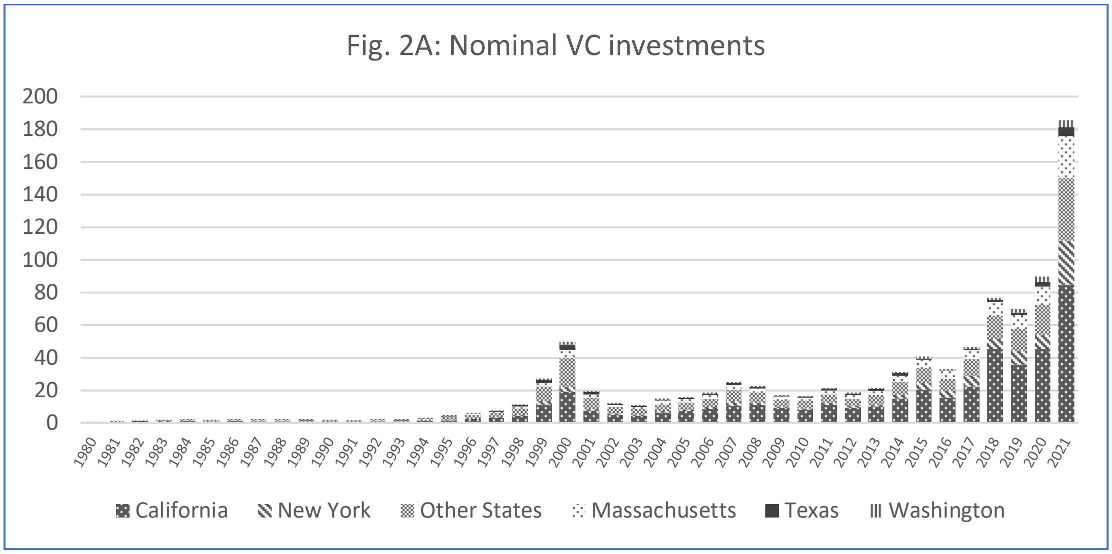


Figure 2: Venture capital investments

The distribution in calendar time of nominal venture capital investments in $ billion between 1980 and 2021. Venture capital investments from Refinitiv's Eikon Private Equity and Venture Capital database are included if the primary security type is either "Common Stock" or "Venture Capital Equity Investment", or contain the keyword "Preferred". In addition, we exclude the deals whose investment stage is not "Early Stage", "Later Stage", "Seed", or "VC Partnership. The five states with the largest total amount of venture capital investments in the sample period are highlighted.



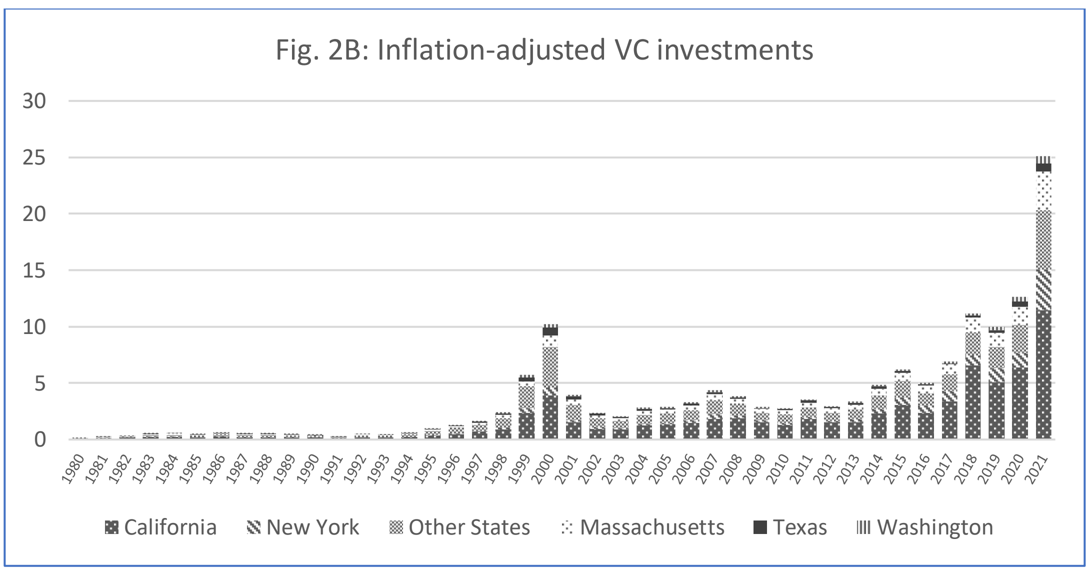
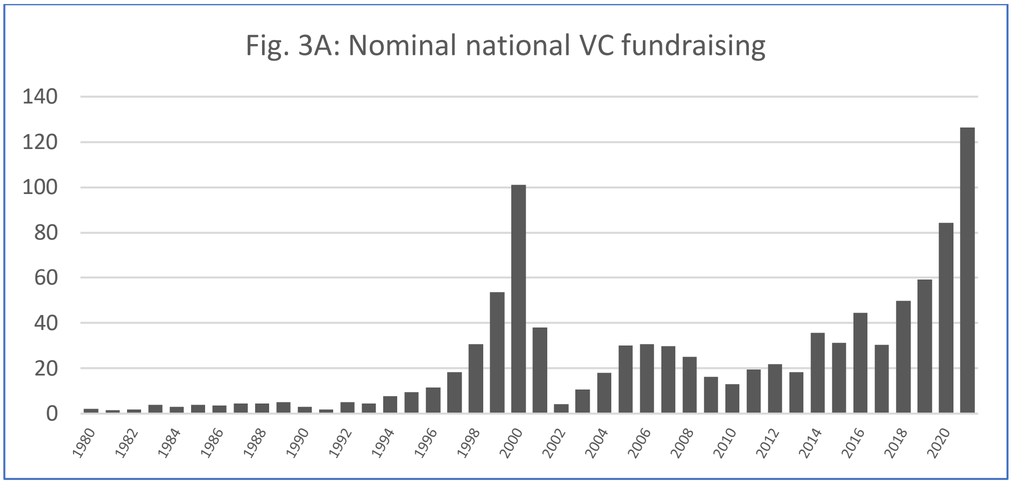


Figure 3: National venture capital fundraising

The distribution in calendar time of nominal and inflation-adjusted venture capital fundraising in $ billion between 1980 and 2021. Historical venture capital fundraising records are downloaded from Refinitiv's Eikon Private Equity and Venture Capital database for all U.S.-based venture capital funds.



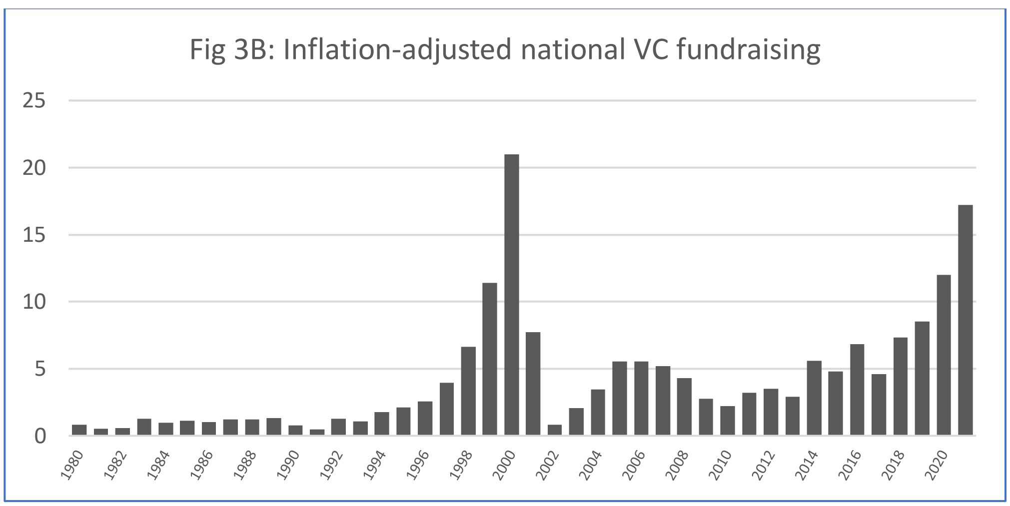
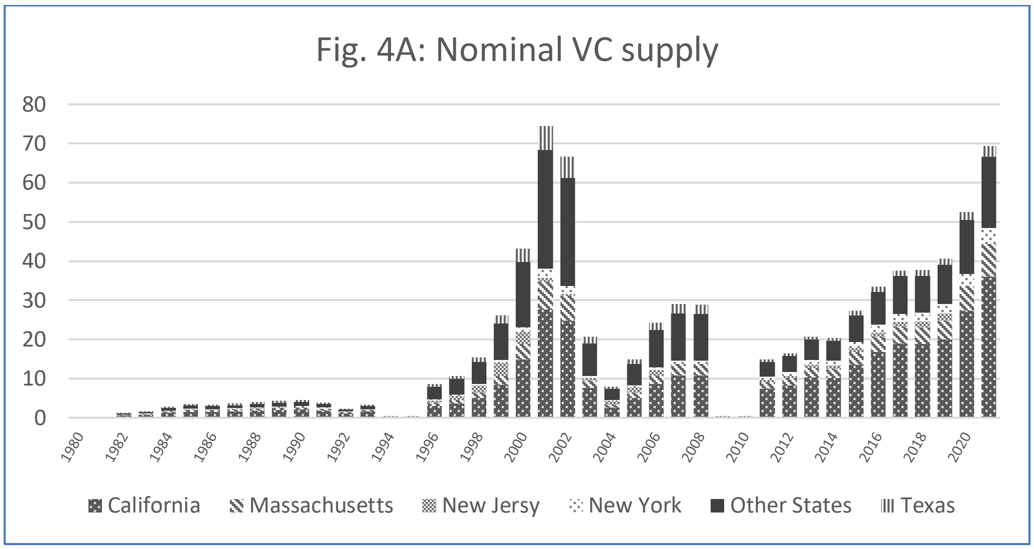


Figure 4: Estimated supply of venture capital

The distribution in calendar time of the estimated supply of venture capital (both nominal and inflation-adjusted) in $ billions between 1980 and 2021. The supply of venture capital to a state is estimated by multiplying state-level shares of VC investment over fixed windows with national level shifts in venture capital fundraising. We use three different fixed windows to estimate states' share of VC investment: (i) Fixed Window 1: Jan 1980 through Dec 1981, (ii) Fixed Window 2: Jan 1994 to Dec 1995 and (iii) Fixed Window 3: Jan 2009 to Dec 2010. For each year between 1982 to 1993 (inclusive), the annual supply of venture capital in state *s* is estimated as the state's share of VC investment during Fixed Window 1 times the average national VC fundraising in years *t-1* and *t-2*. The annual supply of venture capital in state *s* in each year *t* between 1996 and 2008 is estimated as the state's investment share over Fixed Window 2 times the average national VC fundraising in years *t-1* and *t-2*. The same process is used to estimate the annual supply of venture capital over the period 2011 to 2021, with the states' share calculated Fixed Window 3. Note that the three fixed windows over which the investment shares are calculated are excluded from the analysis.



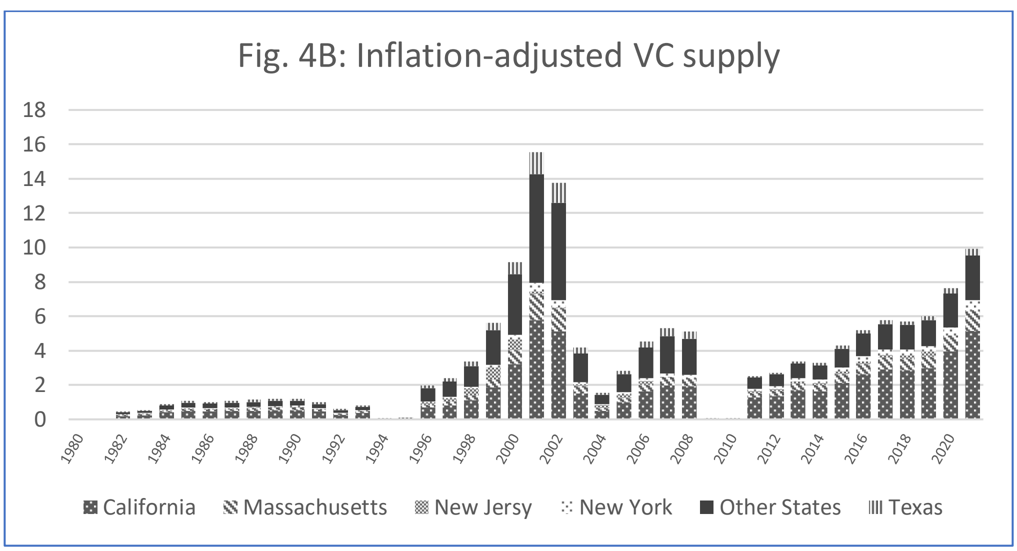


Figure 5: Calendar time abnormal returns

Alphas from Carhart 4-factor portfolio regressions over different investment horizons. For each month from January 1980 till December 2021, we create a High-VC-supply event portfolio and a Low-VC-supply event portfolio with different investment horizons ranging from 6 months to 24 months. For example, when the event horizon is 6 months, the High-VC-supply (Low-VC-supply) event portfolio for each month includes all companies that completed an IPO within the prior 6 months provided VC supply in the firm's state was (not) in the top quartile of the sample period. Both event portfolios are rebalanced monthly to drop firms that reach the end of the horizon *n* which ranges from 6 to 24 months and add firms that have just announced an IPO that meets the event criteria. The portfolio excess returns are regressed on the Carhart 4 factor model. The figure reports alphas from the 4-factor model and the t-statistics of the differences between the alphas of the High-VC-supply portfolio and Low-VC-supply portfolio. Triangles at the end of each bar indicate significance of the alpha at the 90% confidence level. The dotted line in the figure is the t-statistic of the difference between the alphas of the High-VC-supply portfolio and Low-VC-supply portfolio.

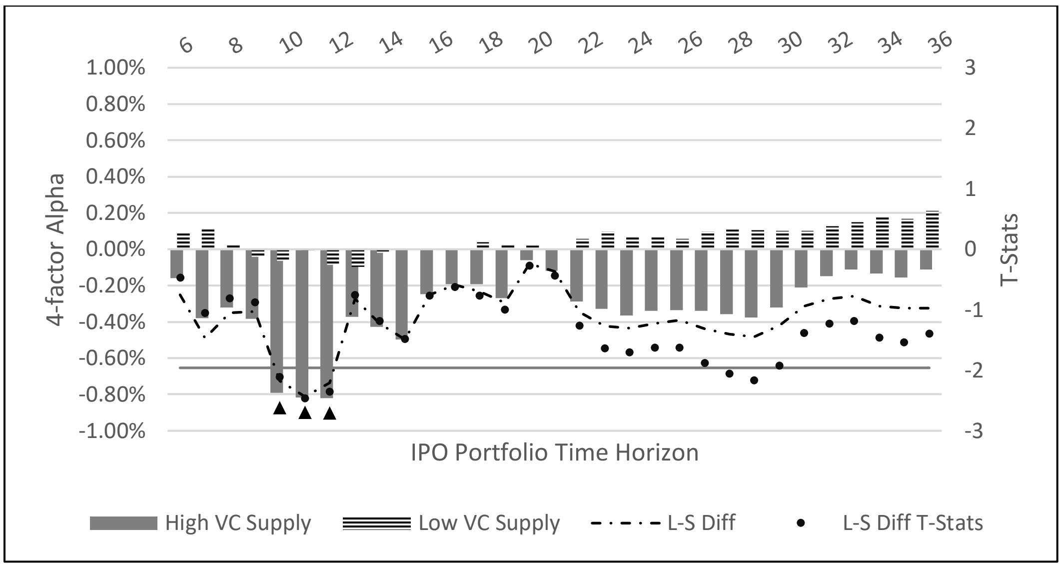


Figure 6: Calendar time abnormal returns using states' pension assets as intrument

Alphas from Carhart 4-factor portfolio regressions over different investment horizons. The method is the same as described for Figure 5, except that the high-VC-supply portfolio and the low VC-supply portfolio are based on the pension asset instrument described in Table 9. For a horizon *n*, an IPO firm is included in the high-VC-supply (low-VC-supply) event portfolio if it went public within the previous *n* months and the pension asset instrument during the issue year to the firm's state was (not) in the top quartile of the sample period. Both event portfolios are rebalanced monthly to drop firms that reach the end of the horizon *n* which ranges from 6 to 24 months and add firms that have just announced an IPO that meets the event criteria. The portfolio excess returns are regressed on the Carhart 4 factor model. The figure reports alphas from the 4-factor model and the t-statistics of the differences between the alphas of High-VC-supply portfolio and Low-VC-supply portfolios. Triangles at the end of each bar indicate significance of the alpha at the 90% confidence level. The dotted line in the figure is the t-statistic of the difference between the alphas of the High-VC-supply portfolio and Low-VC-supply portfolios.

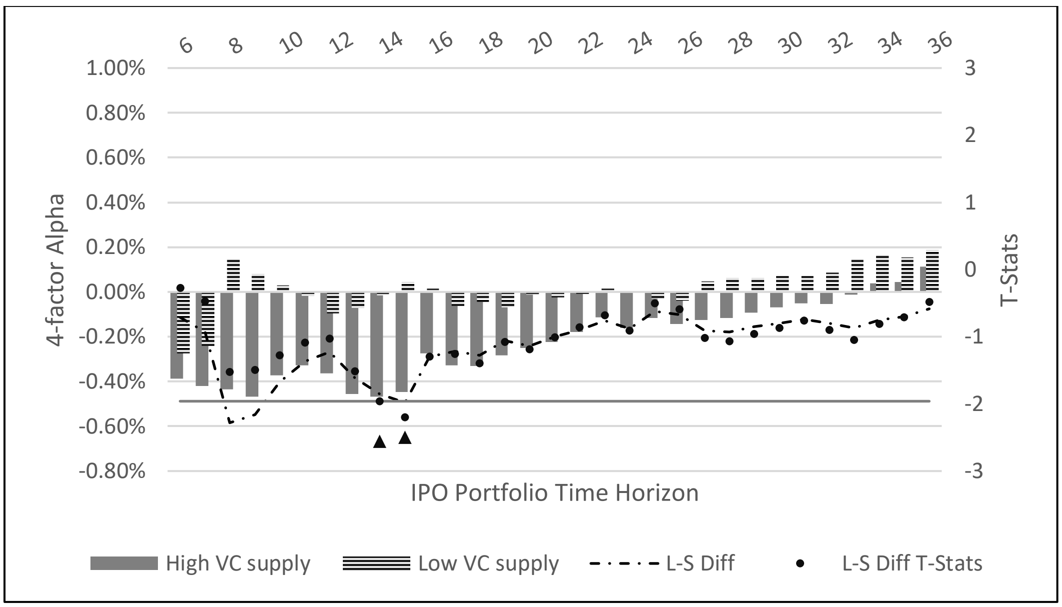


Table 1: IPO characteristics

Characteristics of 8,182 IPOs between 1980 and 2021 obtained from Refinitiv's SDC Platinum database. Unit offerings, foreign issues, ADRs, and IPOs with offer price below $5 are excluded. Panel A and B present two measures of IPO quality: (i) OPER3 is industry-adjusted operating profit, calculated as operating income before depreciation divided by total assets of the issuing firm less the median value for all public firms in the same 2-digit SIC industry, averaged up to three years after IPO, (ii) SG3 is industry-adjusted sales-growth, calculated as the annual growth in sales of the issuing firm less the median value for all public firms in the same industry, averaged for up to three years after IPO. Panel C presents control variables that are described in Appendix A. The following variables are winsorized at the 1% and 99% levels: book-to-market, underpricing, age, OPER3, and SG3. Panel D contains summary statistics of (i) inflation-adjusted venture capital investments by state-year between 1980 and 2021 (ii) inflation-adjusted supply of venture capital by state-year between 1980 and 2021.

Panel A: Measures of IPO quality	N	Mean	Median	p10	p90	StDev
3-year operating profit margin (OPER3)	7957	-0.06	-0.002	-0.35	0.14	0.21
3-year sales growth (SG3)	7529	0.35	0.14	-0.14	0.99	0.70

Panel B: Comparing IPO quality in the pre-dotcom (before 1995) and post-dotcom (1995 and later) periods						
OPER3						
Pre dotcom	3377	-0.024	0.016	-0.253	0.147	0.188
Post dotcom	4580	-0.086	-0.014	-0.416	0.125	0.227
Difference		-0.0620***	-0.0302***			
SG3						
Pre dotcom	3325	0.289	0.128	-0.118	0.773	0.590
Post dotcom	4204	0.396	0.155	-0.156	1.202	0.771
Difference		0.107***	0.0270***			

Panel C: IPO characteristics	N	Mean	Median	p10	p90	StDev
Offer price	8182	13.35	12.50	6.50	20.00	6.83
IPO proceeds	8166	111.71	38	7	215.9	438.61
Sales ($ millions)	8182	333.37	51.86	4.36	517.47	2179
Market capitalization ($ millions)	8167	578.47	145.97	23.04	1122.00	2309
Leverage	7973	0.11	0.03	0.00	0.35	0.16
Book-to-market	7989	0.42	0.33	0.10	0.86	0.31
Underpricing	8167	0.20	0.10	-0.15	0.63	0.38
VC Backed	8166	0.37	0.00	0.00	1.00	0.48
Age (years)	7901	15.94	9.00	2.00	41.00	19.62
IPO hot market	8182	0.55	1.00	0.00	1.00	0.50

Panel D: VC data (state-year level)	N	Mean	p50	p10	p90	SD
VC investment ($ billions)	1838	0.091	0.008	0.000	0.131	0.477
VC supply ($ billions)	1604	0.098	0.011	0.000	0.185	0.395

Table 2: Correlations

Pairwise correlation coefficients between firm-level dependent and independent variables for a sample of IPOs between 1980 and 2021. The sample selection process is described in Table 1. All variables are described in Appendix A.

	OPER3	SG3	Market cap (logs)	Underpricing	Book-to-market	Leverage	VC backed
OPER3	1.00						
SG3	-0.24	1.00					
Market cap (logs)	0.19	0.02	1.00				
Underpricing	-0.04	0.11	0.34	1.00			
Book-to-market	0.02	-0.11	-0.35	-0.30	1.00		
Leverage	0.15	-0.09	-0.03	-0.24	0.32	1.00	
VC backed	-0.26	0.14	0.10	0.22	-0.19	-0.30	1.00
Hot market	-0.04	0.04	-0.15	0.06	-0.02	-0.04	-0.02

Table 3: Supply of venture capital and IPO quality

Regression of IPO quality on the supply of venture capital on a sample of firms that went public between 1980 and 2021. In columns 1 to 6, the dependent variable is either OPER3 or SG3, both described in Table 1. In columns 7 and 8, the dependent variable is a variation of OPER3 or SG3 in which the industry median value is not subtracted. In columns 1 and 2, the main right hand side variable is total inflation-adjusted VC investment in the issuing firm's state during the year of issue. In columns 3 to 8, the main explanatory variable is the inflation-adjusted estimated supply of venture capital based on a shift-share instrument summarized in Table 1. All control variables are described in Appendix A. *t*-statistics reported in parentheses are estimated based on standard errors clustered by year. Statistical significance at the 10%, 5% and 1% levels is highlighted by *, **, and ***, respectively.

	OPER3	SG3	OPER3	SG3	OPER3	SG3	OPER3 No ind. adj.	SG3 No ind. adj.
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
VC investment	-0.012**	-0.021*						
	(-2.259)	(-1.760)						
VC supply			-0.013**	-0.026**	-0.044***	-0.029**	-0.014**	-0.029**
			(-2.108)	(-2.271)	(-3.525)	(-2.235)	(-2.214)	(-2.521)
Market cap (logs)	0.060***	-0.051***	0.059***	-0.046***	0.035***	-0.039***	0.061***	-0.047***
	(16.992)	(-4.970)	(16.076)	(-4.516)	(8.033)	(-4.098)	(15.611)	(-4.557)
Underpricing	-0.002	0.148***	-0.001	0.150***	-0.017	0.106**	-0.008	0.151***
	(-0.137)	(3.529)	(-0.043)	(3.290)	(-0.870)	(2.056)	(-0.601)	(3.444)
Book-to-market	0.054***	-0.210***	0.048***	-0.190***	0.029	-0.159***	0.043***	-0.202***
	(3.846)	(-4.790)	(3.364)	(-3.958)	(1.605)	(-4.122)	(2.768)	(-4.203)
Leverage	0.061***	-0.276***	0.058**	-0.280***	0.079***	-0.114	0.062**	-0.277***
	(3.075)	(-3.261)	(2.613)	(-2.990)	(4.257)	(-1.353)	(2.645)	(-2.885)
VC backed	-0.075***	0.138***	-0.086***	0.144***	-0.110***	0.162***	-0.092***	0.142***
	(-7.049)	(5.760)	(-8.256)	(5.413)	(-8.175)	(6.406)	(-8.417)	(5.373)
Hot market	0.003	0.008	-0.002	0.013	-0.002	0.006	-0.006	0.011
	(0.149)	(0.139)	(-0.075)	(0.172)	(-0.125)	(0.090)	(-0.203)	(0.146)
Constant	-0.363***	0.649***	-0.356***	0.625***	-0.202***	0.563***	-0.290***	0.743***
	(-12.140)	(8.160)	(-10.946)	(7.510)	(-6.369)	(7.265)	(-8.391)	(9.248)
Observations	7,468	7,063	6,433	6,031	6,434	6,031	6,433	6,031
R-squared	0.268	0.103	0.278	0.105	0.171	0.061	0.396	0.111
Industry FE	Yes	Yes	Yes	Yes	No	No	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
State FE	No	No	No	No	Yes	Yes	No	No

Table 4: Supply of venture capital and IPO quality in pre-dotcom and post-dotcom periods

Regression of IPO quality on the supply of venture capital in subsamples of firms that went public in the pre-dotcom period (defined as the years prior to 1995) and the post-dotcom period (defined as the years between 1995 and 2021). The measures of IPO quality are OPER3 and SG3. All variables and details are as described in Table 1. *t*-statistics reported in parentheses are estimated based on standard errors clustered by year. Statistical significance at the 10%, 5% and 1% levels is highlighted by *, **, and ***, respectively.

	OPER3		SG3	
	Pre dotcom	Post dotcom	Pre dot com	Post dotcom
	1	2	3	4
VC supply	-0.052***	-0.010	-0.049	-0.024**
	(-3.225)	(-1.627)	(-0.591)	(-2.112)
Market cap (logs)	0.061***	0.059***	-0.068***	-0.031**
	(13.195)	(12.318)	(-6.473)	(-2.265)
Underpricing	-0.012	0.008	0.075	0.159***
	(-0.597)	(0.592)	(1.271)	(3.053)
Book-to-market	0.020	0.069***	-0.278***	-0.133*
	(1.237)	(3.511)	(-5.755)	(-1.754)
Leverage	0.018	0.088**	-0.340***	-0.254*
	(0.718)	(2.791)	(-3.529)	(-1.824)
VC backed	-0.060***	-0.103***	0.147***	0.141***
	(-7.045)	(-7.995)	(4.914)	(3.306)
Hot market	0.001	-0.002	-0.023	0.027
	(0.061)	(-0.040)	(-0.424)	(0.210)
Constant	-0.264***	-0.423***	0.696***	0.571***
	(-8.399)	(-8.916)	(12.532)	(4.610)
Observations	2,563	3,866	2,501	3,526
R-squared	0.252	0.291	0.131	0.103
Industry FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes

Table 5: Supply of venture capital and IPO delisting rates

Panel A shows the number and percentage of IPOs between 1980 through 2021 that delisted due to failure within one, two years, or three years of going public. Following Yung et al (2008), a firm is classified as having delisted due to failure if the CRSP delist code lies between 400 and 599 (excluding 501, 502, 503, and 573). Panel B presents coefficients from logistic regressions of IPO delisting rates on the supply of venture capital. Columns 1 to 3 focus on delistings due to failure within 2 years after issue date while columns 4 to 6 focus on delistings due to failure within 3 years after issue date. t-statistics reported in parentheses are estimated based on standard errors clustered by year. Statistical significance at the 10%, 5% and 1% levels is highlighted by *, **, and ***, respectively.

Panel A: Number and percentage of delistings due to failure

	Number of IPOs that delist	Percentage of IPOs that delist
within 1 year	17	0.21%
within 2 years	224	2.74%
within 3 years	490	5.98%

Panel B: Likelihood of delisting

	Likelihood of delisting due to failure within:					
	2 years of issue date			3 years of issue date		
	(1)	(2)	(3)	(4)	(5)	(6)
VC supply	0.387***	0.373***	0.235**	0.275***	0.291***	0.313**
	(7.109)	(6.773)	(2.090)	(5.205)	(5.805)	(2.403)
Market cap (logs)	-0.693***	-0.687***	-0.947***	-0.552***	-0.571***	-0.798***
	(-7.128)	(-6.764)	(-9.540)	(-11.414)	(-10.630)	(-14.506)
Underpricing	0.090	-0.029	-0.257	0.449***	0.377***	0.081
	(0.422)	(-0.135)	(-1.343)	(3.481)	(3.243)	(0.527)
Book-to-market	-0.929***	-0.890**	-1.535***	-0.625***	-0.602**	-1.123***
	(-2.813)	(-2.529)	(-4.391)	(-2.754)	(-2.546)	(-4.730)
Leverage	1.420***	1.283**	1.679***	1.530***	1.281***	1.761***
	(2.643)	(2.526)	(2.801)	(4.240)	(3.634)	(4.534)
VC backed	0.406**	0.452**	0.382**	-0.020	0.045	-0.052
	(2.048)	(2.277)	(1.987)	(-0.119)	(0.291)	(-0.320)
Hot market	0.561**	0.469	0.290	0.354**	0.254	-0.001
	(2.045)	(1.619)	(0.618)	(2.311)	(1.571)	(-0.006)
Constant	-0.906*	0.143	1.438**	-0.484*	1.270***	1.774
	(-1.714)	(0.221)	(2.281)	(-1.770)	(3.497)	(1.361)
Observations	6,599	5,952	5,310	6,599	6,463	6,153
R-squared	0.111	0.148	0.234	0.0856	0.126	0.217
Industry FE	No	Yes	Yes	No	Yes	Yes
Year FE	No	No	Yes	No	No	Yes

Table 6: Supply of venture capital and IPO quality conditional on information asymmetry

Regression of IPO quality on the supply of venture capital in subsamples of information asymmetry. The measures of IPO quality are OPER3 and SG3. All variables and details are as described in Table 1. Panel A (Panel B) presents results for firms with high (low) information asymmetry. We use four proxies of information asymmetry: (i) firms in the hi-tech industry (SIC codes 283, 357, 366, 367, 382, 384, 737), (ii) firms in innovative industries, where an industry is classified as innovative if the truncation-bias adjusted number of successful patents by firms in that industry is above the sample median, (iii) firms listing on the NASDAQ, and (iv) young firms, identified as firms with age at IPO below the sample median. *t*-statistics reported in parentheses are estimated based on standard errors clustered by year. Statistical significance at the 10%, 5% and 1% levels is highlighted by *, **, and ***, respectively.

Panel A: Subsample with high information asymmetry

VARIABLES	Hi-tech firms		Innovative firms		Nasdaq firms		Young firms	
	OPER3	SG3	OPER3	SG3	OPER3	SG3	OPER3	SG3
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
VC supply	-0.014**	-0.049***	-0.016**	-0.037**	-0.014**	-0.031**	-0.015*	-0.039**
	(-2.505)	(-2.841)	(-2.660)	(-2.406)	(-2.212)	(-2.346)	(-1.930)	(-2.079)
Market cap (logs)	0.088***	-0.010	0.077***	-0.040***	0.073***	-0.020	0.077***	-0.030
	(11.175)	(-0.497)	(13.166)	(-3.076)	(13.289)	(-1.113)	(11.558)	(-1.529)
Underpricing	0.000	0.141**	0.004	0.134**	-0.005	0.131***	0.015	0.120**
	(0.008)	(2.458)	(0.269)	(2.559)	(-0.401)	(3.219)	(1.372)	(2.662)
Book-to-market	0.170***	-0.174	0.098***	-0.193*	0.090***	-0.219***	0.104***	-0.298***
	(4.549)	(-1.106)	(3.691)	(-1.972)	(4.784)	(-3.216)	(4.552)	(-3.195)
Leverage	0.073	-0.185	0.091**	-0.283	0.090***	-0.247**	0.112***	-0.409***
	(1.172)	(-0.793)	(2.430)	(-1.546)	(2.976)	(-2.191)	(3.477)	(-2.996)
VC backed	-0.083***	0.145***	-0.080***	0.168***	-0.087***	0.132***	-0.083***	0.103***
	(-6.089)	(3.896)	(-7.046)	(4.926)	(-7.857)	(4.856)	(-6.243)	(3.112)
Hot market	0.005	0.098	-0.003	0.076	0.001	0.027	-0.002	0.019
	(0.192)	(1.541)	(-0.108)	(1.015)	(0.026)	(0.361)	(-0.062)	(0.262)
Constant	-0.598***	0.378**	-0.504***	0.548***	-0.440***	0.504***	-0.518***	0.750***
	(-10.206)	(2.277)	(-10.972)	(4.761)	(-10.435)	(4.081)	(-11.614)	(6.110)
Observations	2,476	2,234	3,311	3,020	5,107	4,682	3,087	2,880
R-squared	0.264	0.115	0.283	0.113	0.280	0.108	0.304	0.109
Industry FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Panel B: Subsample with low information asymmetry

	Non-Hi-tech firms		Non-innovative firms		Non-Nasdaq firms		Not Young firms	
	OPER3	SG3	OPER3	SG3	OPER3	SG3	OPER3	SG3
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
VC supply	-0.013	-0.000	-0.009	-0.001	-0.013	-0.009	-0.013***	-0.022
	(-1.574)	(-0.017)	(-1.205)	(-0.042)	(-1.353)	(-0.444)	(-3.033)	(-1.140)
Market cap (logs)	0.044***	-0.057***	0.040***	-0.055***	0.028***	-0.076***	0.037***	-0.037***
	(12.865)	(-5.866)	(9.654)	(-3.849)	(5.905)	(-6.542)	(10.109)	(-3.862)
Underpricing	-0.013	0.143***	-0.017	0.171***	0.030*	0.090	0.000	0.052
	(-1.141)	(3.205)	(-1.320)	(3.213)	(1.726)	(1.580)	(0.001)	(1.543)
Book-to-market	-0.009	-0.178***	0.002	-0.186***	-0.041***	0.020	-0.020	-0.102**
	(-0.589)	(-3.775)	(0.166)	(-3.703)	(-3.224)	(0.306)	(-1.415)	(-2.506)
Leverage	0.055**	-0.286***	0.035	-0.326***	0.028	-0.346**	0.009	-0.163*
	(2.470)	(-3.171)	(1.630)	(-3.714)	(1.111)	(-2.700)	(0.400)	(-1.815)
VC backed	-0.080***	0.115***	-0.081***	0.109***	-0.087***	0.084	-0.062***	0.092***
	(-6.008)	(3.451)	(-5.297)	(3.335)	(-5.052)	(1.625)	(-7.274)	(2.972)
Hot market	-0.013	-0.063	-0.005	-0.075	-0.015	-0.039	-0.000	-0.001
	(-0.502)	(-0.775)	(-0.158)	(-0.869)	(-0.722)	(-0.558)	(-0.008)	(-0.017)
Constant	-0.221***	0.726***	-0.202***	0.726***	-0.132***	0.769***	-0.163***	0.415***
	(-8.057)	(9.725)	(-6.257)	(6.984)	(-3.442)	(9.009)	(-5.765)	(4.590)
Observations	3,957	3,797	3,120	3,009	1,322	1,345	2,931	2,708
R-squared	0.262	0.114	0.250	0.120	0.323	0.178	0.260	0.101
Industry FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Table 7: Funding amounts and valuations received by private firms

Panel A presents descriptive statistics of a sample of start-up firms that received venture capital financing between 2007 and 2021. Data on funding amount, post-money valuation (PMV), revenue, and founding date are obtained from PrivCo. Panel A presents descriptive statistics for 11,151 funding rounds (for 5,437 unique firms) that have non-missing data on revenue. We calculate annualized revenue growth using the most recent revenue data available prior to each funding round, provided the prior revenue data are not more than 4 years before the funding round. If no revenue data are available in the four years preceding a funding round, we drop the funding round from the sample. PMV-to-revenue multiple is calculated as PMV received in a funding round divided by revenue reported in the year of funding. Age is the number of years between funding round date and date the firm was founded.

Panel B presents regressions of funding amount and deal valuation on the supply of venture capital. In columns 1 to 3 of Panel B, the dependent variable is funding amount, which is the total dollar amount (in logs) of VC financing received in the funding round. In columns 4 to 6, the dependent variable is the post-money valuation (PMV, in logs) received in the funding round. In columns 7 to 9, the dependent variable is the PMV-to-Revenue multiple received in the funding round. The multiple is winsorized at the 1% and 99% levels. *t*-statistics reported in parentheses are estimated based on standard errors clustered by year. Statistical significance at the 10%, 5% and 1% levels is highlighted by *, **, and ***, respectively.

Panel A: Descriptive Statistics

Variable	N	Mean	p50	p25	p75	SD
Revenue growth	11151	1.75	0.34	0.07	1.00	31.35
Revenue ($millions)	11151	194.55	20.00	7.40	58.00	2333.51
Funding amount ($ millions)	10504	66.29	18.00	5.00	50.00	238.24
Post money valuation (PMV) ($ millions)	7222	949.67	185.00	60.00	500.00	4541.85
Age	10874	8.59	7.00	4.00	10.00	9.75
PMV-to-revenue multiple	7219	19.55	9.17	4.48	18.92	37.74

Panel B: The impact of supply of venture capital on funding amounts and valuations

	Funding amount (logs)			**Valuation (logs)**			**Valuation to revenue multiple**		
	Low growth sample	High growth sample	Pooled sample	Low growth sample	High growth sample	Pooled sample	Low growth sample	High growth sample	Pooled sample
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
VC supply (β_1)	0.104***	0.183**	0.100***	0.119***	0.183***	0.104***	-0.090	2.048***	0.157
	(3.563)	(2.845)	(3.218)	(4.638)	(3.628)	(3.519)	(-0.525)	(5.714)	(0.650)
High growth			0.327***			0.321**			-4.086**
			(4.026)			(2.798)			(-2.311)
VC supply x High growth (δ_1)			0.095**			0.112***			1.677***
			(2.566)			(3.499)			(3.621)
Age	0.353***	0.391***	0.394***	0.767***	0.808***	0.815***	-5.576**	-4.172***	-4.705**
	(5.821)	(4.347)	(12.871)	(11.330)	(19.684)	(15.284)	(-2.231)	(-4.475)	(-2.940)
Revenue	0.000***	0.000*	0.000***	0.000*	0.001***	0.001**	-0.002*	-0.004***	-0.002**
	(5.183)	(1.937)	(3.852)	(2.174)	(5.186)	(2.792)	(-1.864)	(-6.976)	(-2.545)
Constant	1.757***	1.959***	1.662***	3.452***	3.595***	3.312***	32.235***	22.046***	28.622***
	(14.628)	(11.566)	(23.954)	(33.044)	(27.762)	(35.908)	(6.478)	(11.591)	(7.848)
Observations	4,832	4,945	9,785	3,268	3,632	6,911	3,266	3,632	6,909
R-squared	0.224	0.275	0.232	0.278	0.399	0.328	0.150	0.132	0.131
Industry FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Table 8: Supply of venture capital and IPO quality using an alternative shift-share instrument

Regression of IPO quality on the supply of venture capital on a sample of firms that went public between 1980 and 2021. The dependent variable is OPER3 or SG3, both described in Table 1. Emp Share Instrument is a shift-share instrument constructed by multiplying a state's share of industry employment with shifts in industry venture capital investment. Columns 1 and 6 include the full sample of IPOs. Columns 2 and 7 (4 and 9) are restricted to IPOs in the hi-tech (non-hi-tech) industries. Columns 3 and 8 (5 and 10) are restricted to IPOs in the innovative (non-innovative industries). See Table 6 for the definition of hi-tech and innovative industries All variables are described in Appendix A. *t*-statistics reported in parentheses are estimated based on standard errors clustered by year. Statistical significance at the 10%, 5% and 1% levels is highlighted by *, **, and ***, respectively.

	OPER3					SG3				
	All	Hi-tech	Innovative	Non hi-tech	Non-innovative	All	Hi-tech	Innovative	Non hi-tech	Non-innovative
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Emp share instrument	-0.027	-0.041**	-0.046**	-0.015	-0.007	-0.112**	-0.193**	-0.159**	0.025	0.001
	(-1.321)	(-2.438)	(-2.414)	(-0.741)	(-0.384)	(-2.191)	(-2.530)	(-2.090)	(0.257)	(0.013)
Market cap (logs)	0.058***	0.086***	0.075***	0.044***	0.039***	-0.047***	-0.013	-0.043***	-0.056***	-0.052***
	(14.530)	(10.674)	(12.839)	(11.607)	(8.766)	(-4.103)	(-0.606)	(-3.151)	(-5.274)	(-3.325)
Underpricing	0.005	0.005	0.006	-0.008	-0.008	0.145***	0.141**	0.144***	0.130***	0.140**
	(0.406)	(0.347)	(0.364)	(-0.656)	(-0.649)	(3.147)	(2.553)	(2.939)	(2.824)	(2.470)
Book-to-market	0.050***	0.169***	0.096***	-0.004	0.006	-0.179***	-0.167	-0.192*	-0.170***	-0.181***
	(3.129)	(4.138)	(3.706)	(-0.228)	(0.334)	(-3.759)	(-0.985)	(-1.880)	(-3.732)	(-4.004)
Leverage	0.074***	0.098	0.092**	0.066***	0.046**	-0.298***	-0.334	-0.340*	-0.294***	-0.327***
	(3.725)	(1.435)	(2.672)	(3.227)	(2.169)	(-3.131)	(-1.349)	(-1.976)	(-3.132)	(-3.538)
VC backed	-0.079***	-0.073***	-0.072***	-0.071***	-0.074***	0.129***	0.131***	0.156***	0.099***	0.093**
	(-6.450)	(-4.465)	(-5.593)	(-4.859)	(-4.415)	(4.654)	(3.440)	(4.245)	(2.812)	(2.492)
Hot market	-0.003	0.007	0.001	-0.017	-0.013	0.020	0.106*	0.071	-0.046	-0.052
	(-0.162)	(0.304)	(0.040)	(-0.972)	(-0.611)	(0.319)	(1.825)	(1.019)	(-0.727)	(-0.936)
Constant	-0.368***	-0.605***	-0.509***	-0.235***	-0.208***	0.641***	0.410**	0.584***	0.731***	0.726***
	(-10.700)	(-9.921)	(-11.000)	(-8.108)	(-6.146)	(7.110)	(2.288)	(4.863)	(9.145)	(6.550)
Observations	6,342	2,459	3,367	3,883	2,974	5,995	2,207	3,062	3,788	2,932
R-squared	0.273	0.259	0.274	0.262	0.258	0.102	0.115	0.110	0.110	0.121
Industry FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Table 9: Supply of venture capital and IPO quality using states' pension assets as instrument

Regression of IPO quality on the supply of venture capital on a sample of firms that went public between 1980 and 2021. The dependent variable is OPER3 or SG3, both described in Table 1. Pension assets instrument is calculated as the state's annual pension assets times the home bias in the VC commitments of the state's pension funds. Columns 1 and 6 include the full sample of IPOs. Columns 2 and 7 (4 and 9) are restricted to IPOs in the hi-tech (non-hi-tech) industries. Columns 3 and 8 (5 and 10) are restricted to IPOs in the innovative (non-innovative industries). See Table 6 for the definition of hi-tech and innovative industries All control variables are described in Appendix A. *t*-statistics reported in parentheses are estimated based on standard errors clustered by year. Statistical significance at the 10%, 5% and 1% levels is highlighted by *, **, and ***, respectively.

	OPER3					SG3				
	All	Hi-tech	Innovative	Non hi-tech	Non-innovative	All	Hi-tech	Innovative	Non hi-tech	Non-innovative
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Pension assets instrument	-0.003***	-0.005***	-0.005***	-0.001	-0.001	0.002	0.001	0.003	0.004	0.004
	(-3.114)	(-3.620)	(-3.555)	(-1.297)	(-1.094)	(0.496)	(0.116)	(0.424)	(0.805)	(0.644)
Market cap (logs)	0.062***	0.088***	0.081***	0.044***	0.037***	-0.039**	0.004	-0.027	-0.056***	-0.053**
	(11.640)	(10.233)	(11.492)	(7.888)	(5.487)	(-2.422)	(0.147)	(-1.449)	(-3.222)	(-2.159)
Underpricing	0.008	0.007	0.006	-0.007	-0.010	0.170***	0.151**	0.157***	0.190***	0.205**
	(0.577)	(0.484)	(0.339)	(-0.486)	(-1.048)	(3.304)	(2.536)	(2.868)	(3.107)	(2.659)
Book-to-market	0.078***	0.188***	0.128***	0.007	0.016	-0.163**	-0.101	-0.135	-0.165***	-0.184**
	(3.332)	(3.811)	(3.669)	(0.305)	(0.615)	(-2.694)	(-0.585)	(-1.276)	(-2.939)	(-2.637)
Leverage	0.093***	0.060	0.103*	0.091***	0.069**	-0.177	-0.156	-0.082	-0.142	-0.257*
	(3.134)	(0.676)	(1.912)	(2.981)	(2.051)	(-1.260)	(-0.505)	(-0.353)	(-0.975)	(-1.826)
VC backed	-0.087***	-0.076***	-0.078***	-0.081***	-0.085***	0.140***	0.158**	0.204***	0.094	0.050
	(-6.452)	(-4.400)	(-5.844)	(-4.313)	(-4.898)	(3.142)	(2.698)	(3.820)	(1.673)	(0.965)
Hot market	0.002	0.015	0.007	-0.017	-0.013	0.011	0.085	0.054	-0.064	-0.081
	(0.077)	(0.481)	(0.265)	(-0.590)	(-0.365)	(0.135)	(1.153)	(0.633)	(-0.710)	(-0.999)
Constant	-0.428***	-0.646***	-0.576***	-0.264***	-0.220***	0.575***	0.234	0.407**	0.732***	0.763***
	(-8.645)	(-8.539)	(-9.293)	(-5.845)	(-4.050)	(4.353)	(1.091)	(2.750)	(5.594)	(4.244)
Observations	3,963	1,769	2,322	2,194	1,639	3,699	1,567	2,083	2,132	1,614
R-squared	0.277	0.259	0.283	0.282	0.279	0.101	0.112	0.112	0.119	0.127
Industry FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes