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Investment risk allocation and the venture capital exit market: Evidence from early stage investing[☆]

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ABSTRACT

This study provides evidence on how venture capitalists' (VCs') allocations of capital to riskier investments, as measured by the proportion of early versus late-stage investment in an industry, are linked to exit market conditions. Prior research has primarily focused on how VCs adjust aggregate investment to public equity market conditions. We develop a more inclusive measure of exit market conditions that accounts for recent secular changes that have affected the industry return structure, specifically, the sharp rise in the number of failures and M&A relative to IPO exits. We show that the dollars gained relative to dollars lost in recent exits and failures are significantly positively related to VCs' allocations to early-stage companies over the period 1990–2008. The changes in allocations are large enough to have an effect on the availability of funding for early stage companies. In sum, our evidence shows that exit market conditions have a significant and economically meaningful influence on VCs' allocations to riskier investments.

1. Introduction

The cyclicality of exit market conditions presents a long standing challenge for venture capitalists (VCs). Exit market conditions play a vital role in VCs' ability to monetize their investments, affecting both performance and reputation. Yet, there is relatively little empirical evidence showing the relationship between exit market conditions and VCs' investment decisions. The existing literature has primarily focused on how VCs adjust the amount of investment in relation to conditions in the public equity markets. Prior research finds that aggregate industry-level capital investment is positively related to indicators of public market strength (Gompers et al., 2008), and is negatively related to future fund returns (Gompers and Lerner, 2000; Kaplan and Schoar, 2005; Harris et al., 2014). In this study, we examine another critical aspect of VCs' investment decisions, namely their aggregate capital allocations to riskier investments.

Although VCs can manage the risk of venture investments in multiple ways, we focus on how risk is managed by the funding provided to the stage of investment. The stages of venture investment define a continuum of developmental risks that VCs consider in allocating capital to new investments. VC firms frequently specialize in a particular stage of development, and entrepreneurs seek funds according to the stage of their enterprise. Investments in early stage companies (i.e., seed, start-up, and early stage) are typically the riskiest investments VCs make because the companies lack an extensive track record of performance and, therefore, have a higher probability of failure compared to later stage companies. To capture this risk, we examine VCs' allocations of capital in relation to the proportion of investments made in early stage companies in an industry (hereafter, referred to as "risk allocation"). In so doing, we examine an important but largely unexplored dimension of how the risk of VCs' portfolios is linked to exit market conditions.

Understanding how VCs adjust the capital allocated to early-stage investments is important for several reasons. First, the proportion of VC investments in early stage companies has varied from a high of 44% in 1986 to a low of 20% in 2001, with considerable variation in between. The aggregate availability of funding for early stage companies has historically been important for economic growth, technological innovation, and VC reputation. Moreover, the pronounced swings in risk allocation allude to VCs having a varying tolerance for risk that influences their investment decisions. Second, adjustments in aggregate capital investment and risk allocation likely have offsetting effects on future returns. In response to weak exit markets, VCs tend to reduce investment which, all else equal, should *increase* average future returns because VCs are

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more likely to invest at lower valuations and exercise more selectivity when they perceive less favorable exit outcomes. At the same time, in weak exit markets VCs could reduce allocations to early stage companies, which could significantly *decrease* average future returns because less risky investments entail diminished returns, ceteris paribus. In other words, the boost to future returns associated with a reduction in capital investment ("downsizing") may be offset to some degree by the diminished returns from less risky investments in later stage companies. By examining the relative effects of risk allocation and capital investment together, we provide a more complete picture of the cyclical nature of returns in the industry.

We conjecture that VCs are likely to increase (decrease) their allocations to riskier early-stage investments when they perceive the exit market to be strong (weak). These perceptions are formed based on increases (decreases) in the gains relative to losses from recent investment outcomes.[1] The prior literature examining VCs' capital investment activity has used equity market indices, the number of recent initial public offerings (IPOs) in an industry, and industry Q-Ratio as proxies for market conditions (see Gompers et al., 2008). However, the market signals used in prior studies omit several secular changes in the industry return structure that could influence VCs' perceptions of investment gains relative to losses. First, over the past decade, there has been a sharp decline in the number of IPOs (Gao et al., 2013), and a correspondingly large increase in exits by sale or acquisition (hereafter referred to as "M&A"). We later show these M&A exits have significantly lower returns on average than IPOs. Second, there has been by a large increase in failures and investments that do not pay off and likely result in −100% returns.[2]

To measure exit market conditions, we develop an inclusive measure of exit market conditions, referred to as the "Gains-to-Losses Ratio" (*GLR*), which accounts for both IPO and M&A exits––as well as failed investments. *GLR* is the ratio of the average net dollars gained from exits to average dollars lost to failures in an industry. In the baseline analyses, at any point of time, *GLR* is generated over prior 12 month windows from the exit returns VCs realize on their investments in individual portfolio companies. Exit return is the aggregate return accruing to the group of VCs holding stakes in a portfolio company that has an IPO, M&A, or a failure as an outcome, which we then aggregate for each of the six major industry groups. Our sample of outcomes includes 1436 IPOs, 1222 M&As, and 4468 failures from U.S. venture-backed companies that occur over 1990–2008, for which we can compute exit returns. This framework based on disaggregated portfolio company-level outcomes allows us to judge how subsequent investment decisions are influenced by tangible exit ("upside") and failure ("downside") events. Our approach diverges from prior studies that typically use fund-level returns, which are cumulative in nature and do not reveal the characteristics and timing of specific investment outcomes.[3]

Our main focus is the relation between exit market conditions and the capital that VCs allocate to early-stage companies. We show that, ceteris paribus, VCs' level of early stage investments in an industry is positively related to exit market conditions, as captured by *GLR* computed from recent exits. Our analysis controls for other indicators of exit market strength used in prior studies (e.g., NASDAQ, the number of IPOs), VC industry performance (IRRs), and aggregate capital investment. Notably, *GLR* explains more of the variation in VCs' allocations to early stage investments compared to other frequently used market indicators.

Our main results for *GLR* also hold when we control for the number of startups seeking VC funding, as a proxy for supply-side variation in the investment opportunities available to VCs, as well as the accumulation of investments that have not had an exit, which could lead VCs to become defensive and reduce early stage investments. Because VCs' risk allocations can influence the funding available to early stage companies, we approximate the magnitude of *GLR*'s effect on the funding available to startups in dollar terms. Our results indicate that changes in VCs' risk allocation are large enough to materially affect the aggregate capital available to early stage companies.

An important issue raised by the results is to what extent the changes in risk allocation at the industry level are explained by other attributes of VCs that affect their abilities and investment preferences. For example, a VC's individual investment decision is likely influenced by its general experience, its preferences for investing in a particular stage or industry (Gompers et al., 2008), or its tolerance for failure (Tian and Wang, 2014). These attributes represent other ways VCs can manage risk and thus the operative question is, once we control for the effects of VC attributes, whether the results between aggregate risk allocation and *GLR* hold. Our findings are materially unchanged when we include VC attributes in the industry level regressions. Our results also hold when we estimate the regressions with the dependent variable constructed at the VC firm level and include VC firm fixed effects to control for time-invariant VC firm-level heterogeneities. These additional tests show that our industry level results capture the individual responses of VCs to exit market conditions.

In the latter part of the sample from 2001–08, we observe two significant changes in the nature of exits: an increase in the frequency of M&A exits with lower average returns and an increase in the frequency and the average amount of capital lost to failures. Both of these factors, all else equal, reduce *GLR* and therefore have the potential to reduce allocations to early-stage companies. To explore whether the sensitivity of VCs' risk allocations to *GLR* has increased over time, we include a linear time trend (*Time*) and an interaction term ($GLR \times Time$) in the regressions explaining risk allocation. The coefficient on the interaction term $GLR \times Time$ is significantly positive, indicating that VCs' sensitivity to *GLR* increases over time. In addition, when we decompose *GLR* into its components of average observed gains and losses, both have the predicted signs – subsequent investments in early stage companies are significantly positively related to gains and negatively related to losses. Importantly, the results show that VC risk allocations have become less sensitive to gains and more sensitive to losses over time. Both results suggest that VCs alter the risk of their investments in response to changes in *GLR*, and in the more constrained exit market that followed the dotcom collapse, reduce their allocations to early stage companies.

Next, we turn to the issue of the effect of risk allocation on future exit returns. Conditional on exit, we find a positive relation between VC risk allocation at the time of investment initiation and the future returns associated with these exits. Allocations to early stage investments have a positive effect on the on average returns to future M&A and IPO exits, keeping in mind that this positive effect is expected to be offset unconditionally by a higher likelihood of failures among early stage investments. Because exits are the primary means of capital recovery in the VC industry, risk allocation is likely to have a dampening effect on future exit returns relative to capital investment. For example, over 2001–08, on a per industry basis, we estimate there has been approximately

[1] For example, in their ethnography of the VC investment process, Valliere and Peterson (2004) state that "Successes and failures of investments by other VC firms can be noted and analysed for intelligence about competitive conditions and the dynamics of the market sector in which the investee companies operated."

[2] "The Venture Capital Secret: Three out of Four Start-Ups Fail," Deborah Gage, *Wall Street Journal*, September 20, 2012.

[3] Prior studies of private equity frequently employ VC fund-level returns to assess the performance of the asset class (e.g., Ljungqvist and Richardson, 2003; Kaplan and Schoar, 2005; Phalippou and Gottschalg, 2009 and Harris et al., 2014).

a 37% decrease in capital investment and a 7.2% decrease in the proportion of early stage funding. Based on our regression results, we estimate that it would take an 8.2% decrease in the proportion of early stage investments to offset the marginal improvement in exit returns consistent with such a large decrease in capital investment. Therefore, the resulting decrease in conditional exit returns from lowered allocations to early stage investments is potentially large enough to offset some of the positive benefits of downsizing on exit returns.

In sum, our results suggest that risk allocation is another important dimension of the cyclicality associated with the VC industry that affects investment decisions and subsequent returns.

The outline of the paper is as follows. In Section 2, we review the related literature, describe our proxy for exit market conditions, the *GLR* measure, and propose several hypotheses about VC risk allocation. In Section 3, we describe our data and sample of VC investments and our measure of exit returns. Section 4 explores the distributional properties of exit returns. In Section 5, we examine the relation between *GLR* and VC investment in early stage companies. In Section 6, we examine how subsequent exit returns are related to risk allocation. Section 7 presents our conclusions.

2. Related literature and hypotheses

In this section, we first review the prior literature on how the exit market affects VC investments, introduce our measure of exit market conditions, and offer several hypotheses about how the risk and future returns of investments could change in relation to VCs' perceptions of the exit market.

2.1. Related literature

When venture capital is described as a cyclical business, it typically refers to the fact that aggregate fund inflows, investment, and financial returns are all heavily dependent on the strength of the exit markets. Consistent with this, the prior literature finds that exit markets have a strong influence on VCs' investment decision-making. Large inflows of capital into the industry give VCs the opportunity to put more money to work, so that aggregate capital inflows are positively related to the number of subsequent rounds of investment undertaken by VCs (Gompers et al., 2008). The amount of investment, in turn, influences the price of investments, and the pre-money valuations of investments have been found to increase following periods of high capital inflows (Gompers and Lerner, 1998). As prices rise, however, the returns to investments made in periods of high capital inflows tend to be subsequently lower due to the "money chasing deals" phenomenon (Gompers and Lerner, 2000; Kaplan and Schoar, 2005; Harris et al., 2014). The lower returns ultimately reduce capital inflows into the industry, increasing returns and thus starting the cycle over again.

In a similar spirit to the prior studies on aggregate capital inflows, we examine the influence of exit market conditions on the proportion of VC investments in early stage companies in an industry, arguably the riskiest investments VCs make.[4] A large literature in finance documents that investors exhibit a time varying appetite for risk that is often linked to the broader outlook for aggregate economic conditions. Generally speaking, the greater the risk of the assets, the more funding becomes constrained in weak market conditions (e.g., high yield debt, IPOs). As early stage investments involve a high degree of risk compared to later stage investments, the variation in VCs' risk allocation could similarly affect the funding available to entrepreneurs and early stage companies.[5] Although VCs can draw on their experience, knowledge of an industry, or sector preferences, and diversify their holdings to help manage risk at the portfolio level, the individual choices of VCs may not be sufficient to offset the aggregate trends in risk allocation. Thus, our contribution is to empirically assess the relative influence of exit market conditions on VCs' allocations to riskier investments, controlling for capital investment (the focus of prior literature), and other means VCs have to manage risk.

2.2. Measuring exit market conditions: the Gains-to-Losses Ratio (GLR)

Prior research typically relies on some measure of IPO activity to assess the strength of the exit market. But changes have occurred in the exit market that suggest inferences based on IPO activity alone might not fully capture the variations in VC investment conditions. In Fig. 1, we plot the natural logarithm of annual gross realizations to VCs from IPOs and M&A exits, and the average money invested in failed companies over 1986–2008. One observes in the figure that M&A exits contribute a significant and increasing proportion of realizations from VC exits over time. This is consistent with the results in Smith et al. (2011) and Chaplinsky and Gupta-Mukherjee (2014) that show M&A exits make up a substantial fraction of total VC realizations.

In addition, the market indicators used in prior studies do not account for failures, and Fig. 1 also shows a large increase in the average losses from failures over time. Prior studies find that about 15% of investments in VC-backed companies result in bankruptcies or "zero-valued exits" as described in Hall and Woodward (2010) and, if portfolio companies without an investment in the past five years are included (i.e., "living dead" as described in Ruhnka et al., 1992 and Sahlman, 1990), the incidence of zero-value investment outcomes increases substantially. Thus, the downside risk posed by losses could be an important consideration to VCs that likely influences their investment decisions.

In order to capture market signals associated with the outlook for riskier investments, we develop a more inclusive measure than has been used in the existing literature, the Gains-to-Losses Ratio (*GLR*), to characterize the investment environment in an industry that includes IPOs, M&A exits, and failures. We construct *GLR* as the average net money from exits divided by the average money invested in failures in an industry. For an industry g in month m, the Gains-to-Losses measure is constructed as:

$$GLR_{g,m} = \frac{\text{Net money from exits in industry g during } (m-12) \textit{ to } (m-1)}{\text{Money invested in failures in industry g during } (m-12) \textit{ to } (m-1)}$$

where net money from exits is the average exit value accruing to VCs net of the amount invested in exited companies in industry g during the 12 months $m-12$ to $m-1$.[6] Money invested in failures is the average amount invested in companies in industry g that were recorded as failures over the same period.[7] The sample of failures

[4] A related literature focuses on alternative metrics based on innovative output, specifically patent activity, to measure the outcomes in VC investments (e.g. Nanda and Rhodes-Kropf, 2013; Chemmanur et al., 2014). In Nanda and Rhodes-Kropf (2013), capital inflows or "hot periods" are the signal of increased VC risk appetite. Moreover, they find that periods of strong capital inflows are associated with increased investment into riskier, more innovative companies as measured by patent activity.

[5] Consistent with this, several industry reporting services such as *Pitchbook* and the *Fenwick West Silicon Valley Venture Capital Survey* report the industrywide proportion of early stage rounds (Series A) compared to later stage rounds as a barometer of VC risk appetite and ease of funding availability for entrepreneurs.

[6] In unreported robustness checks, we estimate the results using alternative windows to the 12 months preceding month m, ranging from 18 to 36 months. The results are not sensitive to the length of window used.

[7] So long as there exists a reasonable number of failures in an industry, using the average amount invested for failures in the denominator of *GLR* reduces a potential concern about the underreporting of failures compared to alternatives that depend on the frequency of failures. In Section 4, we discuss several alternative specifications of *GLR* and show that the results are similar for other measures of *GLR*.

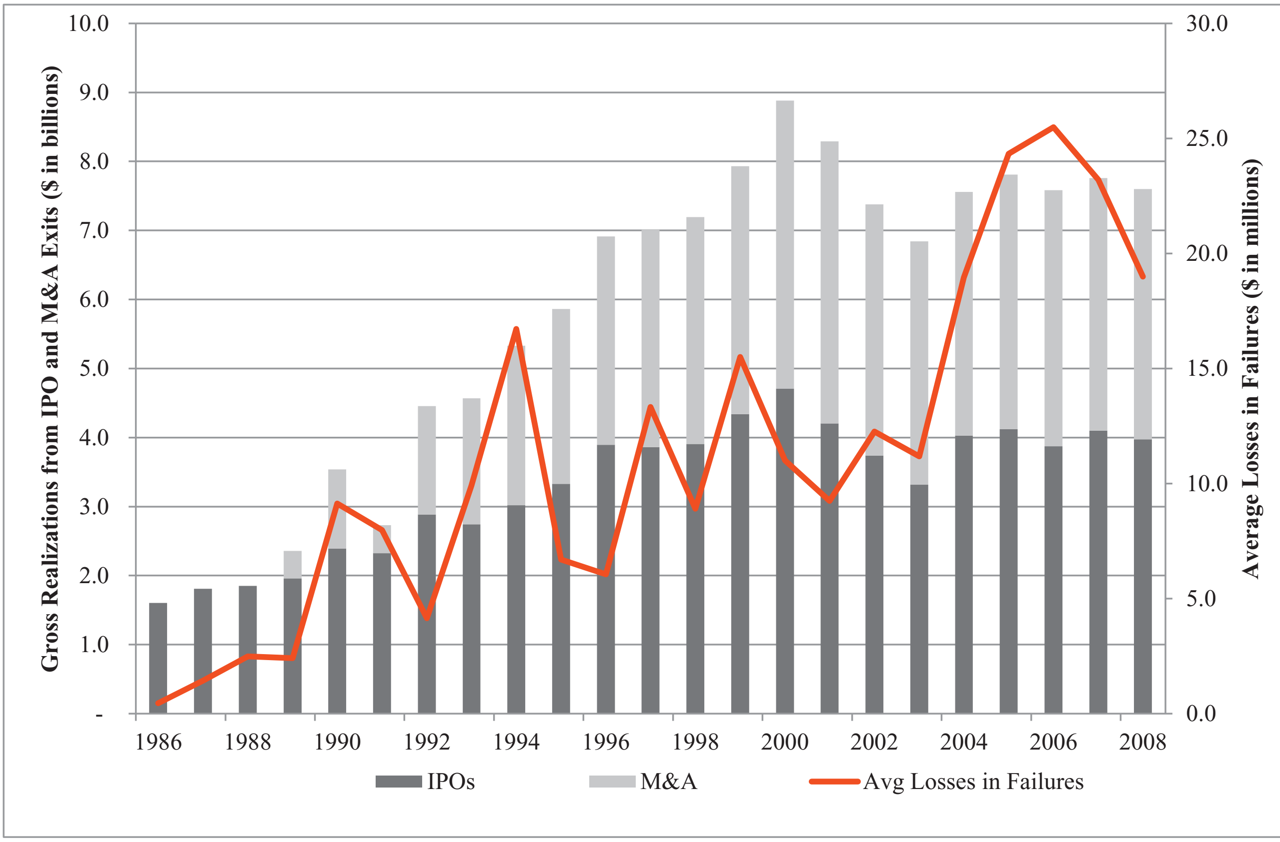

Fig. 1. Venture-backed exits and losses in failures over 1986–2008. The figure plots the natural logarithm of gross realizations from IPO and M&A exits (in $ billions), and the average losses in failures ($ in millions) of companies declared bankrupt, defunct, or "living dead" (i.e. without any rounds of financing for at least five years as of December 2008) over the period 1986–2008. The sample is obtained from *Venture Economics* and includes IPO and M&A exits for which postmoney round valuation data and transaction (for M&A) or offering (for IPOs) data is available. Failures are restricted to portfolio companies that have at least two rounds of investment.

includes defunct companies, bankruptcies, and companies listed as "active" but classified as "living dead." Consistent with prior literature, our baseline definition of living dead is companies with at least five years without any financing activity as of the end of the sample period.

GLR is computed at the industry level for several reasons. First, it is well known that VCs tend to focus on particular industries and gain expertise with the technology, product cycles, market dynamics, regulatory processes, and key personnel through repeated investments in an industry, making industry knowledge an important factor affecting a VC's investment decisions. Second, by computing *GLR* on an industry basis, we account for potential differences in exit values and funding considerations across industries (e.g., size, capital-intensity, and scale requirements).

GLR is constructed to be similar to a "coverage ratio" in order to intuitively convey how, on average, the net dollars returned from exits cover the dollars invested in an industry over the prior 12 months. On average, the net dollars recovered from exits covers almost four times the dollars invested in failed companies, but varies widely over time. To get a sense of its variation over time, Fig. 2 plots *GLR* (averaged across industries) versus the quarter-end values of NASDAQ.[8] The average value of monthly *GLR* is 3.6, and exhibits its lowest values (near zero) in 1991, 1994, and 2003 and its highest values of over 12 in 2000.

[8] Based on Fig. 2 the average *GLR* appears highly correlated with NASDAQ especially at its peak, but for the overall time series, the correlation between NASDAQ and *GLR* over matching windows is 0.31.

2.3. Proposed hypotheses

We propose that when exit markets appear strong and *GLR* is high, VCs can take more risk because fewer successes are necessary to produce acceptable returns. When *GLR* is low, mistakes are more difficult to recover from and VCs are likely to reduce their risk exposure. This leads to our first hypothesis:

Hypothesis 1. An industry's Gains-to-Losses Ratio (*GLR*) is expected to be positively related to VCs' investments in early stage companies in the industry.

An alternative possibility is that some VCs could be so pessimistic about future returns that they choose to "gamble," and increase allocations to early stage companies when *GLR* is low to increase the chances of an extreme positive outcome. Because this strategy has a low ex ante probability of success, it is unlikely to be the aggregate response to lower *GLR* across all VCs. In addition, if VCs do not perceive greater risk to be associated with early stage investments because other investments in their portfolio offset that risk (e.g., are allocated to late stage investments), then VCs' aggregate risk allocation may not be sensitive to *GLR*. Therefore, if VCs respond to *GLR*, it suggests that VCs factor in the risk of early stage investments when they respond to exit market conditions.

Cochrane (2005) finds that VC returns are characterized by high positive skewness. All else equal, as the returns from successful exits (and the degree of positive skewness) increase, the more at liberty VCs are to deemphasize downside risk in making investment decisions. It could be that VCs with reputational capital at stake constantly evaluate downside risk and weigh the potential for success (net money from exits) against the potential cost of failure

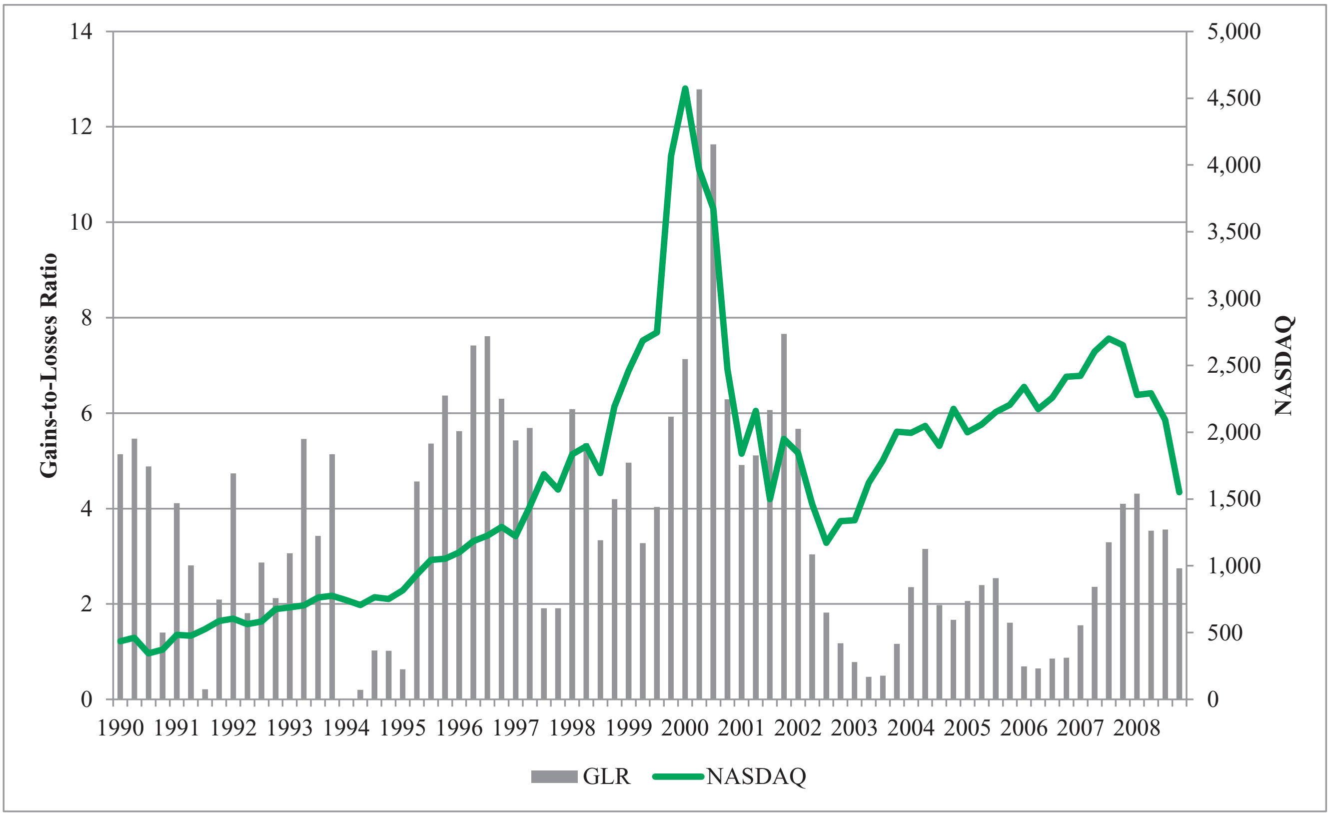

Fig. 2. Average annual Gains-to-Losses Ratio over 1990–2008. The figure plots the average Gains-to-Losses Ratio (*GLR)* across industries against the quarter-end levels of the NASDAQ market index. The values of *GLR* are three month averages corresponding to calendar quarters of the *GLR* ratio for all VC investments across the six VE industry categories.

in making investment decisions. On the other hand, if downside risk becomes greater on a relative basis in particular periods, VCs' sensitivity to downside risk could increase at that time. Our second hypothesis relates to the sensitivity of VC investments to net money from exits and failures over time:

Hypothesis 2. All else equal, the proportion of investment in early stage companies is expected to be positively related to gains and negatively related to losses observed in an industry. If the effects of observed gains and losses on VCs' allocations to early stage companies are constant through time, the coefficients of gains and losses should remain unchanged over time.

In the finance literature, risk is positively related to returns. To the extent that early stage companies pose more risk to VCs than later stage companies, this leads to our final hypothesis:

Hypothesis 3. All else equal, future exit returns from new investments in an industry are expected to be higher (lower) on average following periods when VCs allocate capital to a larger (smaller) proportion of investments in early stage companies.

3. Sample of exit outcomes and returns

This section describes the data on the outcome of investments in venture-backed companies and our calculation of exit returns.

3.1. Sample data

Our primary source of data is *Thomson Reuters's Venture Economics* (VE) database. Because previous papers have raised concerns about the completeness of VE data as well as the self-reported nature of VC data, we supplement the VE data with the *Thomson Reuters's SDC Platinum New Issues* database, *SDC Platinum Mergers and Acquisitions* (*M&A*) database, U.S. Securities and Exchange Commission (SEC) EDGAR filings, and hand collection of data. Our initial sample consists of all U.S.-based portfolio companies with reported investments from VC firms that had final outcomes during the period 1986–2008 resulting in (1) mergers, acquisitions or buyouts (categorized broadly as "M&A" exits); (2) IPOs; or (3) failures. In order to calculate returns from M&A or IPO exits, we require that the companies have a reported deal value (for M&A) or offering information (for IPOs), an exit date, and postmoney valuation data for the rounds of financing. The exit date is the effective date of the deal for an M&A, and is the offering date for an IPO.

The failures are companies listed in VE as bankrupt (Chapter 7 or Chapter 11), defunct, or classified as "living dead." For failures, we assume that VCs lose their entire investment, i.e., earn a −100% return. Of the 4468 total companies identified as failures in our sample, 126 are bankruptcies, 1869 are defunct, and 2473 are living dead. As VCs are naturally reluctant to declare a company bankrupt or defunct, we classify active investments as living dead if they have not received a financing round for at least five years as of December 2008. Our results are insensitive to other definitions of living dead based on four, six, or seven years without a financing round. For bankruptcies, the "exit date" is the date of the bankruptcy filing, and for defunct companies, the date, if available, is when the company is reported defunct in VE, or, if unavailable, five years from the last financing round.

Due to the differences in the scope of reporting requirements, we lose more M&A observations from the initial sample because of missing data compared to IPOs. Missing M&A data results primarily from two sources – missing interim postmoney valuations data and, to a greater extent, missing disclosed deal values. We

Table 1
Frequency of M&A and IPO exits. This table reports the number of M&A and IPO exits from U.S. venture-backed portfolio companies during the period 1986–2008. The sample is restricted to exits with postmoney round valuation data from Venture Economics (VE), and transaction value data (for M&A) or offer price data (for IPOs) from either SDC or VE databases.

Exit year	M&A	IPO	M&A/(M&A + IPO) (%)
1986	0	4	0.0
1987	0	5	0.0
1988	0	3	0.0
1989	1	3	25.0
1990	1	8	11.1
1991	2	19	9.5
1992	9	24	27.3
1993	13	46	22.0
1994	21	30	41.2
1995	30	106	22.1
1996	42	159	20.9
1997	56	108	34.1
1998	71	73	49.3
1999	116	243	32.3
2000	190	218	46.6
2001	120	34	77.9
2002	104	24	81.3
2003	72	31	69.9
2004	114	96	54.3
2005	102	58	63.8
2006	73	59	55.3
2007	61	79	43.6
2008	24	6	80.0
Total	1222	1436	

lose M&A observations in cases where private acquirers choose not to disclose the deal value, and for public acquirers where the deal value falls below the threshold required for mandated disclosure and the acquirer chooses not to disclose it.[9]

To supplement and verify the VE data for M&As, we gather additional information from the *SDC Platinum M&A* database, and hand collect data from the press releases and financial statements of firms frequently listed in VE as acquirers (e.g., Intel, Cisco, Lucent, and Google). Through these additional sources, we are able to fill in approximately 400 missing M&A deal values (i.e., around one-third of our final sample) where the acquirer publicly discloses the deal value but it is not recorded in VE, and we are also able to verify the deal values where we find overlapping observations.

For IPOs, we augment the VE data with data from *SDC Platinum New Issues* database and SEC EDGAR registration statements (S-1 s). EDGAR contains S-1 s starting in 1994, so that our search is restricted to the period thereafter. We use these additional sources to confirm the VE IPO offering (exit) date, and to fill in missing exit dates and other terms of the offering. The use of several data sources ensures greater accuracy and completeness of the VE data and allays some of the concern about self-reporting.

In order to estimate returns for M&A and IPO exits, we require information on VCs' equity stakes in a portfolio company, for which we need postmoney round valuations for consecutive rounds and the amount invested in a round. Eighty-eight percent of the companies reporting post money valuations in our sample have complete data across all rounds with 98% missing not more than one postmoney round valuation. A total of 1222 M&A exits and 1436 IPO exits have sufficient postmoney valuation data to calculate returns. Table 1 reports the annual frequency of M&A and IPO exits in our sample. Of note, is the sharp rise in the frequency of M&A exits over time. With the exception of 2007, M&A make up more than the majority of exits in every year from 2001 onwards.

Since the requirement of both postmoney data and disclosed exit values results in a greater loss of M&As than IPOs, in Appendix A, we compare characteristics of M&A exits with postmoney values with and without disclosed exit values. Our sample with disclosed exit values accounts for nearly 62% of the total dollars invested in portfolio companies exited by M&As. Qualitatively, the two samples are similar in characteristics, especially in terms of medians, but M&As with disclosed deal values have more capital invested on average than those without disclosed deal values. Although, all else equal, higher invested capital reduces the potential return, a likely scenario is that larger amounts of invested capital are associated with higher disclosed deal values. Since a concern with M&As is that they have lower average returns than IPOs, the exclusion of smaller M&A deals likely leads to overstatement of measured M&A returns.

3.2. Calculation of exit returns

We derive estimates of VCs' equity stakes in portfolio companies from the postmoney valuations (*POST*) reported by VE for each round of investment (I) in a portfolio company.[10] We assume before the first round investment that founders of the firm hold 100% of the equity ownership. For each round k, the fraction of ownership sold to VCs (F) is measured as $F_k = I_k/POST_k$. Each round of investment subsequent to the first round results in a larger cumulative share of the company being sold, and the VC stakes (*VC%*) measure the total percentage of ownership stake sold to VCs in the portfolio company by the exit date.

Because the accuracy of the VC stakes computed from VE postmoney valuations are critical to our analysis, we conduct additional checks to verify the accuracy of our estimates by comparing the VC stakes in IPO exits to a matched sample of stakes gathered from S-1 filings.[11] There is no statistically significant difference in the stakes estimated from the S-1 s and VE postmoney valuations for IPOs. Although we do not have a comparable means to verify the stakes in M&A exits, the additional steps taken to confirm IPO equity stakes bolsters confidence in our estimated VC equity stakes.

For each portfolio company j exiting via M&A or IPO in period t, with VC stakes at exit represented by $VC\%_{t,j}$, we compute the exit return ($Exit\_Return_{j,t}$) as the aggregate return accruing to the group of VCs holding stakes in the company as:

$$\text{Exit\_Return (M\&A)}_{j,t} = \left(\frac{\text{VC\%}_{t,j} \times \text{Disclosed transaction value for portfolio company } j}{\text{Total amount invested in portfolio company } j \text{ by VCs}}\right) - 1.$$

$$\text{Exit\_Return (IPO)}_{j,t} = \left(\frac{\text{VC\%}_{t,j} \times \text{Pre}-\text{IPO shares} \times \text{IPO offer price for portfolio company } j}{\text{Total amount invested in portfolio company } j \text{ by VCs}}\right) - 1$$

Following Cochrane (2005), we use the offer price in calculating IPO returns to abstract from the issue of underpricing, which has been the subject of extensive discussion elsewhere in the literature. Bradley et al. (2001) and Ofek and Richardson (2001) find

[9] Deal values must be disclosed to the SEC if a private company is purchased by a publicly listed firm and, depending on the form of payment and year of sale, it represents more than 10–20% of its assets (Rodrigues and Stegemoller, 2007).

[10] See Smith and Smith (2004) for a discussion of the venture capital method. Korteweg and Sorensen (2010) use this method to assess the risk and beta of venture investments.

[11] S-1 filings are publicly-vetted information on VC investments from which we can compare the equity stakes computed from VE data. We search the S-1s of each company to identify the primary stakeholders ("Principal Stockholders") for a match with venture capital firm names obtained from VE. When a match is found, we note the percentage equity ownership the VC holds in the portfolio company, obtaining 4,194 VC firm-company level stakes in the process. We then aggregate the stakes of all VC firms linked to a company to obtain a measure comparable to our construct of VC stakes, *VC%*.

Table 2
Descriptive statistics: sample of portfolio companies with outcomes. The table reports descriptive statistics for U.S. venture-backed portfolio companies that had exit outcomes during 1986–2008. Panel A reports statistics for the sample of M&A and IPO exits. Panel B reports statistics for the sample of failures defined as companies declared bankrupt, defunct, or "living dead" (i.e., companies without a round of financing for at least five years as of December 2008). Mean values are reported for the overall sample along with means across the six major industry classifications used by *Venture economics. No. of rounds* is the number of rounds of financing received by the company prior to exit. *No. firms invested in company* is the number of venture capital (VC) firms that invested in the company. *Round amount* (*$ million*) is the average amount invested per round. *Money – in* (*$ million*) is the total known amount invested in the company by VCs. *Years to exit* is the number of years between the date of first VC investment in the company and the date of outcome (i.e., exit or failure).

	Panel A: Sample of M&A and IPO exits						
	Overall	Biotech	Communications/ media	Computer related	Medical/health/life sciences	Non-high tech	Semiconductor/ other electrical
No. of rounds	4.8	5.8	4.9	4.5	5.4	3.8	4.9
No. firms invested in company	7.4	9.1	8.4	7.1	7.8	4.7	8.3
Round amount (*$million*)	14.1	11.4	18.0	10.6	11.6	25.2	15.6
Money – in (*$ million*)	57.5	63.1	79.5	42.6	53.2	76.4	59.0
Years to exit (*in years*)	4.8	5.4	4.3	4.3	5.8	5.1	5.2
No. of Companies	2658	227	489	1100	340	301	185
	Panel B: Sample of failures						
	Overall	Biotech	Communications/ media	Computer related	Medical/health/life sciences	Non-high tech	Semiconductor/ other electrical
No. of rounds	3.4	4.0	3.4	3.3	4.3	3.3	3.6
No. firms invested in company	4.0	4.7	4.9	4.2	4.4	2.6	4.7
Round amount (*$million*)	6.5	4.4	9.8	5.7	4.1	6.6	6.3
Money – in (*$ million*)	21.4	16.8	34.2	18.4	15.8	18.6	23.8
Years to exit (*in years*)	7.3	8.2	7.1	6.9	8.3	7.6	7.8
No. of Companies	4468	157	816	1932	304	1030	229

strong positive stock price performance between the offer date and IPO lock up expiration dates, suggesting that the offer price assumption likely understates IPO returns. The exit returns we use are similar to the widely used investment multiple, (TVPI − 1). In our construct, a 0% return indicates break even, i.e., the investment returns the capital invested in the portfolio company by VCs. Appendix B provides a more detailed explanation of the components of exit returns and how they bear on our proposed hypotheses.

4. Properties of exit outcome

This section we report descriptive statistics on the exit outcomes from VC investments.

4.1. Basic sample characteristics

In Table 2, we provide descriptive statistics on the M&A and IPO exits and failures in our sample. Statistics are reported for the overall sample and for the six major industry groups used by VE. In Panel A, for the overall sample of exited companies, a typical exit occurs after approximately five rounds of investment and the average total dollars invested per company ("money-in") is $57.5 million. By comparison, failures in Panel B receive an average of 3.4 rounds of investment and average money-in per company of $21.4 million. Not surprisingly, the averages for the number of rounds and money invested in failures are less than the averages for exited companies. This suggests that VCs continually update their assessments of performance and poor performers are less likely to receive further rounds of financing.

In Table 3, we examine the distributional properties of exit returns (*Exit_Return*) for the sample of M&A and IPO exits. For the overall sample, the mean return to VCs from M&A exits is 99.5% compared to 211.7% for IPO exits, a difference of 112.2% that is significant at the 1% level. Both forms of exit display highly skewed returns where the mean returns substantially exceed the median returns (−31.5% for M&A; 109.7% for IPOs). To account for the time taken to achieve an exit, in unreported results we also compute an annualized return (r) derived from the relation $(1+ \mathit{Exit\_Return}) = (1+ r)^t$, where *Exit_Return* is the company-level exit return and t is the number of years to exit. Consistent with results for *Exit_Return*, the average annual return for M&A exits is significantly lower than the average annual return for IPO exits. Our subsequent findings are robust to adjustments for time to exit, and therefore we report only the results for *Exit_Return*.

Table 3
Exit returns from venture-backed M&A and IPO exits. The table reports the mean and median exit returns (*Exit_Return*). The pool of venture-backed IPO and M&A exit returns are sorted into groups based on the top 25% (high), middle 50% (medium) and bottom 25% (low) of returns. The data are winsorized by excluding the top and bottom 5% of the returns for each type of exit. ***, **, * indicates statistical significance at the 1%, 5%, and 10% level respectively. The p-Values are reported based on a t-statistic (Pearson's chi-squared) test for the difference in means (medians).

	Exit returns					
		All	Low	Medium	High	High–Low
All exits (%)	Mean	160.1	−82.6	65.0	593.6	433.5
	Median	50.5	−85.3	50.5	527.8	477.3
	N	2658	665	1329	664	
IPO (%)	Mean	211.7	−79.6	75.0	569.7	358.0
	Median	109.7	−80.4	63.6	504.6	394.9
	% of N	54.0%	24.1%	62.4%	67.3%	
M&A (%)	Mean	99.5	−83.5	48.5	642.8	543.3
	Median	−31.5	−86.5	23.4	617.6	649.1
	% of N	46.0%	75.9%	37.6%	32.7%	
	Mean (IPO – M&A)	112.2***				
	(p-Value)	(0.00)				
	Median (IPO – M&A)	141.2***				
	(p-Value)	(0.00)				

To examine the range of exit returns, in Table 3 we also pool the overall sample of returns and sort them into three groups: Low (bottom 25%), Medium (middle 50%), and High (top 25%). The groups separate the middle 50% of returns, or most likely outcomes, from the extremes. To examine the extremes and the upside and downside potential of exit returns, we compute "High–Low," which is the difference between the mean and median returns in the top and bottom 25% of the sample. Both M&A and IPOs in the lowest 25% of the pooled returns have mean and median returns on the order of −80%, so that the difference in

Table 4
Summary statistics on returns by company stage at first VC round. This table reports the mean and median exit returns and the frequency of failures for investments classified by whether the first round of VC investment occurred at an early stage in a company's development (e.g., a seed, start up, or early stage round) or at a later stage in the company's development (e.g., expansion, second or later round).

		1st VC round at early stage	1st VC round at later stage	Early stage–late stage
All exits (%)	Mean	215.4	167.3	48.0
	Median	88.0	61.5	26.4
IPO (%)	Mean	285.4	238.3	47.0
	Median	173.0	132.2	40.7
M&A (%)	Mean	161.9	78.3	83.7
	Median	3.4	−40.0	43.4
	Mean (IPO – M&A)	123.4	160.1	−36.6
	Median (IPO – M&A)	169.6	172.2	−2.6
% of failures		38.0	10.1	27.9

High– Low is generated by the top 25% returns (543.3% for M&A exits and 358.0% for IPOs). While *some* M&A exits are capable of producing extremely favorable outcomes, M&A exits occur at a lower frequency in the High group (32.7%) compared to the Low group (75.9%). This confirms the common suspicion that many M&A serve as "last resort" exits and, in general, show that IPOs are more likely than M&A to generate capital to cover losses on subpar exits and failures.

In Table 4, we present summary statistics on how the VCs' returns to IPO and M&A exits and frequency of failures vary by the company's stage of development when it receives a first round of VC investment. The results highlight the risk-return trade-offs VCs face as they change their allocations from early to late stage investments. For this analysis, we estimate returns based on whether the first VC round occurs in a seed, startup, or early stage round or occurred in a later stage (e.g., the first investment is an expansion, or B or later round). For the overall sample, the mean return to early stage investments is 215.4% compared to 167.4% for later stage investments, a difference of 48.0%. The fall-off in returns from early to late stage is observed for both IPO and M&A exits. While the difference in exit returns suggests VCs face a large "sacrifice" of potential returns if they reduce allocations to early stage investments, there is also a substantially reduced chance of failure. The frequency of failures for investments initiated at an early stage is nearly four times greater (38.0% compared to 10.1%) compared to investments initiated in a later round, confirming the conventional wisdom that early stage companies are riskier investments.

5. Risk allocation of investments

In this section, we describe our measure of risk allocation in an industry and investigate its relation with *GLR*.

5.1. Effect of GLR on risk allocation

To capture the capital allocation to riskier investments, we use *% Industry Early Stage Rounds* as our baseline measure. In month m for industry g, *% Industry Early Stage Rounds* is defined as the proportion of VC-backed investment rounds in the industry to early stage companies in the next 12 months, specifically:

$$\%\,\text{Industry Early Stage Rounds}_{g,m} = \frac{\text{No. of early stage rounds in industry } g \text{ during } (m{+}1) \text{ to } (m{+}12)}{\text{No. of rounds in industry } g \text{ during } (m{+}1) \text{ to } (m{+}12)}$$

Since our interest is to examine the impact of exit market conditions on subsequent investments, risk allocation is measured over rolling 12 month *forward-looking* windows. Here, No. of early stage rounds and No. of rounds in industry g are the number of financing rounds raised by early stage companies and total number of VC-backed financing rounds over the 12 months $m{+}1$ to $m{+}12$ in industry g, respectively. For the full sample, on average, 30.4% of rounds in an industry are early stage rounds.

We also consider two alternative measures of risk allocation. *% Industry ES First Rounds* is the proportion of investments in the industry that are first round investments in early stage companies. Although in principle, *% Industry ES First Rounds* represents the purest measure of risk, it is based on the fewest observations that can lead to less precise estimates. *% Industry First Rounds* measures the proportion of first round investments. A VC making a first round investment will not have its own track record of performance to observe before making the investment and thus it indicates VCs' willingness to initiate positions and put capital at risk rather than keeping it as "dry powder." On the other hand, not all first round investments are made in early stage companies.

Table 5 presents regressions explaining risk allocation where the dependent variable in Panel A is *% Industry Early Stage Rounds*. Based on Hypothesis 1, *GLR* should be positively related to VCs' future allocations to early stage companies in an industry. All of the independent variables are constructed using prior rolling 12 month periods over $m{-}12$ to $m{-}1$ in recognition that VCs continually assess market conditions, and will refer to the most recent information when evaluating potential investments.[12] As indicators of the strength of the public equity markets, we include the cumulative monthly percentage return on the NASDAQ market index (*NASDAQ*) (column (2)), and the natural logarithm of the number of IPOs in an industry (log (*No. IPO Exits*)) (column (3)). Gompers et al. (2008) find that capital investment is positively related to public market signals and, to distinguish the effects of capital investment from *GLR*, we include a measure of capital investment in column (4). Capital investment represents the paid-in or drawn capital into an industry. In addition, to control for VC industry performance based on fund-level returns, we include *Industry IRR* in column (5), which is the average since-inception IRR reported for the major VE industry category in the most recent quarter prior to month m.

The sample in Table 5 is constrained to be identical across the specifications to allow for comparison of the incremental explanatory power (R-square) of the proxies for exit market conditions. The specifications include industry fixed effects that capture industry-specific heterogeneities, and year fixed effects to control for general time-related factors that may impact the VC industry.[13] The fixed effects by themselves (unreported) explain 69.6% of the variation in risk allocation. The t-statistics are reported based on robust standard errors that account for clustering by year. In unreported tests, standard errors clustered by industry provide qualitatively similar results, although clustering by year yields generally more conservative t-statistics than industry clustering. Comparing models (1)–(5), the coefficients of *GLR,* log (*No. IPO Exits*), and log *(capital investment)*, are significantly positive, but *GLR* has the highest incremental explanatory power.

In model (6) of Table 5, we also include two control variables, *Startup Opportunities* and *Unexited Investments*, to account for broader dynamics that could affect early stage investments. Similar to VCs' investments, we expect entrepreneurs to respond to exit market signals and, therefore, as a result of supply-side variation, the establishment of startups should expand (decrease) when the

[12] Alternative measurement windows such as calendar year, or prior six month rolling windows do not have a material impact on the results in this paper.

[13] Both *GLR* and early stage investments can be endogenously determined by other unobserved factors. To mitigate this concern, the regressions include control variables highly correlated with economic forces that should affect both investments and investment outcomes. They also include time and industry fixed effects to capture the effects of other unobserved factors.

Table 5

Regressions examining risk allocation of VC investments. The sample consists of venture-backed companies with known outcomes (i.e., IPO, M&A, failures) during 1990–2008. The dependent variable in Panel A is *% Industry Early Stage Rounds*$_{g,m}$ in month m computed for industry g as the percentage of rounds in industry g over a 12 month period m+1 to m+12 that were raised by early stage companies; and in Panel B columns (1)–(5) is *% Industry ES First Rounds*$_{g,m}$ in month m computed for industry g as the percentage of rounds in industry g over months m+1 to m+12 that were raised by early stage first rounds, and in Panel B columns (6)–(10) is *% Industry First Rounds*$_{g,m}$ in month m computed for industry g as the percentage of rounds in industry g over months m+1 to m+12 that were first rounds. *GLR* is the Gains-to-Losses Ratio for industry g computed in month m, measured as the ratio of the average net money from exits to the average dollars lost in failures in industry g over the 12 month period m-12 to m−1. *NASDAQ* (%) is the cumulative monthly return on the NASDAQ index over months m−12 to m−1. log (*No. IPO exits*) is the natural logarithm of the number of IPO exits in industry g over months m−12 to m−1, plus one. log (*capital investment*) is the natural logarithm of the sum of capital invested in industry g (in $ millions) over months m−12 to m−1, plus one. *Industry IRR* is the percentage return for industry g in the most recent quarter before month m reported in *Venture Economics. Startup Opportunities*$_m$ is the natural log of the number of establishment entries one year in age or less for the most recent calendar year before month m. *Unexited Investments*$_{g,m}$ is the natural log of the number of unexited portfolio companies in industry g started in the last ten years averaged across all VCs on a rolling basis in each month m. All specifications include industry and time fixed effects. The t-statistics reported in parentheses below coefficient estimates are based on robust standard errors clustered by year. ***, **, * indicate statistical significance at the 1%, 5%, and 10% level, respectively.

Panel A: % Industry Early Stage Rounds

Variable	All (1)	All (2)	All (3)	All (4)	All (5)	All (6)	All, ex-high tech (7)	1990–97 (8)	2001–08 (9)
GLR	0.342***					0.281***	0.205***	0.120**	0.304***
	(4.28)					(4.16)	(3.25)	(2.61)	(2.79)
NASDAQ (%)		0.012				0.012	0.014	0.003	−0.001
		(1.14)				(0.72)	(0.85)	(0.11)	(−0.16)
log (*No. of IPO Exits*)			1.631***			0.901*	1.609**	0.706	−0.713
			(2.95)			(1.98)	(2.61)	(1.11)	(−1.03)
log (*capital investment*)				3.730***		2.968***	2.724**	0.441	3.916**
				(3.45)		(3.25)	(2.64)	(0.52)	(2.82)
Industry IRR					0.001	−0.021	0.014	0.054	−0.024
					(0.04)	(−0.55)	(0.40)	(1.83)	(−0.54)
Startup Opportunities						0.308***	0.277***	0.309***	0.326***
						(3.27)	(2.84)	(3.43)	(3.11)
Unexited Investments						−0.492	−0.576	−0.488	−0.622
						(1.12)	(1.39)	(0.97)	(1.40)
Industry dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
R-squared	0.743	0.696	0.715	0.720	0.699	0.754	0.848	0.868	0.700
No. of obs.	1203	1203	1203	1203	1203	1203	1043	476	572

Panel B: Alternative proxies for risk allocation

	% Industry ES First Rounds					*% Industry First Rounds*				
	All	All	All, ex-high tech	1990–97	2001–08	All	All	All, ex-high tech	1990–97	2001–08
Variable	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
GLR	0.237***	0.200***	0.157***	0.052**	0.244***	0.303***	0.264***	0.241***	0.102**	0.196**
	(3.99)	(4.33)	(3.24)	(2.31)	(2.94)	(4.15)	(4.40)	(3.85)	(2.27)	(2.61)
NASDAQ (%)		0.013	0.016**	0.002	0.003		0.016	0.017	0.013	0.010
		(1.05)	(2.09)	(0.14)	(0.45)		(1.00)	(0.95)	(0.68)	(0.97)
log (*No. of IPO Exits*)		0.760*	1.360***	0.827	−0.364		1.444***	2.114***	−0.211	0.587
		(2.04)	(4.51)	(1.49)	(−1.09)		(3.27)	(4.25)	(−0.22)	(1.19)
log (*capital investment*)		1.529*	1.493***	0.173	1.529**		−0.687	−0.423	−0.444	−0.966
		(2.08)	(2.69)	(0.24)	(2.48)		(−0.71)	(−0.33)	(−0.40)	(−1.29)
Industry IRR		−0.021	0.008	−0.005	0.002		−0.018	0.027	−0.056**	0.001
		(−0.90)	(0.39)	(−0.27)	(0.07)		(−0.74)	(1.20)	(−3.26)	(0.03)
Startup Opportunities		0.300***	0.337**	0.203**	0.348***		0.375***	0.377**	0.383***	0.388***
		(2.98)	(2.42)	(2.38)	(3.05)		(2.92)	(2.40)	(3.08)	(2.95)
Unexited Investments		−0.775	−1.112	−0.704	−1.223		−0.775	−1.112	−0.704	−1.223
		(1.23)	(1.35)	(1.19)	(1.31)		(1.23)	(1.35)	(1.19)	(1.31)
Industry dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
R-squared	0.649	0.663	0.734	0.810	0.495	0.792	0.801	0.841	0.879	0.841
No. of obs.	1203	1203	1043	476	572	1203	1203	1043	476	572

gains relative to losses appear higher (lower) on risky investments. *Startup Opportunities* in any month m is the natural logarithm of the number of establishment entries one year in age or less. The data on startups are from the *Longitudinal Data Series* on business development from the U.S. Census Bureau for the most recent calendar year before month m. Limitations of this data are that it is not available on an industry basis and it does not measure the quality of startups.

Additionally, since living-dead investments remain active investments but have been in VCs' portfolio at least five years, an accumulation of these investments could create an incentive to prefer later stage over early stage investments, irrespective of exit market conditions. *Unexited Investments* in month m in industry g is the natural logarithm of the number of unexited portfolio companies started in the last ten years averaged across all VCs on a rolling basis in month m in the industry.[14] As constructed, this variable captures the number of active investments potentially requiring additional capital or time that could influence VCs' preferences for the stage of new investments. When these control variables are included in model (6), the coefficient of *GLR* remains highly significant.

[14] Alternatively, we also construct the variable as the number of unexited portfolio companies started in the last ten years that are older than five years, but the results are similar to those reported.

Because the dotcom era has been the focus of concerns about whether VCs overinvested in high tech sectors, or otherwise represented an anomalous period of extraordinary exit activity, we report specifications in Table 5 that exclude high tech firms from the sample in model (7), and divide the sample into observations over 1990–97 in model (8), and 2001–08 in model (9). In all three models, the coefficients of *GLR* remain positive and significant, suggesting that the results for *GLR* generalize beyond the specific issues raised by the dotcom era.

In Panel B of Table 5, we show that *GLR* is significantly positively related to alternative measures of the dependent variables, such as *% Industry ES First Rounds* (columns (1)–(5)) and *% Industry First Rounds* (columns (6)–(10)). The results of later analyses are also not sensitive to the measure of risk allocation and, henceforth, for the sake of brevity we only report the results using *% Industry Early Stage Rounds*. In Appendix C, we also show that the results are robust to three alternative constructs of *GLR*.[15]

5.2. Impact on funding

Because VCs' risk allocations can influence the funding available to early stage companies, we estimate the magnitude of *GLR*'s effect on the level of funding available to startups. Based on estimates in model (1) of Table 5 for the overall sample, a one standard deviation change in *GLR* (5.6) leads to a 1.92% change in the rounds allocated to early stage companies. The mean proportion of financing rounds allocated to early stage companies across all periods is 30.4%, indicating that such a change is equivalent to a 6.3% (= 1.92%/30.4%) change from the mean. These results are based on the proportion of rounds invested in early stage companies, which are similar in the pre- and post-dotcom periods. If, alternatively, VCs had allocated the same percentage of dollars to early stage companies in these periods as in the dotcom period, we estimate that approximately $1 billion more per industry, or $6 billion more in aggregate, would be available per year to invest in early stage companies. At an average round size of $5 million per early stage investment, approximately 200 additional companies in each industry, or 1200 in total across industries, could have received funding per year. Consequently, these estimates suggest that the changes in VCs' risk allocation are sufficiently large in magnitude to affect early stage funding opportunities.

5.3. VC firm-level attributes

In addition to altering risk allocation, VCs have other means at their disposal to manage risk. For example, VCs could have extensive experience, or specialize in early stage investments or a particular industry to draw on in making their investment decisions. Tian and Wang (2014) show that VCs' failure tolerance also affects their willingness to make riskier investments. These "styles" and preferences suggest that VCs are heterogeneous with respect to risk-taking and, thus, their investment decisions could be influenced by these attributes, independent of exit market conditions captured by GLR. Moreover, such VC attributes could vary by industry and over time.

In establishing the importance of *GLR* for risk allocation in an industry, in Table 6 we include VC firm-level attributes to control for preferences for investment stage (*VC ES Preference*) and industry (*VC Industry Preference*), experience (*VC Experience*), and failure tolerance (*VC Failure Tolerance*). These variables have been used in prior research to differentiate VCs' abilities and preferences that could affect their ex ante selection of investments (Gompers et al., 2008; Smith et al., 2011; Tian and Wang, 2014). In the month of observation, VC firm-level attributes are averaged across the VCs active in the industry, where the average is calculated across the VC firms which participated in at least one round in the industry in the prior 60 months.[16] We average the VC attributes in an industry to match the industry level dependent variable, i.e. allocations to early stage investments in an industry. For example, $VC\ ES\ Preference_{g,m}$ is the percentage of rounds raised by early stage companies in industry g in which a VC firm invested over $m-60$ to $m-1$, averaged across the VC firms that participated in at least one round in industry g over $m-60$ to $m-1$.$VC\ Industry\ Preference_{g,m}$ and $VC\ Experience_{g,m}$ are constructed in an analogous manner for the percentage of rounds invested by a VC firm in industry g, and the number of rounds invested by a VC firm in industry g, respectively. Finally, $VC\ Failure\ Tolerance_{g,m}$ is the natural logarithm of the weighted average of a VC firm's investment duration in projects that failed in the prior five years, where failed projects are those that are eventually written off by the VC.

In Table 6 we focus on how the results for *GLR* change when include the VC attributes with and without industry fixed effects. In the absence of industry dummies, the VC attributes control for any cross-sectional and time-series variation in the average VC attributes for these specific attributes within industries. When we compare column (1) without VC attributes to column (2) with VC attributes, the coefficients and statistical significance of *GLR* are virtually unchanged from the values reported in Table 5. Moreover, the R-square in column (2) (50.3%) reveals little by way of additional explanatory power compared to column (1) (49.7%). By contrast, including industry fixed effects in column (3) increases the R-square to 75.4%, but does not materially change the coefficient of *GLR* or the other variables. Adding VC attributes in column (4) does not appreciably alter the results from those in column (3).

Of the newly added VC firm-level attributes, only the coefficient of *VC Failure Tolerance* is positive and significant in all specifications. In column (5), we interact *GLR* with the VC attributes to allow for the marginal impact of *GLR* to vary with the attributes of VCs in an industry, but the coefficients on the interaction terms are either insignificant or marginally significant. The overall results show that industry fixed effects absorb the effect of the VC attributes, and other means VCs have at their disposal to manage risk are not strong enough to offset the effects of *GLR* on aggregate risk allocation.

In Table 7, we re-estimate the industry-level regressions in Table 6 with the dependent variable and all independent variables constructed at the VC firm-level. By reconstructing the variables at the firm level, the specifications allow us to control for time-invariant heterogeneities in VC attributes, such as basic skills, resources, or the fixed component of industry specialization using VC firm fixed effects, as well as other time-varying VC firm-level attributes, such as specialization or experience adapted to market timing. Similar to Table 6, in most specifications we include VC firm-level fixed effects, and in one specification we include the VC attributes and exclude VC firm fixed effects. Notably, controlling for VC firm-level fixed effects helps alleviate concerns about endogeneity, since the fixed effects absorb time-invariant VC-level unobservable attributes (see, for example, Tian et al., 2016). In all cases, the results show a significantly positive relation between VC firm-level allocations to early-stage companies and *GLR*. Consequently, the firm level regressions show that the individ-

[15] In Appendix C, in three alternative specifications, *GLR* is measured as: (1) the sum of net money from exits divided by the sum of capital invested in failures, (2) the sum of net money from exits divided by the average capital lost in failures, or (3) the sum of capital invested in exits divided by the sum of capital invested in failures. As shown there, our results are robust to other specifications of the exit market indicator.

[16] The results are robust to VC attributes constructed over rolling prior 36 month periods.

Table 6

Regressions examining risk allocation of VC investments with VC attributes. The sample consists of venture-backed companies with known outcomes (i.e., IPO, M&A, failures) during 1990–2008. The dependent variable is *% Industry Early Stage Rounds*$_{g,m}$ in month *m* computed for industry *g* as the percentage of rounds in industry *g* over a 12 month period *m*+1 to *m*+12 that were raised by early stage companies. *GLR* is the Gains-to-Losses Ratio for industry *g* computed in month *m*, measured as the ratio of the average net money from exits to the average dollars lost in failures in industry *g* over the 12 month period *m*−12 to *m*−1. *NASDAQ* (%) is the cumulative monthly return on the NASDAQ index over *m*−12 to *m*−1. log (*No. IPO Exits*) is the natural logarithm of the number of IPO exits in industry *g* over *m*−12 to *m*−1, plus one. log (*capital investment*) is the natural logarithm of the sum of capital invested in industry *g* (in $ millions) over *m*−12 to *m*−1, plus one. *Industry IRR* is the percentage return for industry *g* in the most recent quarter before month *m* reported in *Venture economics. Startup Opportunities*$_m$ is the natural log of the number of establishment entries one year in age or less for the most recent calendar year before month *m. Unexited Investments*$_{g,m}$ is the natural log of the number of unexited portfolio companies in industry *g* started in the last ten years averaged across all VCs on a rolling basis in each month *m*. The VC firm-level attributes are computed on a rolling basis for industry *g* in month *m* as follows: *VC ES preference*$_{g,m}$ is the percentage of rounds raised by early stage companies in industry *g* in which a VC firm invested over *m*−60 to *m*−1, averaged across the VC firms that participated in at least one round in industry *g* over *m*−60 to *m*−1. *VC Industry Preference*$_{g,m}$ is the percentage of rounds raised by companies in industry *g* in which a VC firm invested over *m*−60 to *m*−1, averaged across the VC firms that participated in at least one round in industry *g* over *m*−60 to *m*−1. *VC Experience*$_{g,m}$ is the natural logarithm of the number of rounds raised by companies in industry *g* in which a VC firm invested over *m*−60 to *m*−1, averaged across the VC firms that participated in at least one round in industry *g* over *m*−60 to *m*−1. *VC Failure Tolerance*$_{g,m}$ in month *m* computed for industry *g* is the natural logarithm of the weighted average of a VC firm's investment duration in projects that failed in the prior five years, where failed projects are those that are eventually written off by the VC, averaged across the VC firms that participated in at least one round in industry *g* over *m*−60 to *m*−1. The *t*-statistics reported in parentheses below coefficient estimates are based on robust standard errors clustered by year. ***, **, * indicate statistical significance at the 1%, 5%, and 10% level, respectively.

Variable	All (1)	All (2)	All (3)	All (4)	All (5)
GLR	0.306***	0.297***	0.281***	0.280***	0.293***
	(3.62)	(3.60)	(4.16)	(3.91)	(3.59)
NASDAQ (%)	−0.005	−0.007	0.012	0.011	−0.004
	(−0.25)	(−0.33)	(0.72)	(0.67)	(−0.17)
log (*No. of IPO Exits*)	3.676***	3.201***	0.901*	0.910**	2.966***
	(4.67)	(4.12)	(1.98)	(2.10)	(3.73)
log (*capital investment*)	−5.667***	−5.376***	2.968***	2.940***	−4.952***
	(5.35)	(4.94)	(3.25)	(3.10)	(4.13)
Industry IRR	−0.072**	−0.068*	−0.021	−0.022	−0.053
	(−2.08)	(−1.72)	(−0.55)	(−0.57)	(−1.34)
Startup Opportunities	0.413**	0.403***	0.308***	0.311***	0.412***
	(2.17)	(3.03)	(3.27)	(3.19)	(3.01)
Unexited Investments	−0.502	−0.501	−0.492	−0.234	−0.508
	(−0.92)	(−0.88)	(1.12)	(−0.90)	(−1.13)
VC ES Preference		0.113**		0.101	0.122*
		(2.08)		(1.48)	(1.95)
VC Industry Preference		0.772		0.339	0.623
		(0.91)		(0.99)	(1.02)
VC Experience		−0.014*		0.007	−0.005
		(−1.823)		(0.71)	(−1.30)
VC Failure Tolerance		0.145**		0.144*	0.133**
		(2.02)		(1.82)	(2.11)
GLR × *VC ES Preference*					−0.005
					(1.51)
GLR × *VC Industry Preference*					−0.100
					(−0.91)
GLR × *VC Experience*					−0.001
					(0.35)
GLR × *VC Failure Tolerance*					−0.008*
					(1.96)
Industry dummies	No	No	Yes	Yes	No
Year dummies	Yes	Yes	Yes	Yes	Yes
R-squared	0.497	0.503	0.754	0.755	0.509
No. of obs.	1203	1203	1203	1203	1203

ual VC allocations do not depart but rather mirror the aggregate trends in risk allocation, which are captured in the industry-level regressions**.**

5.4. Sensitivity of risk allocation to GLR over time

Because M&A exits and failures, investments with typically lower returns, have increased in frequency and economic significance over time, it is plausible that the sensitivity of VCs' investment decisions to *GLR* has also increased over time. In Table 8, we investigate whether VCs' risk allocation has become more sensitive to *GLR* over time (Hypothesis 2) by including *Time* and a *GLR* × *Time* interaction term in the regressions. *Time* is a linear trend variable that takes on a value of one for each industry starting in January of the first year of the sample interval (i.e., 1990) and is augmented by one each successive month through the end of the respective period (i.e., December 2008). The coefficients of *GLR* × *Time* are significantly positive in all specifications, implying that risk allocation has become more sensitive to *GLR* over time. One interpretation of this result is that VCs' investment decisions reflect greater concern for downside risk in the later, less favorable, sample periods compared to the earlier periods.

In Table 8, the coefficient on *Time* is significantly negative with the exception of model (5) for the 1990–97 period, suggesting a downward trend in risk allocation over time. After controlling for other market indicators, the significance of *Time* suggests other forces, beyond market conditions, explain some of the decrease in risk allocation over time.[17]

[17] Reduced allocations to early stage companies by VCs could also be related to institutional changes in the VC industry that have occurred over time. For instance,

Table 7
Regressions examining risk allocation of VC investments at VC firm-level. The sample consists of venture-backed companies with known outcomes (i.e., IPO, M&A, failures) during 1990–2008. The dependent variable is *% VC Early Stage Rounds*$_{i,g,m}$, computed for VC firm i in month m for industry g as the percentage of rounds VC firm i invested in industry g over a 12 month period $m+1$ to $m+12$ that were raised by early stage companies. *GLR* is the Gains-to-Losses Ratio for VC firm i computed in month m, measured as the ratio of the average net money from exits to the average dollars lost in failures by VC firm i in industry g over the 36 month period $m-36$ to $m-1$. The VC attributes are as follows: *VC ES Preference*$_{i,g,m}$ computed for VC firm i in month m for industry g is the percentage of rounds in which the VC firm invested over $m-60$ to $m-1$ that were raised by early stage companies. *VC Industry Preference*$_{i,g,m}$ computed for VC firm i in month m for industry g is the percentage of rounds in which the VC firm invested over $m-60$ to $m-1$ that were raised by companies in industry g. *VC Experience*$_{i,g,m}$ for VC firm i in month m for industry g is the natural logarithm of the number of rounds in which the VC firm invested over $m-60$ to $m-1$ in industry g. *VC Failure Tolerance*$_{i,g,m}$ computed for VC firm i in month m for industry g is the natural logarithm of the weighted average of a VC firm's investment duration in projects that failed in the prior five years, where failed projects are those that are eventually written off by the VC. *Corporate VC dummy* is an indicator variable that equals a value of one if the VC firm is categorized as a corporate VC, and zero otherwise. The t-statistics reported in parentheses below coefficient estimates are based on robust standard errors clustered by year. ***, **, * indicate statistical significance at the 1%, 5%, and 10% level, respectively.

Variable	All (1)	All (2)	All (3)	All (4)	All (5)	All (6)	All (7)
GLR	0.145***					0.095**	0.224**
	(2.98)					(2.26)	(2.31)
NASDAQ (%)		0.123**				0.031	0.035*
		(2.57)				(0.45)	(1.69)
log (*No. of IPO Exits*)			5.182**			9.592**	7.593**
			(3.01)			(2.78)	(2.53)
log (*capital investment*)				1.730**		1.968	2.010
				(2.13)		(1.55)	(1.51)
Industry IRR					0.294	0.275	0.302
					(1.32)	(1.20)	(1.25)
Startup Opportunities						0.308	0.311*
						(1.31)	(1.82)
Unexited Investments						−0.492	−0.350
						(1.12)	(1.20)
VC ES Preference							0.292**
							(2.11)
VC industry Preference							0.220
							(0.89)
VC Experience							−0.016*
							(1.65)
VC Failure Tolerance							0.219**
							(2.21)
Corporate VC dummy							−0.014
							(0.72)
VC firm dummies	Yes	Yes	Yes	Yes	Yes	Yes	No
Industry dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes
R-squared	0.072	0.069	0.069	0.068	0.068	0.075	0.019
No. of obs.	975,456	975,456	975,456	975,456	975,456	975,456	969,349

5.5. Sensitivity to gains and losses over time

A natural question is whether the previous results for *GLR* are primarily driven by gains observed in the exit market, i.e., net money from exits, or the losses incurred from failures. In Table 9, we decompose *GLR* into its components of *Net Money from Exits* (numerator) and *Losses in Failures* (denominator), and include these variables along with their interaction with *Time* to explain risk allocations. In model (1), both the components of *GLR* have the predicted signs – the proportion of capital invested in early stage companies significantly increases with the gains observed in exit markets and significantly decreases with the observed losses. These results confirm the predictions of Hypothesis 2 that both upside potential signaled by gains and downside risk signaled by losses influence VCs' subsequent investment decisions.

The results also show that VC risk allocations are less influenced by signals of gains and more influenced by losses over time. This is observed in Table 9 model (2), where the positive effect of *Net Money from Exits* decreases, and the negative effect of *Losses in Failures* increases, when interacted with *Time*. These results are consistent with VCs' allocations to early-stage investments becoming more sensitive to downside risk.

6. Future exit returns

In this section, we examine whether VCs' allocations to early stage companies at the time of investment initiation are predictive of future exit returns (*Exit_Return*). As formalized in Hypothesis 3, conditional on exit, we expect that exit returns should be higher on average following periods when VCs allocate more capital to early stage companies. In Table 10, the independent variables that control for exit market conditions are measured at the time of the first VC investment in the company. The design of the regression allows us to investigate how allocations to early-stage investments, *% Industry Early Stage Rounds*, observed over the prior 12 months are related to the returns on investments initiated shortly thereafter. Because public equity markets (*NASDAQ*), number of industry VC-backed IPO exits, industry capital investment, and VC industry performance (*Industry IRR*) at the time of investment can also influence investment decisions, we include them as control variables.

if VC fund sizes have grown larger as a function of the overall growth in the industry, it may be less economical to make smaller investments that are more typical of early stage financing. In our regressions, capital investment is highly correlated with the average round size (correlation = 87%) and, therefore, capital investment should control for trends in fund size over time. If we replace capital investment with the average round size, the coefficients of *GLR*, *GLR* × *Time*, and *Time* remain similar to those reported in Table 7, which suggests that lower risk allocations are not explained by the growth in fund and investment size.

Table 8
Regressions examining sensitivity of VC risk allocations to *GLR*. The sample consists of venture-backed companies with known outcomes (i.e., IPO, M&A, failures) during 1990–2008. The dependent variable is *% Industry Early Stage Rounds* for industry *g* in month *m*, defined in Table 5. *Time* is a trend variable that takes on a value of one for each industry starting in January of the first year of the sample period (e.g., All=1990) and is augmented by one each successive month through the end of the respective period. Other explanatory variables are as defined in Table 6. The *t*-statistics reported in parentheses below coefficient estimates are based on robust standard errors clustered by year. ***, **, * indicate statistical significance at the 1%, 5%, and 10% level, respectively.

	% Industry Early Stage Rounds					
Variable	All (1)	All (2)	All (3)	All, ex-high tech (4)	1990–97 (5)	2001–08 (6)
GLR		0.297***	0.283**	0.201***	0.108**	0.699***
		(3.23)	(2.37)	(3.05)	(2.25)	(2.86)
GLR × *time trend*		0.008**	0.010**	0.007**	0.006**	0.011**
		(2.31)	(2.16)	(2.23)	(2.48)	(2.30)
Time	−0.033***	−0.026***	−0.053***	−0.032***	0.083*	−0.056***
	(−3.27)	(−3.42)	(−4.90)	(−2.96)	(1.90)	(−2.91)
NASDAQ (%)			0.006	−0.006	−0.051**	0.015**
			(0.40)	(−0.30)	(−2.28)	(2.48)
log (*No. of IPO Exits*)			0.785***	1.338***	0.159	−0.911***
			(2.76)	(3.37)	(0.18)	(−2.85)
log (*capital investment*)			1.450**	−0.090	−1.480	3.880***
			(2.58)	(−0.08)	(−1.25)	(5.77)
Industry IRR			0.050**	0.082**	0.072	0.003
			(2.15)	(2.22)	(1.59)	(0.09)
Startup Opportunities			0.302***	0.266***	1.437***	0.144***
			(3.29)	(2.75)	(4.14)	(2.73)
Unexited Investments			−0.338	−0.404	−0.550	−0.474
			(−0.73)	(−1.13)	(−1.29)	(−0.79)
VC ES Preference			0.108	0.103	0.168	0.101
			(1.16)	(1.22)	(1.57)	(0.69)
VC Industry Preference			0.294	0.301	0.199	0.391
			(0.77)	(1.35)	(0.70)	(1.12)
VC Experience			−0.008	−0.010*	−0.006	−0.007
			(1.03)	(1.81)	(0.45)	(0.50)
VC Failure Tolerance			0.144**	0.149*	0.148*	0.132*
			(1.99)	(1.79)	(1.92)	(1.73)
Industry dummies	Yes	Yes	Yes	Yes	Yes	Yes
R-square	0.542	0.597	0.644	0.736	0.851	0.743
No. of obs.	1203	1203	1203	996	419	572

Additionally, we include *Years to exit* to control for the differences in investment holding periods across companies.

The results in Table 10 show a significant positive relation between exit returns and *% Industry Early Stage Rounds* at the time of investment initiation in all specifications. Supporting Hypothesis 3, a reduction in VCs' early-stage allocations, all else equal, is associated with lower future exit returns on an absolute basis. Among other results, the coefficients on *GLR* are also significantly positive in all specifications, suggesting that the returns from IPO and M&A exits are higher on average for investments made following periods of more favorable signals of Gains-to-Losses.

There are several important caveats to this analysis. First, these results are conditional on exit whereas unconditional returns likely reflect a higher probability of failure for early-stage investments.[18] As a result, declining exit returns do not necessarily imply declining fund returns because we do not capture the incidence of failures, which is a component of fund returns (see Appendix B). Second, we cannot conclude on a risk-adjusted basis that future exit returns have fallen. If the marginal return of investing in early stage over later stage investments does not justify the additional risk, then it would be rational for VCs to shift toward later stage investments. Third, there may be endogeneity issues between the exit returns and the proportion of early stage financing, where both are influenced by unobserved factors such as VC attributes. However, the endogeneity concern is alleviated here to some extent because the exit return is constructed at the portfolio company-level, whereas the proportion of early stage financing is an aggregate industry factor, making them less likely to be closely linked to the same unobservable factors. Finally, there are also relatively fewer exits from which to estimate the effects over 2001–08. We find, however, similar results for exit returns in Table 10 based on the more complete data from 1990–97.

Exits are, however, the primary means of capital recovery in the industry, and therefore examining how *Exit Return* varies with respect to risk allocation and capital investments at investment initiation can shed on the cyclical nature of industry performance. We assess the relative influence of risk allocation and capital investment on exit returns, using the regression results in Table 10. From 2001 to 2008, capital investment per industry declines by 37%. Based on our regression in model (3), we estimate that it would take an 8.2% decrease in the proportion of early stage investments across industries to achieve a similar marginal improvement in exit returns consistent with a 37% decrease in capital investment. Over the same period, *% Industry Early Stage Rounds* decreases by 7.2% (35.1%–27.9%), a reduction large enough to offset at least some of the benefits of reduced capital investment on returns. The results suggest that decreased allocations to early stage investments have the potential to mitigate some of the positive effects of industry downsizing that occurred over 2001–08. More broadly, the results show that changes in VCs allocations to riskier investments is an independent factor on returns that affects the cyclicality of VC performance.

[18] In unreported results, logistic regressions predicting the probability of failure show that it increases significantly with the proportion of early stage investments at the time of first investment.

Table 9
Regressions examining sensitivity of VC risk allocation to gains and losses. The sample consists of venture-backed companies with known outcomes (i.e., IPO, M&A, failures) during 1990–2008. The dependent variable is *% Industry Early Stage Rounds* for industry *g* in month *m*, as defined in Table 5. *Net Money from Exits* is the average net money from exits in industry *g* over a 12 month period $m-12$ to $m-1$. *Losses in Failures* is the average loss of capital invested in companies in industry *g* declared bankrupt, defunct, or not having received a new round of investment for at least five years as of 2008 over months $m-12$ to $m-1$. Other variables are as defined in Table 6. The *t*-statistics reported in parentheses below coefficient estimates are based on robust standard errors clustered by year. ***, **, * indicate statistical significance at the 1%, 5%, and 10% level, respectively.

	% industry early stage financing					
Variable	All (1)	All (2)	All (3)	All, ex-high tech (4)	1990–97 (5)	2001–08 (6)
Net money from exits	0.024**	0.139***	0.037	0.022**	0.233**	0.017
	(2.10)	(3.71)	(1.62)	(2.25)	(3.10)	(0.41)
Losses in failures	−0.124***	−0.255***	−0.222**	−0.138**	−0.067	−0.341**
	(−3.24)	(−2.78)	(−2.31)	(−2.30)	(0.72)	(−2.22)
Time × net money from exits		−0.008***	−0.011**	−0.007**	−0.012***	−0.006
		(−2.69)	(−2.35)	(2.18)	(−4.28)	(−0.97)
Time × losses in failures		−0.011**	−0.017**	−0.010*	−0.001	−0.023**
		(−2.34)	(−2.46)	(−1.81)	(0.10)	(2.25)
Time		−0.031**	−0.031**	−0.050**	0.109**	−0.020**
		(−2.23)	(−2.38)	(−2.50)	(2.27)	(−2.21)
NASDAQ (%)			−0.002	0.001	−0.004	0.001
			(0.18)	(0.09)	(0.41)	(0.50)
log (*No. IPO Exits*)			0.916*	1.393*	0.550	0.934
			(1.88)	(1.87)	(0.82)	(0.65)
log *(capital investment)*			1.790**	1.221	1.224	3.802**
			(2.01)	(1.26)	(0.98)	(2.33)
Industry IRR			0.040	0.084**	0.081**	−0.014
			(1.44)	(2.26)	(2.50)	(−0.24)
Startup Opportunities			0.473	0.400	1.355***	0.022
			(1.62)	(1.20)	(5.40)	(0.36)
Unexited Investments			−0.489	−0.590	−0.483	−0.502
			(−1.11)	(−1.01)	(−0.88)	(−0.71)
VC ES Preference			0.113**	0.120	0.181*	0.093
			(1.98)	(1.25)	(1.80)	(0.58)
VC Industry Preference			0.291	0.310	0.199	0.362
			(1.01)	(1.31)	(0.96)	(1.16)
VC Experience			0.003	−0.006	−0.006	0.006
			(0.30)	(1.51)	(0.29)	(0.30)
VC Failure Tolerance			0.149**	0.152*	0.141**	0.102
			(2.14)	(1.76)	(2.18)	(1.03)
Industry dummies	Yes	Yes	Yes	Yes	Yes	Yes
R-square	0.533	0.617	0.647	0.738	0.870	0.758
No. of obs.	1203	1203	1203	996	419	572

7. Conclusion

Our article analyzes the relation between exit market conditions and VCs' aggregate capital allocations to riskier early-stage investments. To gauge the exit market conditions, we construct the Gains-to-Losses Ratio (*GLR*), which is the ratio of the average dollars gained to dollars lost relative to breakeven from recent exits. *GLR* provides a time-varying indicator of how many failures on average are covered by an exit in an industry, which, in turn, influences VCs' ability to absorb losses on new investments.

Based on the returns to 1436 IPO exits, 1222 M&A exits, and 4468 failures of U.S. venture-backed companies over the period 1986 to 2008, we find IPO exits have two times higher returns on average and a substantially higher frequency of top 25% returns compared to M&A exits. Over the sample period, there is a marked increase in the number of M&A exits relative to IPO exits, and in the funds lost to investments that do not pay off. The net effect of these trends is an overall reduction in the *GLR* over our sample period.

We find that the proportion of funding for early stage companies in an industry is significantly positively related to *GLR* and the strength of exit market conditions. Our main findings are unchanged by the inclusion of variables that control for supply-side variation in the number of startups and the amount of capital VCs have at stake in Unexited Investments. We also control for other potential ways VCs can manage risk related to their preferences, experience, or failure tolerance. In general, VC firm-level attributes do not alter the aggregate relation we find between risk allocation and *GLR*.

When we decompose *GLR* into its components of average gains and losses from recent outcomes, we find that gains have a significantly positive effect and losses a significantly negative effect on risk allocation, and this effect of losses significantly increases in magnitude from 1990–97 to 2001–08. As the latter period has been characterized by more constrained exit market conditions, VCs have grown more conservative in their allocations to early stage investments. This is what would be expected if VCs alter risk allocation in response to changing exit market conditions.

Finally, we find that, conditional on the occurrence of an exit, exit returns are lower on average when initiated in periods where VCs have been less willing to allocate capital to early stage investments. This finding addresses a point of debate in the VC industry – exit returns are generally lower from 2001–08 but we do not know the extent to which changes in VCs' allocations to early-stage companies have contributed to the decline in returns. Reduced capital investment over 2001–08, ceteris paribus, should portend an improvement in future returns. We show, however, that the lower allocations to early stage investments over 2001–08 have the potential to offset some of the positive effects of industry downsizing on returns. Our results show that exit market conditions also affect VCs allocations to riskier investments, and, therefore, the potentially offsetting nature of capital investment and risk allocation on returns can help explain the industry's cyclical swings.

Table 10
Regressions explaining conditional exit returns. The sample consists of venture-backed companies with IPO or M&A exits during 1990–2008. The dependent variable is the exit return (*Exit_Return*) for an exit of a portfolio company in industry g which raised the first round of VC financing in month m, defined as the return accruing to the group of VCs holdings stakes in the company at the time of exit. *% Industry Early Stage Rounds* is the percentage of rounds in industry g that were raised by early stage companies in the 12 month period $m-12$ to $m-1$. log (*Years to Exit*) is the natural logarithm of the number of years between the exit date and the first date of VC financing received in month m. Other explanatory variables are as defined in Table 6. The 1990–97 and 2001–08 subsamples include exits with first round dates that fall during 1990 to 1997 and 2001 to 2008, respectively. All specifications include industry and time fixed effects. The coefficients and t-statistics (reported in parentheses below coefficient estimates) are based on robust regressions, accounting for clustering by year. ***, **, * indicate statistical significance at the 1%, 5%, and 10% level, respectively.

	Exit_Return				
Variable	All (1)	All (2)	All (3)	1990–97 (4)	2001–08 (5)
% Industry Early Stage Rounds		0.575***	0.580***	0.217**	1.016***
		(3.03)	(2.88)	(2.08)	(2.84)
GLR			0.702***	0.284**	0.899***
			(2.39)	(2.12)	(2.67)
NASDAQ (%)	−0.220	−0.227	−0.198	−0.073	−1.283**
	(−0.78)	(−0.71)	(−0.72)	(−0.18)	(−2.24)
log (*No. of IPO Exits*)	−31.983***	−32.238***	−29.980***	−6.336	18.183
	(−4.21)	(−3.95)	(−3.97)	(−0.36)	(1.04)
log (*capital investment*)	−10.499**	−10.491***	−10.330**	−6.331*	−12.651**
	(−2.11)	(−2.99)	(−2.31)	(−1.80)	(−2.32)
% Industry IRR	0.108	0.111	0.110	−0.501	2.921***
	(0.28)	(0.25)	(0.39)	(−0.58)	(4.41)
log (*Company age* (years))	−60.230***	−60.003***	−58.996***	−74.821***	13.883
	(−6.59)	(−6.45)	(−6.67)	(−4.73)	(0.65)
VC ES Preference	0.903**	0.892**	0.886**	0.386	1.001**
	(2.02)	(2.05)	(2.01)	(1.59)	(2.15)
VC Industry Preference	2.609	2.632	2.627	2.990	1.838
	(1.55)	(1.12)	(1.09)	(1.51)	(1.30)
VC Experience	1.295**	1.289**	1.251*	1.303**	1.093
	(2.13)	(2.19)	(1.96)	(2.18)	(1.55)
VC Failure Tolerance	3.102***	3.003***	2.994***	2.332*	2.921***
	(2.52)	(2.52)	(2.38)	(1.81)	(2.43)
Industry dummies	Yes	Yes	Yes	Yes	Yes
Year dummies	Yes	Yes	Yes	Yes	Yes
No. of obs.	2215	2215	2215	1136	231
R-square	0.114	0.120	0.123	0.072	0.785

Appendix A. Comparison of M&A exits with and without disclosed deal values

The M&A sample (with deal values) are U.S. venture-backed portfolio companies that exited via M&A during 1986–2008, had reported postmoney valuations in *Venture Economics*, and had reported deal values at exit. The M&A sample (missing deal values) are U.S. venture-backed portfolio companies that exited via M&A during 1986–2008, had reported postmoney valuations in *Venture Economics*, and did not have reported deal values at exit. The significance test for the difference of means is based on t-statistics for a two-sample means test, with t-statistics reported in parentheses. Dollar amounts are reported in millions. The significance test for the difference of medians is based on chi-squared statistics with continuity correction for a nonparametric K-sample test, with the Pearson Chi-square statistic reported in parentheses. ***, **, * indicate statistical significance at the 1%, 5% and 10% level, respectively.

	M&A sample (with deal values)		M&A sample (missing deal values)		Diff. of means	Diff. of medians
	Mean	Median	Mean	Median	(t-statistic)	(Pearson Chi-sq)
Avg. amount per round	11.28	6.79	9.74	6.51	1.54	0.28
					(2.41)	(1.45)
No. of rounds received	4.73	4.00	4.36	4.00	0.37	0.00
					(3.05)	(1.02)
No. of firms per company	7.09	6.00	6.29	6.00	0.80	0.00
					(4.34)	(0.98)
Total amount invested	45.07	27.15	32.68	25.21	12.39	1.94
					(3.24)	(2.31)
VC stakes (%)	51.08	50.50	51.33	50.89	−0.25	−0.39
					(0.17)	(0.15)
Industry distribution (%)						
Biotechnology	4.42					
Communications and media	19.31		18.40			
Computer related	49.75		52.72			
Medical/health/life science	9.49		7.53			
Non-high technology	9.90		13.54			
Semiconductors/other elect.	7.12		4.39			
N	1222		1040			

Appendix B. Measure of exit return

Prior studies of VC performance typically use fund-level returns, which are constructed as (since inception) Internal Rates of Return (IRRs), and multiples of invested capital (TVPIs) that ignore the time value of money. In this appendix, we describe our measure of

VC investment outcomes – exit return (*Exit_Return*) in more detail and discuss how some of its components relate to our hypotheses.

Assuming that a VC fund i with an expected lifecycle of T time periods deploys all the capital in time period $t = 0$, the ex-ante aggregate expected fund return can be parsimoniously summarized using the following expression:

$$\mathrm{E(Fund\_Return)}_{i,T} = \sum_{t=1}^{T}\sum_{j=1}^{N} w_{i,j}\ \mathrm{E(Outcome)}_{i,j,t}$$

where $w_{i,j}$ is the portfolio weight of company j in fund i's portfolio, and $\mathrm{E(Outcome)}_{i,j,t}$ is the expected return associated with an M&A, IPO, or Failure of company j over the lifecycle of the fund. N is the set of portfolio companies in i's portfolio. The outcome for company j occurs in time period t, where $t = 1,\ldots, T$. For simplification, we ignore the time value of money in assessing outcomes. Rewriting Eq. (1) to match our empirical approach, we get:

$$\mathrm{E(Fund\_Return)}_{\mathrm{i,T}} = \sum_{t=1}^{T}\sum_{j=1}^{N} w_{i,j}[(1-p_{f,t})\mathrm{Exit\_Return}_{i,j,t} + p_{f,t}\mathrm{Failure\_Return}_{i,j,t}]$$

where $p_{f,t}$ is the ex-ante probability of a failure, so that $(1-p_{f,t})$ is the ex-ante probability of a M&A or IPO exit in period t in i's lifecycle of T time periods. $Exit\_Return_{i,j,t}$ ($Failure\_Return_{i,j,t}$) is the estimated return to fund i from portfolio company j conditional on exit via M&A or IPO (Failure) in period t.

From Eq. (2), exit outcomes are a fundamental component of fund returns. Conditional on the occurrence of an exit, $Exit\_Return_{i,j,t}$ measures the capital recovered from specific VC investments that exit as an M&A or IPO. $Failure\_Return_{i,j,t}$ represents the dollars lost to failures, which we later assume to be −100% for empirical purposes. The disaggregated portfolio company-level tangible outcomes allows us to capture the variation in exit ("upside") and failure ("downside") events that relate to the perceived gains and losses from investment. Because we do not estimate all the components of fund returns in Eq. (2), our approach does not capture heterogeneities in skill across VC funds reflected in, for example, $p_{f,t}$ (the ability to identify failures) or $w_{i,j}$ (the ability to avoid failures and increase holdings in successes). On the other hand, to the extent there is a generally downward trend in investment returns ($Exit\_Return_{i,j,t}$), it suggests VCs must exhibit greater investment skill to be able to generate superior fund performance.

A priori, it is not clear from Eq. (2) how capital investment and risk allocation cumulatively affect the future performance of investments. Declining capital investment has two reinforcing effects that elevate both fund returns and exit returns. All else equal, fund returns likely increase when capital investment is low because VCs are more selective, which decreases the likelihood of failures ($p_{f,t}$) and decreases the weight ($w_{i,j}$) assigned to lower quality investments. Similarly, exit returns likely increase because valuations are lower at initiation and the average quality of selected investments is higher. In contrast, risk allocation has an opposing effect on the components in Eq. (2). First, less risky investments could increase fund returns because, all else equal, they tend to be later stage and have lower chance of failure (i.e., $p_{f,t}$ is lower). On the other hand, a greater proportion of less risky later stage investments should decrease the average level of exit returns ($Exit\_Return_{i,j,t}$) since valuations of late stage companies are higher at initiation. Therefore, conditional on exit, reduced capital investment should *increase* future exit returns, whereas less risky capital allocations should *decrease* future exit returns.

Appendix C. Robustness of alternative measures of Gains-to Losses Ratio

The table reports regressions explaining the proportion of VC investment rounds in early stage companies for alternative measures of the Gains-to-Losses Ratio (*GLR*). The dependent variable is: *% Industry Early Stage Rounds*$_{g,m}$, in industry g in month m, computed as the percentage of rounds in industry g over the months m+1 to m+12 that were raised by early stage companies. *GLR* in columns (1) and (2) is defined as the ratio of the sum of net money obtained from exits occurring in industry g over the period $m-1$ to $m-12$ to the sum of the total capital lost in failures recorded in industry g over the same period. In columns (3) and (4), *GLR* is defined as the ratio of the sum of net money obtained from exits occurring in industry g over the period $m-1$ to $m-12$ to the average capital lost in failures recorded in industry g over the same period. In columns (5) and (6), *GLR* is defined as the ratio of the sum of the capital invested in companies that have an exit via IPO or M&A in industry g over the period $m-1$ to $m-12$, to the sum of the capital invested in companies that were recorded as failures in industry g over the same period. Other variables are as defined in Table 6. All specifications include industry and time fixed effects. The t-statistics reported in parentheses below coefficient estimates are based on robust standard errors and adjust for clustering of observations by year. ***, **, * indicate statistical significance at the 1%, 5% and 10% level, respectively.

	Dependent variable: %industry early stage rounds					
	GLR = (Sum of net money from exits)/(Sum of capital lost in failures)		GLR = (Sum of net money from exits)/(Average loss of capital invested in failures)		GLR = (Sum of capital invested in exits)/(Sum of capital lost in failures)	
Variable	(1)	(2)	(3)	(4)	(5)	(6)
GLR	0.041***	0.030***	0.013***	0.009***	0.019***	0.011***
	(5.55)	(3.95)	(5.51)	(3.47)	(3.10)	(2.89)
NASDAQ (%)		0.015		0.013		0.018
		(1.46)		(1.28)		(1.62)
log (*No. IPO exits*)		0.509		0.398		0.892**
		(1.46)		(1.06)		(2.49)
log (*capital investment*)		2.502**		2.346**		3.157**
		(2.75)		(2.63)		(2.25)
Industry IRR		−0.021		−0.014		−0.012
		(−0.71)		(−0.48)		(−0.40)
Startup Opportunities		0.137***		0.106*		−0.010
		(3.32)		(1.75)		(−0.16)
Unexited Investments		−0.336		−0.221		−0.313
		(1.20)		(0.62)		(0.77)
Industry dummies	Yes	Yes	Yes	Yes	Yes	Yes
Year dummies	Yes	Yes	Yes	Yes	Yes	Yes
R-square	0.733	0.735	0.731	0.732	0.709	0.724
No. of obs.	1203	1203	1203	1203	1203	1203

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