

SPECIALIZATION AND SUCCESS: EVIDENCE FROM VENTURE CAPITAL

PAUL GOMPERS

*Harvard Business School
Soldiers Field Road
Boston, MA 02163
pgompers@hbs.edu*

ANNA KOVNER

*Federal Reserve Bank of New York
33 Liberty Street
New York, NY 10045
Anna.Kovner@ny.frb.org*

JOSH LERNER

*Entrepreneurship and Finance Units
Harvard Business School
Rock Center 214
Soldiers Field Road
Boston, MA 02163
and NBER
josh@hbs.edu*

This paper examines how organizational structure affects behavior and outcomes, studying the performance of different types of venture capital organizations. We find a strong positive relationship between the degree of specialization by individual venture capitalists at a firm and its success. When the individual investment professionals are highly specialized themselves, the marginal effect of increasing overall firm specialization is much weaker. The poorer performance by generalists appears to be due to both an inefficient allocation of funding across industries and poor selection of investments within industries. Venture capital organizations with more experience tend to outperform those with less experience.

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1. INTRODUCTION

The central goal of organizational economics is to understand how organizational structure affects behavior and performance. This paper tries to address this question by examining the structure and performance of venture capital firms.

The venture capital industry is a good setting for studying the effects of organizational structure for three reasons. First, there is considerable heterogeneity in how venture capital organizations are organized. While some firms specialize in making investments within a particular industry, others take a more generalist approach, diversifying their investments across industries. Some of these generalist firms are comprised of venture capitalists who are themselves generalists, while others are comprised of a diversified group of industry specialists. For example, Kleiner, Perkins, Caufield and Byers, one of the leading venture capital firms, is a generalist firm comprised largely of generalists such as John Doerr who has made investments in the Internet (Amazon, Google), computer software (Intuit) and computer hardware (Sun Microsystems). By contrast, Alta Partners is a generalist firm, with investments in life sciences and information technology but its partners tend to specialize in one industry or the other. And, Domain Associates is a specialist firm (of course comprised of specialists) that focuses on life sciences.

A second reason to study organizations in the environment of venture capital is that we can get detailed information on their specific investments and the individuals responsible for these investments. This allows us to measure the behavior of venture capital firms at a much more detailed level than is typical of studies in this area (such as those on the effects of corporate diversification by Rajan et al. (2000) and Scharfstein (1998)). Finally, studying the venture capital industry allows us to measure the outcomes of investments, thereby enabling us to gauge the effect of organizational structure on performance at a very detailed level.

How might the degree of specialization of venture capital firms and their venture capitalists affect behavior and performance? In theory, it can affect both the quality of capital allocation across industries and the performance of investments within an industry. With respect to cross-industry capital allocation, there are a number of theories about how specialization might affect performance. Stein (1997), for example, sees organizational diversification across industries (i.e., generalist firms in the context of venture capital) as an important element of efficient cross-industry capital allocation. When investment opportunities are poor in one industry, he argues, managers can maintain their overall

capital budget (which they value in and of itself) while still making good investments in their other industries. By contrast, managers of narrowly focused firms with poor investment opportunities have no place else to invest and, in an effort to maintain their capital budget, may end up investing in negative net present value projects. In the context of venture capital, Stein's model would suggest that when investment opportunities are poor in one sector (say life sciences), generalist firms will be more prone than specialist firms to scale back investments in that sector and scale up their investments in more promising sectors (say communications).

One of the critical elements of the Stein model is that the CEO—who has no vested interest in making investments in any particular sector—gets to decide where capital is allocated. However, these capital allocation decision rights are not as clear cut in venture capital firms, where partners often decide by committee where to make investments. Thus, the advantage of a generalist form of organization may not be as large as suggested by Stein, particularly when the venture capitalists themselves are industry specialists with vested interests in making investments in their particular industry. This prediction is in line with the view that diversified firms have a difficult time redeploying capital into sectors with better investment opportunities, as suggested by Rajan et al. (2000), Scharfstein (1998), and Scharfstein and Stein (2000).

However, there are at least three factors that could mitigate the potential for misallocation of capital within generalist firms. First, generalist venture capital firms could be comprised of venture capitalists who are themselves generalists and who presumably would have no vested interest in making investments in any particular industry. Second, venture capitalists have very high-powered incentives, with profit-sharing (carried interest) of 20% of fund returns, well in excess of the type of incentives observed in publicly traded firms. The carried interest that goes to an individual venture capitalist typically does not depend on the returns of his or her own deals, but is a set fraction of the overall fund return. Thus, the incentive to allocate resources correctly should be very powerful. (On the other hand, this share of the profits is set by negotiation among the partners, and a venture capitalist who has not made many good investments may lose bargaining power.) Third, when generalist firms are comprised of specialists, they may be more likely than generalists to spot good investment opportunities in their own industries. Thus, although they may have more at stake in having capital allocated to their own industry, they may also be more informed about good investments.

As noted above, another channel through which organizational specialization could affect performance is through the quality of

investments within (not across) industries. Whether or not specialized firms are better than generalist firms at allocating capital across industries, one might think that specialized firms would make better investments if specialization makes them industry experts who have a better understanding of technology, markets, and people. This would presumably improve the quality of the investment, conditional on making an investment in the industry. Moreover, by the same reasoning, venture capitalists who are industry specialists themselves should be more likely to make higher quality investments in an industry (again conditional on committing capital to the industry).

Thus, to summarize, these theories suggest a number of alternative hypotheses.

1. Generalist venture capital firms will be better at allocating capital across industries (Stein 1997).
2. Generalist venture capital firms will be worse at allocating capital across industries (Rajan et al. 2000; Scharfstein and Stein (2000)).
3. Capital will be allocated better in generalist venture capital firms if the venture capitalists themselves are generalists.
4. To the extent that venture capitalists have high-powered financial interests in the performance of the firm as a whole, any misallocation of capital by generalist firms will be mitigated.
5. To the extent that venture capitalists are specialists, their greater knowledge of investment opportunities will lead to better allocations of capital across industries.
6. Specialization by venture capital firms and venture capitalists will lead to greater expertise and better investments within an industry.¹

We find that generalist firms tend to *underperform* relative to specialist firms. Generalist firms do not appear to allocate capital as well across industries, and may also underperform in their investments within an industry. Importantly, however, this underperformance is mitigated to the extent that the individual venture capitalists in generalist firms are industry specialists. We similarly find in a supplemental analysis that investment specialists seem to be the most responsive to signals of investment opportunity, but that this is mitigated when the average specialization level of their partners is high.

Our findings are inconsistent with hypotheses (1) and (3). Generalist firms are not better than specialist firms, as predicted by (1). In fact, they are worse than specialist firms to the extent that their venture

1. An alternative approach is suggested by Fulghieri and Sevilir (2009) who highlight the consequences of venture capitalists' portfolio choice for the decisions of entrepreneurs to devote effort to their ventures. The paper is also related to Sorensen's work on venture capitalist exploration and exploitation (2008).

capitalists are generalists, contrary to the hypothesis (3). Moreover, there is not much difference in the performance of specialist and generalist firms, when the venture capitalists in the firms are specialists. This finding would appear to be more consistent with hypotheses (4), (5), and (6). Venture capitalist specialization increases the likelihood that venture capital firms spot good industries in which to invest, and make good investments within those industries (as suggested by (5) and (6)). And, because venture capitalists have high-powered financial incentives in the firm's overall performance, there are constraints in how much misallocation venture capitalists are willing to do (as suggested by (4)).

These findings would suggest that specialization at the individual level is more important than specialization at the firm level. However, our findings do not indicate that firm-level characteristics are irrelevant. We find that venture capital firms with more experience tend to outperform those with less experience, and that both firm- and person-level industry experience matters for investment success.

One caveat must be noted about the results. It is important to acknowledge that we are taking the organizational choices of the venture firms as given, and do not explore the determinants of being a generalist or specialist at the firm or individual level. Presumably, this is an endogenous response to firm and industry dynamics, such as competition, industry expertise, and past success, rather than an exogenous feature. Although we explore the characteristics of focused and unfocused firms below, we cannot resolve the question of which firms choose to become specialized. Assuming that firms settle on an optimal organizational form, we are measuring only small effects from deviations from the optimum. We discuss ways that this limitation might be overcome in future work in the conclusion.

The paper is organized as follows. The next section describes the construction of the data and provides some basic summary statistics. Section 3 examines the determinants of successful investments and the characteristics of the venture capital organizations and individual venture capitalists. Section 4 concludes the paper.

2. THE DATA

2.1 CONSTRUCTING THE SAMPLE

Our data on venture investments come from Dow Jones Venture Source (formerly VentureOne). This database provides information about venture capital investors and the portfolio companies in which they invest, as well as the board composition of the portfolio companies. Gompers and Lerner (2004) provide a detailed description of this dataset.

We consider only observations in which the venture capital investor serves on the board of the company.² The date associated with this relationship is the date of the first record of a venture capital organization and portfolio company pair, that is, the first time the venture capitalist invests in a particular company, or if that information is not available, the founding date of the company. This approach results in a dataset with multiple observations for most portfolio companies because representatives of several venture capital firms typically serve on the board of a company. It does not consider the influence of other venture investors who do not serve on the board of directors. This focus seems reasonable because it is the board members who play a key role in selecting and overseeing the funds' investments.

Our analysis focuses on data covering investments from 1975 to 2003, dropping information prior to 1975 due to data quality concerns.³ In keeping with industry estimates of a maturation period of 3 to 5 years for venture capital financed companies, we drop companies receiving their first venture capital investment after 2003 so that the outcome data can be meaningfully interpreted.⁴

In the analysis below, we will seek to relate the organizational characteristics of the firm to its investment success. To do this, the organization needs to have a sufficient track record so that we can meaningfully characterize their approach. We consider only venture capital firms⁵ who are associated with more than five boards, individual venture capitalists who serve on more than three boards, and firms with at least two investment professionals (i.e., those firms with more than one professional serving on the board of three or more portfolio companies in the sample period).⁶

2. We consider the individual representing the venture capital firm on the board to be the one having made the investment decision: typically, the individual who champions the initial investment by a venture organization will also provide its oversight. While this is usually the case, there are rare instances in which one individual at the venture capital firm made the investment decision and another sits on the board.

3. Gompers and Lerner (2004) discuss the coverage and selection issues in Venture Source data prior to 1975.

4. We received the bulk of the data from VentureSource in 2002, and obtained updated outcome information in 2008 for each company in the sample that had received additional funding subsequent to 2002. Outcomes for companies that did not receive additional capital between 2002 and 2008 are not updated; however, this is unlikely to affect a significant number of outcomes.

5. We identify venture capital firms by requiring that the organization that the board member is affiliated with be recorded as being included as an investor in the Venture Source database. This enables us to eliminate organizations that may have employees who are directors of venture-backed firms but are not venture capital investors (such as Harvard Business School).

6. In the approximately 2,700 instances where a venture firm has multiple representatives on the board of a company, we count each board member – company pair as a separate investment. The results are robust to treating these cases in alternative ways.

From 1975 to 2003, Venture Source provides information on 3,518 venture capitalists from 822 venture capital firms⁷ serving on the boards of 11,297 portfolio companies that met our criteria.⁸ This results in a sample of 24,331 observations of unique venture capitalist—portfolio company pairs.

Reflecting the lack of concentration in the venture industry, no single group or set of groups dominates the sample. The most represented five venture organizations—New Enterprise Associates, Kleiner Perkins, U.S. Venture Partners, Bessemer Venture Partners, and Venrock Associates—collectively represent fewer than 6% of the sample.

One complication is introduced by the fact that in some cases, we do not have corroboration that the fund of the venture capitalist serving on the board actually invested in the firm. We are able to confirm that the venture capitalist's firm invested in the company in 20,762 observations (85%).⁹ There are three reasons why might this discrepancy have come about. First, the venture capitalist may serve on the board without their venture capital firm having invested, such as when he or she invests in a company as a private individual (though in many cases, limited partnership agreements prohibit such activities). Second, the investment data may be incomplete. Finally, and probably less frequently, Venture Source codes venture capitalists with their most recent venture capital firm affiliation. Thus, for venture capitalists that have switched firms, we cannot always match the investment of their previous firm to the portfolio company. In supplemental regressions described below, we repeat the analysis using only the 20,762 observations where we can confirm that the venture organization invested.

2.2 CRITICAL MEASURES AND SUMMARY STATISTICS

Before we turn to an analysis of the impact of organizational structure, there are two data construction issues we need to address. The first issue is how to classify the portfolio companies of the venture capitalists

7. Venture capital firms typically raise funds several years apart. In the analysis presented, we ignore to which fund a given venture firm assigned an investment. For instance, when computing cumulative firm experience, we consider all investments made by Mayfield, ignoring whether they were made by Mayfield III or Mayfield VI.

8. Venture Source provides information on all board members. We assume that a firm associated with a board member is a venture capital firm if the firm is observed making an investment in any company in the sample, although we may not have the information on the firm's investment in the company. We drop all observations for firms who we do not ever observe as making investments.

9. Of the 20,762 matched observations, we confirmed that the venture capitalist invested in the company in 17,946 cases from Venture Source. We supplemented this with information from Thomson Venture Economics. Using this database, we were able to corroborate that the venture fund made the investment in an additional 2,816 observations.

TABLE I.
SUMMARY STATISTICS: INDUSTRY COMPOSITION

Industry	Companies	Observations
Internet and computers	4,918	10,555
Communications and electronics	1,629	3,555
Business/industrial	163	271
Consumer	542	1,016
Energy	29	39
Biotech and health care	2,126	5,187
Financial services	237	485
Business services	1,260	2,553
All other	393	670
Total	11,297	24,331

Notes: The compilation of observations includes only cases where board members associated with firms have made more than five investments over the course of the sample, with more than one active person at the firm, and with the board member serving on more than three boards in the sample.

into industries. Our approach is to follow our earlier work (Gompers et al., 2008) and assign all investments into nine broad industry classes based on Venture Source's classification of the industry. The original sample of investments was classified into 125 separate industry segments. However, these 125 industries are too narrowly defined for our purposes, as they do not correspond to lines of specialization within or across venture capital firms. These 125 industries were thus combined to arrive at nine broader industries. The industries we construct from the narrower definitions are: Internet and Computers, Communications and Electronics, Business and Industrial, Consumer, Energy, Biotech and Healthcare, Financial Services, Business Services, and all other. Although any industry classification is somewhat arbitrary, we believe that our classification scheme captures businesses that have similarities in technology and management expertise that would make specialization in such industries meaningful. In addition, this scheme minimizes the subjectivity associated with classifying firms into narrower industry groupings.

Table I shows the distribution across the nine broad industries. The first column is the number of companies in each industry. It is no surprise that internet and computers is the largest industry with 4,918 companies. Communications and electronics, biotech and health care, and business services are the next largest industries with between 1,260 and 2,126 companies. The other industries are considerably smaller. The table also reports the number of observations for each industry in our sample; there are more observations than companies because there are

multiple board members in most of the companies in our sample. On average, there are 2.2 venture capital board members in each company who meet our criteria: that is, we begin with the subset of venture capitalists who serve on more than three boards. We then drop venture capitalists who are the sole person at their firm. The overall industry distribution provides some comfort that our industry classification is meaningful. Although there is variation in the number of observations across industries, there are enough observations in each industry to make our analysis feasible.

The second issue is to measure the organizational structure and specialization choices of the venture capitalists and venture capital firms in the sample. The first panel of Table II presents data on characteristics of venture capital firms and people that we use throughout the paper. The first such characteristic, "Herfindahl," is the Herfindahl–Hirschman Index for the firm or person, that is, the sum of the squares of the percentage of all previous investments in each industry (excluding the "all other" industry classification). Thus, a firm or person with a Herfindahl of 1 has invested in only one of the industries. We calculate this measure on the firm level and the person (venture capitalist) level. We consider this measure for all the previous investments of the firm or person as well as for just the investments in a given year.

In addition, when considering the firm characteristics, we calculate an "average Herfindahl," which is the average of the Herfindahls of all the individual venture capitalists active at the firm. We consider a venture capitalist to be active at the firm in a given year when they have made an investment in that year, or if they made an investment at any point prior to that year and at any point after that year.¹⁰

As controls, following Gompers et al. (2008), we consider the following data items: "General Experience" is the total number of investments made by a venture capital firm prior to the time of the investment in question. (In the regression analyses below, we will compute the firm experience measures as the difference between the logarithm of the number of investments made by the venture capital organization prior to year t and the average in year t of the number of investments made by all organizations prior to year t , and similarly the person experience as the difference between the number of investments made by all venture capitalists prior to year t and the average in year t of the number of investments made by all venture capitalists prior to year t . We present unadjusted experience measures here for expositional clarity.) "Industry Experience" is constructed similarly, but includes

10. In the person-level calculations, we only compute these measures for investors who were active in a given fund and year.

TABLE II.
SUMMARY STATISTICS—CHARACTERISTICS

Panel A: Characteristics of Firms and People					
	25%	Median	75%	Mean	N
Firm-Level Statistics					
Firm Herfindahl	0.2968	0.3878	0.5363	0.4468	5,576
Firm Herfindahl in Year	0.4306	0.5556	1.0000	0.6690	5,576
Avg. Herfindahl of people at firm	0.5278	0.6670	0.8125	0.6755	5,576
End of Sample (2003 or last observation)					
Firm Herfindahl	0.2939	0.3728	0.5000	0.4196	822
Firm Herfindahl in year	0.5000	1.0000	1.0000	0.7834	822
Avg. Herfindahl of people at firm	0.4106	0.5556	0.6860	0.5703	822
Person-Level Statistics					
Person Herfindahl	0.4286	0.5556	1.0000	0.6416	14,579
Person Herfindahl in year	0.6250	1.0000	1.0000	0.8559	14,579
End of Sample (2003 or last observation)					
Person Herfindahl	0.3750	0.5510	0.6800	0.5661	3,518
Person Herfindahl in year	1.0000	1.0000	1.0000	0.8737	3,518
Panel B: Specialization by Firm and By Person					
	Average Person Herf. Quartile				
Firm Herf. Quartile	1 <i>0 to 0.53</i>	2 <i>0.53 to 0.67</i>	3 <i>0.67 to 0.81</i>	4 <i>0.81 to 1</i>	Total
1 0 to 0.30	703	436	202	53	1,394
2 0.30 to 0.39	427	454	392	144	1,417
3 0.39 to 0.54	249	382	439	301	1,371
4 0.54 to 1	25	112	386	871	1,394
Total	1,404	1,384	1,419	1,369	5,576
Panel C: Evolution of Firm Specialization Over Time					
Firm Age	0–2 Years	3–4 Years	5–9 Years	10 + Years	
Mean firm Herfindahl	0.7748	0.6785	0.5224	0.4030	
Mean firm rolling 5-year Herfindahl	0.6619	0.6035	0.5651	0.4446	
Mean Avg. Herf. of people at firm	0.8577	0.8092	0.7120	0.5634	
N	539	539	539	539	

One observation per firm-year or person-year in years in which the firm or person made an initial investment in the company in which they are serving on the board (or the founding date of the company if investment information is not available). Includes only observations of board members associated with venture capital firms who have made more than five investments, with more than one active person at the firm, and with the board member serving on more than 3 boards in the sample. Panel C includes only companies that remain in the sample for more than 10 years.

Note: Correlation of firm Herfindahl and average Herfindahl of people at firm for this sample as of the final observation in the sample was 0.5766.

only investments in the same industry as the investment in question. The third characteristic, "Specialization," is the fraction of all previous investments that the venture capital organization made in a particular industry, that is, this specialization measure is the ratio of industry to general experience. The specialization measure is not calculated for the first investment by each venture organization.

Panel A of Table II summarizes the level of specialization for firms and individuals in our sample. We compare the Herfindahl of firms and individuals for the entire sample across all years and the Herfindahl that exists for firms at the end of our sample. Firms and individuals appear to have remained similarly specialized over the sample.

Panel B of Table II shows the distribution of specialization by firms and people by quartile. The quartiles represent increasing degrees of specialization, where 1 indicates generalists and 4 specialists. A majority of observations are across the center diagonal, indicating that firms and venture capitalists tend to reflect each other: that is, firms of generalists tend to be comprised of generalist partners while specialist firms are, not surprisingly, typically comprised of specialist individuals. However, we do see some observations where firms of specialists have combined to become generalist firms (Firm quartile 1, Person quartiles 3 and 4).

Panel C of Table II shows the evolution of firms' specialization over time for the subset of firms that survived for more than 10 years in our sample. The mean firm Herfindahl declines from 0.77 for firms that are less than 3 years old to 0.40 for firms that are more than 10 years old. The pattern of decreasing specialization is also found when calculating firms' Herfindahls on a 5-year rolling basis, suggesting firms are more likely to become generalists over time. In addition, the average Herfindahl of the individuals at the firm decreases over time, suggesting that this decrease in specialization at the firm level is the result of decreased specialization at the partner level, rather than the addition of specialists in new industries to the firm.

Table III presents descriptive characteristics for each of the firm quartiles. Generalist firms (that is, firms in the lowest specialization quartile) have a mean firm Herfindahl of 0.23 versus a mean firm Herfindahl of 0.76 for specialists. Generalist firms have higher levels of general experience, perhaps indicating a tendency to drift from specialization over time (as seen in Panel C of Table II). Firms in the top two quartiles of generalists also appear to be larger, with more than four active people. Those in the highest specialization quartile tend to be somewhat smaller (three active people) and less established (with less than half the general experience of the firms in the other quartiles).

TABLE III.
SELECTED STATISTICS BY FIRM HERFINDAHL QUARTILE

Firm Herf. Quartile		Mean	SD	N
1	Firm Herfindahl	0.2327	0.0488	1,394
	Firm Herf. in year	0.5149	0.3015	1,394
	Avg. Herf. of people at firm	0.5203	0.1725	1,394
	General experience	34.09	47.95	1,394
	Number of active people	4.43	3.19	1,394
2	Firm Herfindahl	0.3421	0.0261	1,417
	Firm Herf. in year	0.5925	0.2731	1,417
	Avg. Herf. of people at firm	0.6232	0.1558	1,417
	General experience	32.96	41.20	1,417
	Number of active people	4.28	2.91	1,417
3	Firm Herfindahl	0.4579	0.0442	1,371
	Firm Herf. in year	0.7006	0.2670	1,371
	Avg. Herf. of people at firm	0.6985	0.1636	1,371
	General Experience	20.31	27.49	1,371
	Number of active people	3.47	2.11	1,371
4	Firm Herfindahl	0.7564	0.1764	1,394
	Firm Herf. in year	0.8697	0.2091	1,394
	Avg. Herf. of people at firm	0.8612	0.1384	1,394
	General experience	13.94	17.82	1,394
	Number of active people	3.05	1.43	1,394
Total	Firm Herfindahl	0.4468	0.2174	5,576
	Firm Herf. in year	0.6690	0.2964	5,576
	Avg. Herf. of people at firm	0.6755	0.2011	5,576
	General experience	25.38	36.65	5,576
	Number of active people	3.81	2.57	5,576

Notes: One observation per firm year or person year in years in which the firm or person made an initial investment. Includes only observations of board members associated with venture capital firms who have made more than five investments, with more than one active person at the firm, and with the board member serving on more than three boards in the sample.

3. THE ANALYSIS

We now turn to examining how the structure of venture capital organizations affects the success of their investments. We begin with cross-tabulations and then turn to a series of regression analyses.

3.1 CROSS-TABULATIONS

A natural question is how to define investment success. Ideally, we would have data on the actual returns on the firm's investment. Unfortunately, the best we can do is to determine whether the investment resulted in what would appear to be a profitable exit for the venture capital firm. This is most likely the case if the company went public,

registered for an IPO (as of the date we collected the data from Venture Source), or was acquired or merged. Venture Source does not collect valuation information for all of the companies that were merged or acquired and it is possible that these outcomes were not as lucrative as those where the company exited with a public offering. However, investments in the category we characterize as successes are likely to have generated higher returns than did investments that have not yet exited or are characterized as bankrupt or defunct. This approach is consistent with the evidence in Hochberg et al. (2007), who show that venture capitalists generate the bulk of their returns from the minority of investments that are taken public or acquired. When defining success only as an initial public offering, the results were consistent, although not across all specifications. This may reflect the fact that IPOs are not a precise measurement of success, or that exiting by acquisition may be a different skill set

Our data also allows us to breakdown success into its components. We examine "Mean Success," that is, the raw rate of IPO, registration, or acquisition. Our second success measure, is a given venture firm's abnormal performance. We define abnormal performance as the difference between the firm's investment success and the average investment success in that industry in that year. We denote this as "Industry Alpha" in the tables. Finally, we adjust success to examine the ability of a venture capital group to select investments in good industries at good times, denoted "Mix" in the tables. In each year, we calculate a firm's "Mix" as the average success rate of all investments in that same year in the industries in which the firm invests, using the actual percentages invested in each industry as weights. Thus, we measure industry timing ability by assuming a firm achieves *industry average* success rates for the industries in which it invested.

To illustrate these measures, consider a firm that invested in eight deals, four in consumer and four in internet in 1 year. Further assume that two of the firm's consumer deals were successful (a 50% success rate) and one of the firm's internet deals was successful (25%). The overall mean yearly success for this firm would be 37.5%. Assume that the average success rate in consumer deals in that year was 25%, and the average success rate in internet deals was 75%. The "Mix" measure, or the average success rate in that year of the industries in which the firm invested, would be 0.50 ($=0.50 \times 0.25 + 0.50 \times 0.75$). The "Industry Alpha," or the difference between the actual and predicted success rates, would be $-0.125 (= 0.375 - 0.500)$.

Table IV provides some initial indications of the patterns of success by venture capital firm characteristics. Panel A examines our three measures of success for each quartile of specialization at both the firm

TABLE IV.
PERFORMANCE MEASURES

Panel A: Performance Measures by Firm and Person Quartiles		Mean	SD	N	Avg. Person Herf. Quart.	Mean	SD	N
Firm Herf. Quartile								
1	Mean success	0.4731	0.3703	1,394	1	Mean Success	0.4272	0.3787
	Industry alpha	0.0069	0.2871	1,394		Industry Alpha	-0.0024	0.2986
	Mix	0.4673	0.1944	1,394		Mix	0.4295	0.1978
2	Mean success	0.4603	0.3690	1,417	2	Mean Success	0.4515	0.3548
	Industry alpha	-0.0068	0.3059	1,417		Industry Alpha	0.0084	0.2876
	Mix	0.4668	0.1966	1,417		Mix	0.4439	0.1905
3	Mean success	0.4603	0.3870	1,371	3	Mean Success	0.5015	0.3789
	Industry alpha	-0.0068	0.3321	1,371		Industry Alpha	0.0076	0.3166
	Mix	0.4656	0.1961	1,371		Mix	0.4931	0.1904
4	Mean success	0.5026	0.4046	1,394	4	Mean Success	0.5165	0.4123
	Industry alpha	-0.0055	0.3593	1,394		Industry Alpha	-0.0264	0.3783
	Mix	0.5084	0.1898	1,394		Mix	0.5426	0.1808

Panel B: Correlation Matrix

	Mean Success	Incl. Alpha	Mix	# of People at Firm	Gen'l Firm Exp.	Avg. Exp. of People at Firm	Mean Focus of Firm in Deals	Mean Round # of Deals
Mean success	1.0000							
Industry alpha	0.8396*	1.0000						
Mix	0.5122*	0.0018	1.0000					
Number of people at firm	0.0271*	-0.0855*	-0.0876*	1.0000				
General firm experience	-0.0854*	0.0839*	-0.3046*	0.6534*	1.0000			
Avg. Experience of people at firm	0.0750*	0.0869*	0.0009	0.2851*	0.5720*	1.0000		
Mean focus of firm in deals	0.0195	0.0156	0.0113	-0.0648*	-0.0409*	-0.0260	1.0000	
Mean round number of deals	0.0694*	0.0651*	0.028	-0.0383*	0.0066	-0.0438*	-0.0018	1.0000
Connections	0.0262	0.1156*	-0.1405*	0.6636*	0.8245*	0.5838*	-0.0353*	0.0328*

Notes: One observation per firm year or person year in years in which the firm or person made an investment. Includes only observations of board members associated with venture capital firms who have made more than 5 investments, with more than 1 active person at the firm, and with the board member serving on more than 3 boards in the sample. In Panel B, "generalist" and "specialist" refer to people below and above the median Herfindahl index. *Indicates significance at the 5% level.

and the individual level. The tabulations suggest that the industry mixture chosen by venture capital firms with more specialization—particularly on the individual level—is more successful. The specialized firms and individuals, however, appear to select poorer companies in which to invest within these industries, that is, their industry alpha is more negative. The best overall and industry adjusted performance is associated with more generalist venture capital firms. These results, as we shall see in the regressions, are influenced by generalist firms being more experienced on average. Hence, our conclusions here are only tentative, as the univariate comparisons do not control for other factors associated with success.

In Panel B, we look at the correlation between these measures. Interestingly, we see that picking the right industries and industry-adjusted alpha are uncorrelated. The correlation matrix also provides important insights into other variables that we need to control for in the regressions. Firm size (number of people at firm), the average experience of individuals and the average stage of investment (round number) are all positively correlated with success. Interestingly, firm general experience is positively correlated with industry alpha, but not with overall success.

One consideration in the definition of specialization is that less experienced venture capital firms are more likely to be in the fourth quartile (the most specialized). We later consider the results looking only at organizations at the point in time where they made more than twenty investments and achieve weaker, but consistent results.

3.2 REGRESSION ANALYSES OF SUCCESS

We approach the regression analyses of success in a similar manner to the cross-tabulations above. We first consider the mean yearly success rate, and then decompose this rate into the selection of the proper industry mixture and the selection of firms that exceeded the average industry performance in that year.

In Table V, we examine overall annual success. We construct observations in each year in which the venture capital firm made an initial investment in a company. For each firm-year observation, we indicate the average success of all initial investments made by the venture capital firm in that year. We use as observations each year in which a venture capital group made an initial investment: that is, we omit cases where the venture group did not make an investment in a given year, as well as cases where all investments were into firms in which the group had previously invested. In all regressions we add controls for the year of the investment to control for differences in macroeconomic conditions across the periods.

TABLE V.
MEAN YEARLY SUCCESS

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	OLS	OLS	OLS	OLS	Weighted OLS	OLS	OLS
Firm Herfindahl	0.4123 [3.34]***	0.3866 [3.24]***	0.2315 [1.86]	0.2247 [1.12]	0.2697 [2.37]**	0.3756 [3.07]***	0.3676 [3.00]***
Avg. Herfindahl of people at firm	0.1219 [1.99]**	0.1026 [1.69]**	0.1555 [2.37]	0.2204 [2.13]**	0.1418 [2.35]**	0.0802 [1.30]	0.0790 [1.25]
Firm × Avg. person Herfindahl	-0.4375 [3.06]***	-0.3371 [2.43]**	-0.2088 [1.41]	-0.2173 [0.85]	-0.2347 [1.66]**	-0.3591 [2.52]**	-0.3183 [2.24]**
Firm general experience		0.0582 [7.69]***	0.0264 [2.08]	0.0604 [2.77]**	0.0363 [3.17]**		0.0505 [4.36]***
Avg. gen'l experience of people at firm		-0.0024 [1.19]	-0.0016 [0.67]	-0.0035 [1.32]	-0.0017 [0.94]		-0.0054 [2.31]**
Controls:							
Year fixed effects	yes	Yes	yes	yes	yes	yes	yes
Number of people at firm			yes	yes	yes	yes	yes
Connections			yes	yes	yes	yes	yes
Mean round number of deals			yes	yes	yes	yes	yes
Percent in each industry							
Experience restriction	5 total	5 total	5 total	>20 previous	5 total	5 total	5 total
Observations	5,576	5,576	4,150	1,800	4,150	5,576	5,576
R ²	24.0%	25.3%	30.5%	37.2%	41.3%	25.4%	25.7%

Notes: The sample consists of 822 VC firms with 3,518 firm members serving on the boards of 11,297 companies from 1975 to 1998, inclusive, as compiled by Venture Source, with one observation per VC-year including only board members associated with venture capital firms who invested in more than 5 companies in the sample with more than one active person at the firm, and with all board members who served on more than 3 boards. The fourth specification includes observations only for firms that had made more than 20 investments previous to the year of observation. The fifth specification weights observations by the number of investments made by that firm in that year. The dependent variable is *Mean Yearly Success*, the average of the success rates for all companies invested in by the VC in the sample. The success rates being averaged is a binary variable = 1 if the portfolio company was acquired, merged, in registration for an IPO (as of the date we collected the Venture Source data), or went public, and = 0 otherwise. *Firm Herfindahl* is the sum of the squares of the percentage of all previous investments in each industry on the board of (excluding the industry all other). *Avg. Herfindahl of People at Firm* is the average of the Herfindahl for each active venture capitalist at the VC firm. *Firm General Experience* is the difference between the log of the number of investments made by venture capital organization *f* prior to year *t* and the average in year *t* of the number of investments made by all organizations prior to year *t*. *Avg. Gen'l Experience of People at Firm* is the difference between the average number of average investments by all people prior to date *t* and number of investments made by people associated with the firm prior to date *t*. Standard errors are clustered at the VC firm level. *T*-statistics are in brackets; italics below coefficient estimates. ***, **, * indicate statistical significance at the 1%, 5% and 10% level, respectively.

In the basic regressions, increased specialization of the venture capital organization is associated with greater average success, indicated by the consistent positive sign on the firm Herfindahl. The interaction between firm and individual specialization, however, is negative. Examining the relative size of the coefficients indicates that the marginal effect of increasing individual specialization for relatively specialized firms negatively affects performance although it enhances the performance of very generalist firms. On the other hand, holding individual venture capitalists' specialization constant, increasing firm specialization enhances firm performance. The poorest performance is associated with unspecialized firms with generalist investors. These findings are consistent with the first and third hypotheses delineated in the introduction.

In addition to the specialization measures, we include measures of investment experience for the firm and individuals to identify the impact that experience has on investment performance.¹¹ Firm experience is defined as the difference between the logarithm of the number of investments made by the venture capital organization prior to year t and the average in year t of the number of investments made by all organizations prior to year t . Similarly, person experience is the difference between the logarithm of the number of investments made by all venture capitalists prior to year t and the average in year t of the number of investments made by all venture capitalists prior to year t . We find that firm generalist experience is positively related to success. Firm-level experience dominates the effect of individual generalist experience, which has a negative or not significant coefficient in the estimation.¹² The result may indicate that broader reputation and network issues are present at the firm level as well as the presence of learning (knowledge spillovers) across firm partners.

The differences in success are also economically meaningful. For instance, using the estimates from column 3, a generalist firm (that is, at the 25th percentile of firm Herfindahl, or 0.30) with generalist people (a Herfindahl of 0.54) has an annual success rate that is 2.7% below that of a generalist firm with specialized people (at the 75th percentile, or an average person Herfindahl of 0.81). Thus, if a generalist firm with generalist people in a given year had an success rate of 50% in 1998, the success rate of an equivalent firm with more specialized people

11. We want to ensure that the results from specialization are not driven by the relative experience of specialized and generalist venture capital groups (individuals).

12. The presence of a relationship between venture firm experience and success is documented by Kaplan and Schoar (2005) and Lerner, Schoar, and Wongsunwai (2007), but those works does not attempt to disentangle the importance of individual and firm experience.

would be 52.7% in that year. The incremental difference in success between a generalist firm with specialized people and a specialized firm (a Herfindahl of 0.54) with specialized people is slightly smaller: an additional 1.5%. This translates into an approximately 1% difference in fund IRR.¹³

These results continue to be robust when we make a number of changes. These include adding controls for the number of investment professionals, and a measure of the firms' connections (the number of other venture capital firms a firm has invested with as per Hochberg et al. (2007)). In addition, we tried adding a control for the round number at which the venture group typically invested (which sharply decreases the sample size), restricting the sample to venture groups that made twenty or more investments, weighting the observations by the number of investments made by the venture capital firm in the observation year, and controlling for the percentage of transactions in each industry. The results were similar in magnitude for all additional controls, although in some cases coefficients are significant only at the 10% level, in part reflecting the reduced number of observations. Our results are strongest when weighting the sample by the number of investments, perhaps because we have the least noise in our success measure for firms that have the greatest number of investments.

We next examine the determinants of a successful investment mixture. The dependent variable is the average industry success for investments made in a given year for each year in which the venture capitalist made an investment. In other words, Table VI examines what fraction of the firm's overall success is driven by picking the right industry at the right time.

Table VI reports that both firm and individual specialization are associated with greater success, but again the interaction is negative. If the individual investors within a venture capital firm are generalists, the marginal effect of increasing firm specialization will be to boost the probability of selecting a good industry mix substantially. Firm specialization enhances performance at the margin when individual investors are generalists. Said another way, when venture capitalists individually invest across industries, they are better off if their partners are investing in the same industries. If individual investors are specialists already, the marginal impact of increasing firm specialization will be close to zero. This result is consistent with the second hypothesis in the introduction.

13. Assuming a \$100 million fund invested over 3 years with a 3:1 ratio of dollars invested for successful to unsuccessful investments, a 5 year holding period, and an average exit multiple of 10x investment for successful investments and 0x for unsuccessful investments. Assumptions are based on VentureXpert data.

TABLE VI.
PERFORMANCE DUE TO MIX

	(1) OLS	(2) OLS	(3) OLS	(4) OLS	(5) Weighted OLS	(6) OLS
Firm Herfindahl	0.1192 [5.87]***	0.1161 [5.55]***	0.1104 [4.80]***	0.1193 [2.88]***	0.1183 [5.94]***	0.0946 [4.83]***
Avg. Herfindahl of people at firm	0.0638 [5.85]***	0.0636 [5.73]***	0.0783 [6.30]***	0.1076 [5.04]***	0.0927 [8.72]***	0.0535 [5.26]***
Firm × Avg. person Herfindahl	-0.1149 [4.93]***	-0.1078 [4.57]***	-0.1148 [4.26]***	-0.1492 [2.92]***	-0.1282 [5.27]***	-0.0996 [4.51]***
Firm general experience		0.0031 [2.04]**	0.0005 [0.21]	0.0010 [0.22]	0.0036 [1.75]*	-0.0027 [1.19]
Avg. Gen'l experience of people at firm		0.0001 [0.20]	0.0002 [0.32]	-0.0004 [0.63]	0.0001 [0.16]	0.0004 [0.86]
Controls:						
Year fixed effects	yes	yes	yes	yes	yes	yes
Number of people at Firm						
Connections						
Mean round number of deals						
Max industry fixed effects						
Experience restriction						
Observations	5 total 4,150	5 total 5,576	5 total 4,150	>20 previous 1,800	5 total 4,150	5 total 5,576
R ²	88.3%	88.3%	91.1%	91.8%	93.6%	89.2%

Notes: The sample consists of 822 VC firms with 3,518 firm members serving on the boards of 11,297 companies from 1975 to 1998, inclusive, as compiled by Venture Source, with one observation per VC-year including only board members associated with venture capital firms who invested in more than 5 companies in the sample with more than one active person at the firm, and with all board members who served on more than 3 boards. The fifth specification includes observations only for firms that had made more than 20 investments previous to the year of observation. The sixth specification weighted observations by the number of investments made by that firm in that year. The dependent variable is *Yearly Success due to Mix*, the product of the percentage of deals by the VC firm in given industries and the average success rate for all VCs in that industry in that year. The success rates being averaged across all VCs is a binary variable = 1 if the portfolio company was acquired, merged, in registration for an IPO (as of the date we collected the Venture Source data), or went public, and = 0 otherwise. *Firm Herfindahl* is the sum of the squares of the percentage of all previous investments in each industry that the VC firm partners are on the board of (excluding the industry all other). *Avg. Herfindahl of People at Firm* is the average of the Herfindahl for each active venture capitalist at the VC firm. *Firm General Experience* is the difference between the log of the number of investments made by venture capital organization *t* prior to year *t* and the average in year *t* of the number of investments made by all organizations prior to year *t*. *Exp. Gen'l Experience of People at Firm* is the difference between the average number of average investments by all people prior to date *t* and number of investments made by people associated with the firm prior to date *t*. Standard errors are clustered at the VC firm level. *T*-statistics are in brackets (t-stat below coefficient estimates). ***, **, * indicate statistical significance at the 1%, 5% and 10% level, respectively.

These effects continue to be strong when we control for experience at the firm and venture capitalist level and firm size, firm connections, and stage of investment, add fixed effects for the main industry focus of the firm (i.e., to control for the fact that biotechnology deals are more successful on average and also that venture firms specializing in biotechnology transactions tend to be more specialized), limit the sample to firms with more than twenty investments prior to the year of the observation, weight the observations by the number of deals done by the venture firm in a year, and control for the industry with the most investments.

The differences are of a reasonable economic magnitude as well as being statistically significant. If a generalist firm with specialist people achieves only the average success rate of the overall venture capital industry, that firm is expected to exceed the success rate of generalist firm with generalist people by 1.7%. This could aggregate to a 2% increase in the fund's IRR.¹⁴ A change from a generalist firm with specialist people to a specialized firm with specialized people leads to an increase of an additional 1.3%.

One interpretation of this result is that a very generalist individual may not be able to identify the best time to invest in unfamiliar sectors. A modicum of specialization at the individual and/or firm level may provide the ability and knowledge to identify them (or perhaps better access to deals). This is consistent with Gompers et al. (2008), which finds that the most *industry* experienced venture capitalists are able to respond the most to market signals. However, too much specialization may mean a lack of relevant expertise or deal access in other promising sectors.

Table VII looks at excess performance. The dependent variable is the difference between the firm's industry-year performance and the average industry-year performance for all venture capital investments made in that year. The patterns here are much less consistent. Initially, the familiar pattern of a positive coefficient on firm Herfindahl terms and a negative interaction term appears. But the coefficients vary in significance as we add additional control variables, limit the sample to the most seasoned experienced investors, and weight the observations. Thus, this analysis provides only weak support for the sixth hypothesis in the introduction.

One result that remains strong throughout the table, however, is the effect of firm general experience. Firm general experience is always significantly related to outperforming industry average success rates. Controlling for firm experience, average individual experience seems to

14. Using the same assumptions in footnote 13.

TABLE VII.
PERFORMANCE DUE TO INDUSTRY ALPHA

	(1) OLS	(2) OLS	(3) OLS	(4) OLS	(5) Weighted OLS
Firm Herfindahl	0.2696 [2.41]**	0.2489 [2.30]**	0.1299 [1.14]	0.0707 [0.38]	0.1229 [1.17]
Avg. Herfindahl of People at Firm	0.0434 [0.78]	0.0237 [0.43]	0.0639 [1.10]	0.0705 [0.73]	0.0138 [0.26]
Firm × Avg. Person Herfindahl	-0.2949 [2.26]**	-0.2041 [1.61]	-0.0924 [0.68]	-0.0098 [0.04]	-0.0620 [0.48]
Firm General Experience		0.0544 [7.37]**	0.0272 [2.23]**	0.0593 [2.76]**	0.0303 [3.05]**
Avg. Gen'l Experience of People at Firm		-0.0027 [1.38]	-0.0022 [0.98]	-0.0038 [1.47]	-0.0022 [1.21]
Controls:					
Year Fixed Effects	yes	yes	yes	yes	yes
Number of People at Firm			yes	yes	yes
Connections			yes	yes	yes
Mean Round Number of Deals			yes	yes	yes
Experience Restriction?:			5 total	>20 previous	5 total
Observations	5,576	5,576	4,150	1,800	4,150
R-squared	0.6%	2.3%	2.4%	4.2%	4.2%

Notes: The sample consists of 822 VC firms with 3,518 firm members serving on the boards of 11,297 companies from 1975 to 1998, inclusive, as compiled by Venture Source, with one observation per VC-year including only board members associated with venture capital firms who invested in more than 5 companies in the sample with more than one active person at the firm, and with all board members who served on more than 3 boards. The fourth specification includes observations only for firms that had made more than 20 investments previous to the year of observation. The fifth specification weights observations by the number of investments made by that firm in that year. The dependent variable is *Yearly Success due to Performance*, the weighted average of the difference between the mean success rate of a given VC firm and the average success of all VC firms in that industry, with weights equal to a firm's actual mix. The success rate being averaged across all VCs is a binary variable = 1 if the portfolio company was acquired, merged, in registration for an IPO (as of the date we collected the VentureSource data), or went public, and = 0 otherwise. *Firm Herfindahl* is the sum of the squares of the percentage of all previous investments in each industry that the VC firm partners are on the board of (excluding the industry all other). *Avg. Herfindahl of People at Firm* is the average of the Herfindahl for each active venture capitalist at the VC firm. *Firm General Experience* is the difference between the log of the number of investments made by venture capital organization *f* prior to year *t* and the average in year *t* of the number of investments made by all organizations prior to year *t*. *Avg. Gen'l Experience of People at Firm* is the difference between the average number of average investments by all people prior to date *t* and number of investments made by people associated with the firm prior to date *t*. Standard errors are clustered at the VC firm level. *T*-statistics are in brackets below coefficient estimates. ***, **, * indicate statistical significance at the 1%, 5%, and 10% level, respectively.

have a negative or no effect on success. Firms that have invested in more deals are either matching with better entrepreneurs, selecting better investments or are better able to make their investments successful.

In Table VII, we estimated alpha looking at annual differences from industry averages. In Table VIII, we can estimate alpha more directly. We use each investment by a venture group as a separate observation rather than averaging success for the venture group by industry and year. The dependent variable is the success of the venture firm's investment in the individual company. Here we see the familiar pattern, with more concentrated investments at the individual and firm level being associated with greater success, but a negative interaction term. The significance of the interaction term, however, varies across various specifications. This is not surprising, because in the previous specifications some of the impact of organizational structure on annual success rate was through mix. In Table VIII, mix is effectively captured by the controls for industry and year.

Because we are looking at individual deals, we can control for individual investor characteristics. We substitute the Herfindahl of the person at the firm who serves on the board for the average Herfindahl of all people at the firm, and find similar results, with positive coefficients on the person and firm's Herfindahl and a negative coefficient on the interaction. The results using the actual board member's Herfindahl are stronger than using the average of people at the firm. In addition, we control for individual and firm experience in and outside of the particular industry. Unlike the results from Table VII, only the individual's industry experience is significantly positively related to success while the firm's industry experience is negatively related to success. An individual investor's experience outside the industry is also negatively related to success to his/her success in the particular investment.

It is natural to wonder if generalist venture firms are simply failed specialists. If so, our results might be explained by the tendency of firms to abandon their initial area of specialization if these investments prove unsuccessful. In unreported analyses, the evidence appears mixed. For instance, when we compare in univariate tests venture firms' specialization after their first ten and twenty deals, the firms whose first ten transactions were more successful diversify less quickly than the others. But when we estimate regressions to understand this relationship more systematically (i.e., when we regress the average Herfindahl at 3-year intervals on previous success and various control variables), a consistent pattern does not appear.

TABLE VIII.
DEAL-LEVEL PERFORMANCE

	(1) OLS	(2) OLS	(3) OLS	(4) OLS	(5) OLS
Firm Herfindahl	0.1798 <i>[1.89]*</i>	0.2199 <i>[3.07]***</i>	0.1985 <i>[2.78]***</i>	0.2209 <i>[2.16]**</i>	0.1734 <i>[2.32]**</i>
Avg. Herfindahl of people at firm	0.0929 <i>[1.71]*</i>				
Firm × Avg. person Herfindahl	-0.1281 <i>[1.09]</i>				
Herfindahl of person		0.0909 <i>[2.61]***</i>	0.0880 <i>[2.52]**</i>	0.1022 <i>[2.09]**</i>	0.0332 <i>[0.84]</i>
Firm × Person Herfindahl		-0.1653 <i>[1.95]*</i>	-0.1406 <i>[1.66]*</i>	-0.1472 <i>[1.16]</i>	-0.0960 <i>[1.06]</i>
General experience (Firm)	0.0245 <i>[3.69]***</i>	0.0247 <i>[3.70]***</i>	0.0258 <i>[3.88]***</i>	<i>[0.04]</i>	
Industry experience (Person)					0.0188 <i>[2.39]**</i>
Nonindustry experience (Person)					0.0195 <i>[2.25]**</i>
Nonindustry experience (Firm ex. person)					-0.0290 <i>[1.47]</i>
Industry experience (Firm ex. person)					-0.0069 <i>[0.45]</i>
Controls:					
Year fixed effects	yes	yes		yes	yes
Industry fixed effects	yes	yes		yes	yes
Round fixed effects	yes	yes	yes	yes	yes
Connections	yes	yes	yes	yes	yes
Industry × year fixed effects			yes		
Experience restriction?:	<i>5 total</i>	<i>5 total</i>	<i>5 total</i>	<i>>20 Previous</i>	<i>5 total</i>
Observations	17,910	17,910	17,910	11,660	19,197
R ²	15.9%	15.9%	16.9%	15.3%	16.0%

Notes: The sample consists of 822 VC firms with 3,518 firm members serving on the boards of 11,297 companies from 1975 to 1998, inclusive, as compiled by Venture Source, with one observation per VC-company, including only board members associated with venture capital firms who invested in more than 5 companies in the sample with more than one active person at the firm, and with all board members who served on more than 3 boards. The dependent variable is *Success*, a binary variable =1 if the portfolio company was acquired, merged, in registration for an IPO (as of the date we collected the Venture Source data), or went public, and =0 otherwise. *Firm Herfindahl* is the sum of the squares of the percentage of all previous investments in each industry that the VC firm partners are on the board of (excluding the industry all other). *Avg. Herfindahl of People at Firm* is the average of the Herfindahl for each active venture capitalist at the VC firm. Experience is the difference between the log of the number of investments made by venture capital organization *f* (or person *p*) prior to year *t* and the average in year *t* of the number of investments made by all organizations prior to year *t*. *Industry Experience* is the difference between the log of the number of investments made by venture capital organization *f* in industry *g* prior to year *t* and the average in year *t* of the number of investments made by all organizations in industry *g* prior to year *t*. *Non Industry Experience* is the difference between the log of the number of investments made by venture capital organization *f* (or person *p*) in industries other than *g* (~*g*) prior to year *t* and the average in year *t* of the number of investments made by all organizations in all industries other than *g* (~*g*) prior to year *t*.

Standard errors are clustered at the portfolio company level. T-statistics are in brackets italics below coefficient estimates.

***, **, * indicate statistical significance at the 1%, 5% and 10% level, respectively.

3.3 ROBUSTNESS CHECKS

We conducted a series of unreported robustness checks. First, one limitation of the earlier analysis, as previously noted, is that the dependent variables only measure the type of exit achieved and not the actual rates of return. Investments that are labeled as successes above may have widely different performance, with some generating spectacular returns and others much more modest ones (for evidence regarding the skewness of venture capital returns, see Cochrane (2005)).

An alternative approach is to examine actual returns of venture funds. To do this, we match the investments made by each venture organization to the fund returns. Our source for return data is the *2004 Private Equity Performance Monitor*, which presents return data on over 1,700 private equity funds. This information is compiled by Mark O'Hare, who over the past 5 years has created a database of returns from public sources (e.g., institutional investors who have posted their returns online), Freedom of Information Act requests to public funds, and voluntary disclosures by both general and limited partners. Due to the limitations of the Venture Source data, we need to make some assumptions in order to do this mapping. (For instance, because Mayfield V was raised in 1984 and Mayfield VI in 1988, we attribute all new investments made between 1984 and 1987 to Mayfield V.) In an unreported analysis, a familiar performance pattern emerges: a positive effect of individual specialization on performance. Firm specialization and the interaction term, however, are insignificant, which may reflect the noise in fund returns data and the smaller sample size.

It is possible that the organizational structure of a firm might change over time as partners join and exit the firm. Thus, we considered an alternate measure of firm Herfindahl that looks only at the firm's investments and/or board memberships within 5 years, rather than the primary measure used in the paper. Results were similar consistently to those reported in the paper, although in some cases the statistical significance was reduced.

We also considered an alternate specification for the measure of success due to industry mix. We ran a two stage regression in which the first stage controlled for the fixed effect of percentage investment in industry in a year, and the second stage used the residual from the first stage as the dependent variable. The residual from the first stage regression had a correlation of 0.8943 with the primary measure of success due to mix used in the paper. The results were similar to those reported.

We also use as our measure of success an indicator of the percentage of portfolio companies that went public (that is, we do not

count firms that were acquired or simply registered to go public as successes.) The results are little changed. We also redo the analysis using the 125 industries employed by Venture Source separately and find the results weaker, perhaps because the use of excessively narrow industries introduces noise to the Herfindahl measures.

Finally, as previously noted, in a fraction of cases, we are unable to be sure that the venture capital firm of a venture capitalist who is a director of a company invested in that concern. We repeated the analyses using only the 20,762 cases where we can confirm that the venture capitalist's firm invested in the company. The results are once again little changed.

3.4 REGRESSION ANALYSIS OF MARKET RESPONSIVENESS

In addition to examining the impact of organizational structure on outcomes, we also look at shifts in investment rate among investors with different levels of specialization. In our earlier paper (2008), we show that experienced and specialized groups appear to be more responsive to changing investment opportunities, as proxied for by the number of venture-backed IPOs and Tobin's q in an industry. The increased responsiveness of investment appears to be a rational response to changing opportunities, as they perform as well or even better than those made when market conditions are less favorable.

In Table IX, we examine how VC firm organization affects the propensity of individual venture capitalists to make investments in industries where they have been previously active. Our previous paper analyzed only the perspective of the whole firm. This analysis adds an understanding of the interaction between *individual*-level characteristics and *firm*-level characteristics, because we now have person-level information. We look at the response to the number of IPOs in the industry in question, which, as we argued in the earlier paper, is a proxy for investment opportunities. We also look at the sensitivity to IPOs in other industries, which may affect the competition for internal resources, but should not affect investment opportunities in the given industry. Column 1 reports that, just as we found at the firm level in our 2008 paper, there is positive interaction between individual specialization and the number of IPOs in a given industry. When market signals are positive, more specialized partners will increase their investment rate, while less specialized ones will not. This is consistent with our findings on mix in Table VI.

However, when there are more opportunities in *other* industries, all else equal, venture investors will decrease their investment rate only if the other investment professionals in the firms are not specialized. The

TABLE IX.
RESPONSIVENESS TO MARKET CONDITIONS

	(1) OLS	(2) OLS
Person Herfindahl	-0.0107 [0.26]	-1.3563 [7.36]***
Avg. Herfindahl of people at firm	0.7891 [8.84]***	-0.6125 [3.13]***
Person Herfindahl × Avg. person Herf. at firm		2.0003 [7.54]***
<i>Impact of This Industry</i>		
IPOs in Industry	0.0663 [7.84]***	-0.0338 [1.68]*
IPOs in industry × Person Herf.	0.0382 [5.00]***	0.1845 [6.04]***
IPOs in industry × Avg. person Herf. at firm	-0.0541 [3.85]***	0.1013 [3.21]***
IPOs in industry × avg. person Herf. at firm × Person Herf	-0.2188 [5.06]***	
<i>Impact of Other Industries</i>		
IPOs in firm's other industries	0.1298 [9.16]***	-0.1340 [4.15]***
Other IPOs × Person Herf.	0.1298 [9.16]***	-0.1340 [4.15]***
Other IPOs × Avg. Firm Herf.	-0.1982 [7.97]***	0.2192 [4.15]***
Other IPOs × Avg. Person Herf. at firm × Person Herf		-0.6152 [8.52]***
Controls:		
Year fixed effects	yes	yes
Industry fixed effects	yes	yes
Observations	31,940	31,940
R ²	12.2%	12.8%

Notes: The sample consists of 3,518 venture capitalists active in 822 firms from 1975 to 2003, with one observation per person industry year. Industries are included only if that person has been on the board of a company in that industry from 1975 to 2003. The dependent variable is the log of the number of investments by a person in an industry in a year plus one. *IPOs in Industry* is the log of one plus the number of venture-backed IPOs in that industry in the previous year. *Person Herfindahl* is the sum of the squares of the percentage of all previous investments in each industry that the person is on the board of (excluding the industry all other). *Avg. Herfindahl of People at Firm* is the average of the Herfindahl for each active venture capitalist at the VC firm. *IPOs in Firm's Other Industries (Other IPOs)* is the log of one plus the number of venture-backed IPOs in other industries in the previous year weighted by the percentage of deals the venture firm has done in those industries in all previous deals.

Standard errors are clustered at person level. Robust *t*-statistics are in brackets below coefficient estimates.

***, **, * indicate statistical significance at the 1%, 5% and 10% level, respectively.

results in column 2, which adds a series of interaction terms, are similar: it is the people working at firms which have the most specialists that are simultaneously the most responsive to the IPOs in a given industry, and the least responsive to IPOs in other industries. We estimated a

similar specification replacing the Herfindahl index with a measure of specialization in a particular industry, and found similar results.

This analysis suggests a possible reason for the poor performance of firms with generalist venture investors. If a firm is comprised exclusively of generalists, it is unlikely to be willing or able to respond to shifts in investment opportunities. If the firm adds a small number of specialists to its ranks, a second distortion appears: an apparently inefficient allocation of capital along the lines discussed by Rajan et al. (2000), Scharfstein (1998), and Scharfstein and Stein (2000). It is only in organizations dominated by specialized individuals where these problems are avoided.

4. CONCLUSIONS

This paper seeks to understand the impact of organizational structure—and in particular, industry specialization—on the success of venture capital investments. Venture capital is an attractive setting to examine these issues because of the diversity of organizational structures, the detailed information available about the activities of organizations and individuals, and the youth of the industry.

We find that the performance of specialized firms appears to be better in general. This may reflect the industry-specific human capital developed by specialist venture investors: in cases where the individual partners are highly specialized, the marginal benefit of increased venture capital firm concentration appears to be very limited. This result seems consistent with the views expressed in Rajan et al. (2000) and Scharfstein and Stein (2000), but counter to that in Stein (1997). Organizational characteristics, however, are not irrelevant: we see that venture capital firms with more experience outperform those with less (especially in mix), and that there is a marginal benefit of individual experience (conditional on firm experience) (especially in alpha).

This work leaves a number of questions unanswered. It is difficult to determine whether the superior performance of specialists is driven by their ability to better select investments or whether specialists are also better able to add value to those investments. Another important issue is what drives the structure of venture organizations. In this paper, we have taken the organization of the venture capital funds as given. While this may be reasonable in the short run—typically venture firms are loath to replace partners over the course of a given partnership, particularly those serving on boards of directors—over time various changes are made. Presumably, these changes reflect a variety of firm- and industry-level considerations, and thus are at least partially

endogenous. In subsequent work, we hope to better understand how the mixture of both junior and senior investment professionals evolves over time. In particular, we hope to exploit the opening of branch offices and the deaths of partners in venture funds, among other changes.

A second question relates to the generality of the results. The activity of venture capital organizations is based primarily on intangible assets, human capital in particular. We might expect other firms that have a high dependency on human, as opposed to physical, capital might be affected similarly by experience and specialization. This would argue for examining these effects in accounting, consulting, financial service, or law firms (see, e.g., Berger et al., 2005, and Garicano and Hubbard, 2007, 2009). Examining the relative activity and performance of differentially specialized service based companies would be particularly interesting.

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