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Allocation of Attention to Portfolio Companies and the Performance of Venture capital firms

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Allocation of Attention to Portfolio Companies and the Performance of Venture capital firms

This paper proposes that the attention allocated by venture capitalists to portfolio companies impacts their performance. The paper develops arguments for optimal portfolio size and for the moderating roles of syndication frequency and role. The hypotheses receive support from analyses employing longitudinal data of the leading U.S. venture capital firms. Our results indicate the value of venture capitalist involvement and give guidance for its optimal allocation and syndication.

Prior research has identified that venture capitalists commonly participate actively in the monitoring and management of their portfolio companies (Sahlman 1990). According to Gorman and Sahlman (1989), venture capitalists typically spend 60% of their time managing their investments, while the balance is spent on screening new investments and on administration. Active management of investments is widely regarded as a defining characteristic of venture capitalists (Ehrlich, et al. 1994; Fried and Hisrich 1995; Hellmann and Puri 2002; Lerner 1995; Sapienza, et al. 1996), although the level of involvement varies according to the chosen investment strategy, stage of the venture, role of the venture capitalist in a syndicate, level of innovation of the venture, and experience of the venture capitalist (Elango, et al. 1995; Macmillan, et al. 1989; Sapienza, et al. 1994).

The motivation of venture capitalists is to maximize the performance of their investments by providing value-added support and by controlling and monitoring the development of the companies (Gorman and Sahlman 1989; Lerner 1995; Macmillan, et al. 1989; Rosenstein, et al. 1993; Sahlman 1990; Sapienza 1992; Sapienza and Gupta 1994; Sapienza, et al. 1996). While the research has been able to validate the value added by a venture capitalists' involvement in a venture (Busenitz, et al. 1997; Higashide and Birley 2000; Macmillan, et al. 1989; Rosenstein, et al. 1993; Sapienza 1992; Sapienza, et al. 1996), the limitations that they face in these tasks have received less attention. Although the scarcity of their time has been widely acknowledged in the earlier research on venture capitalist involvement (e.g. Gifford

1997), the empirical analysis concerning this issue has been scarce (Lerner 1995) and mainly based on anecdotal evidence (Gorman and Sahlman 1989; Macmillan, et al. 1989; Sapienza, et al. 1996). The challenge is that the performance of an individual portfolio firm does not directly translate to the whole portfolio's performance. A venture capitalist seeks to allocate the optimal amount of attention to an individual venture in order to maximize the performance over all portfolio companies. Thus, although there is evidence for value added by venture capitalists, the link between their level of involvement and the performance of the portfolio has not been established.

We set out to examine how venture capitalist involvement in portfolio firms is related to the performance of the venture capital firm. We explore the limitations of venture capitalists' involvement considering the nature of informational and interpersonal aspects of their assistance and governance. The key proposition of the paper is that the way a venture capital firm allocates attention to portfolio companies affects the performance of those companies and thus the overall performance of the venture capital firm. We divide our argumentation in two parts. The first part addresses the effects of attention allocated to individual portfolio companies, and the second discusses the effects of that attention on the portfolio level. Furthermore, we argue that cooperation via syndicated co-investments with other venture capitalists and sharing the workload effectively alleviates the constraints on providing attention. Our analysis on the dataset of the 94 leading venture capital firms provides support for our arguments.

Our findings have both theoretical and practical implications. The results support the recent theoretical research on the optimal portfolio size of venture capitalists (Gifford 1997; Kanniainen and Keuschnigg 2003) and expand the theory by introducing the moderating role of syndication on optimal portfolio size. The findings also show that venture capitalist involvement enhances the outcomes of the ventures. This validates the results of earlier

research on the value added by venture capitalist involvement and shows that these efforts are most productive when focused on a suitable number of portfolio companies. Furthermore, our findings provide guidance for venture capitalists on successful strategies and resource allocation, underlining the effects of involvement and the use of time in ventures.

The remainder of the paper is organized as follows. Section 2 builds testable hypotheses. Section 3 presents the data and the methods used. Section 4 presents the empirical results. Finally, conclusions and implications are discussed in section 5.

THEORY AND HYPOTHESES

Motivations for Involvement

The earlier literature has suggested two motivations for venture capitalists' involvement in their portfolio companies: monitoring and supporting the companies. First, the venture capitalist's role in a venture is primarily that of an owner. A venture capital fund (VC) typically holds a significant proportion of the shares of the ventures, received in exchange for their financial input (Sahlman 1990). VCs are only rarely directly involved with the daily operations of the ventures and thus this separation of ownership and control leaves them reliant on the CEO of the firm to manage it in a way that maximizes the value of the VC's investment (Fama and Jensen 1983). However, the interests of VCs and CEOs may not be perfectly aligned, potentially leading to opportunistic behavior and the pursuit of private interest by the CEO (Admati and Pfleiderer 1994; Bergemann and Hege 1998; Gompers 1995; Jensen and Meckling 1976). In addition, the entrepreneur's potentially limited ability to manage the venture introduces an agency problem requiring venture capitalist involvement (Sapienza and Gupta 1994). Agency risk gives rise to the venture capitalist's governance with a need to monitor the activities of the ventures to ensure that the management's conduct is aligned with the interests of the venture capitalist (Fama and Jensen 1983; Sapienza, et al.

1996). In addition, monitoring the management and the venture in general transfers information about the venture's quality to the venture capitalist, reducing the amount of asymmetric information between the two entities (Akerlof 1974; Chan 1983; Gompers 1995).

The second motivation for allocating attention to an investment is based on the value of the venture capitalist's assistance. While the governance of ventures concentrates on the value of reduced risks and prevention of undesirable outcomes, the assistance perspective considers the venture capitalist's involvement as a valuable resource for the focal ventures. Venture capitalists contribute resources that serve the development of the company as an additional input. The literature has focused on the level of involvement and roles assumed by the venture capitalists (Ehrlich, et al. 1994; Elango, et al. 1995; Gorman and Sahlman 1989; Macmillan, et al. 1989; Rosenstein, et al. 1993; Sapienza, et al. 1994) and value added by the venture capitalist's assistance (Busenitz, et al. 1997; Higashide and Birley 2000; Macmillan, et al. 1989; Rosenstein, et al. 1993; Sapienza 1992; Sapienza, et al. 1996). Prior research has identified multiple forms of value-added assistance provided by venture capitalists. In addition to the main contribution – arrangement of financing and related activities such as financial monitoring and interfacing with investors – the venture capitalists contribute to the strategy process, operational issues and recruitment of key personnel (Barney, et al. 1996; Gorman and Sahlman 1989; Hellmann and Puri 2002; Macmillan, et al. 1989; Rosenstein, et al. 1993; Sapienza 1992; Sapienza, et al. 1996).

Attention Allocated to an Individual Venture

The assistance provided by venture capitalists to their portfolio companies is largely based on the experience and information offered by the venture capitalists (Barney, et al. 1996; Bygrave and Timmons 1992; Fried and Hisrich 1995; Norton and Tenenbaum 1993; Rosenstein, et al. 1993; Sahlman 1990; Sapienza 1992; Sapienza, et al. 1996; Steier and

Greenwood 1995). Operating as a sounding board, supplying business advice and general business knowledge, and participating in strategic and operational planning draw on the venture capitalist's earlier experience and existing information.

While part of the information is explicit, such as contacts and market information, the experience of a venture capitalist is the result of the knowledge cumulated throughout his or her career and is thus largely tacit know-how (Kogut and Zander 1992; Polanyi 1967). Know-how is expressed through application (Grant 1996), and thus the transfer of such knowledge requires interaction (Kogut and Zander 1992). Due to the low transferability of the knowledge based on experience, the venture capitalists may choose to address a venture-specific problem directly instead of trying to transfer the specific knowledge to the entrepreneur. Thus, in order to provide assistance based on know-how, the venture capitalist can provide either information or information-processing capacity (Sapienza, et al. 1996). In both cases, the attention allocated is specific to an individual venture, and thus unavailable to other ventures.

Governance of portfolio companies faces restrictions similar to those related to providing assistance and information. The monitoring is based on the presumption that, once the venture capitalist acquires information to verify the behavior of the entrepreneur, the behavior of the entrepreneur is more likely to be aligned with the interests of the venture capitalist (Eisenhardt 1989; Fama and Jensen 1983). The venture capitalist gathers information on the behavior of the management and the performance of the firm and assesses this information against his experience and expectations. Similar to the assistance, the time and attention allocated to the governance and monitoring of an individual portfolio company consumes the attention available to other ventures.

Although the value of the assistance increases with the amount of attention allocated, the knowledge base of a venture capitalist is limited, thus implying a limit to the value of

assistance at high levels of involvement. In addition, the benefits of the governance are also likely to become exhausted at higher levels of monitoring. Extensive involvement may also be destructive if the venture capitalist attempts to assist the venture beyond the saturation of the learning, or if the monitoring becomes intrusive and interferes with the venture's development. Thus, extensive involvement can reduce the marginal return on attention to zero or even negative. However, based on the generally noted opportunity cost of venture capitalists and their tendency to economize on time, it is likely that they normally operate at such levels of involvement that the return on effort is increasing, although at a decreasing rate.

Portfolio Size and the Effects of the Allocation of Attention

Since a venture capitalist must allocate time among many investments, the amount of attention that is available to each venture is closely related to the number of investments managed by the venture capitalist. The average time available for each company rapidly decreases as the number of companies in the portfolio increase, thus decreasing the potential for value added.

As an increasing number of managed companies reduces the amount of attention available to an individual venture, it also reduces the total time available to the management of these companies due to the portfolio's increasing size and diversity. Each additional venture introduces more overhead in the form of non-productive tasks, such as travel time to visit the ventures. This accumulating overhead reduces the total time available for the management of the portfolio companies.

A larger number of managed companies also increases the diversity of the ventures. In their article on the diversification of companies, Prahalad and Bettis (1986) suggest that the factor limiting diversification is the ability of management to handle the strategic variety of

the business units. The management acts on and interprets new information based on existing experiences. These belief structures and mental representations enhance the processing of information from situations and businesses that are familiar to the management. Thus, strategically similar businesses can be managed using a single dominant logic. However, although efficient in a given context, the dominant logic hinders the ability to manage businesses that do not fit within that sphere. Considering venture capital, the venture capitalist faces a similar situation as the management of a diversified firm. Each company in the portfolio differs from the other and, although possibly operating in the same industry, may face situations that are strategically very different. The venture capitalist may be fully able to manage an individual investment, but when a portfolio has a number of companies in different strategic situations, development stages and environments, managing the diversity becomes difficult. The larger the number of managed companies, the more diversity there is and the slower it is for the venture capitalist to adapt to each specific situation. Thus, each additional portfolio company reduces the total time available for the management of the portfolio due to its increasing diversity.

To summarize, the effect of dividing a venture capitalist's attention is two-fold. Firstly, the average time available for each company decreases in relation to the number of managed companies, therefore reducing the effect of venture capitalist's involvement. Secondly, the increasing number of companies increases the size and diversity of the portfolio and thus increases the time required to switch the focus of attention from one firm to another. This reduces the total amount of time available to supporting the companies under management.

On the portfolio level, the above implies two opposite effects. On one hand, if we consider a venture capitalist managing a single company, more time is available for the company than might be beneficial for its development. Therefore, a second company could be managed without affecting the attention needed for the first company. As the number of

managed companies increases, the potential outcome also increases since more companies will be going public. On the other hand, if the venture capitalist continues to increase the number of portfolio companies, the time available to each of them reduces, thus decreasing the value added from the venture capitalist. The positive effect of portfolio size eventually slows and begins to reverse. That is, economies of scale initially exist in relation to venture capitalist attention, but diseconomies of scale eventually emerge as the portfolio increases beyond a manageable size.

Therefore, we propose a curvilinear (inverted U-shaped) relationship with respect to the extent of the involvement of the venture capitalist in portfolio companies and the performance of the venture capital firm. In particular, we propose that the relationship between the extent of involvement and the performance of the firm will exhibit diminishing marginal returns, and will pass the point of diminishing total returns and thus eventually exhibit negative marginal returns for each additional portfolio company.

Hypothesis 1: There is a curvilinear (inverted U-shaped) relationship between the attention allocated to the investments (i.e. portfolio companies per partner) and the performance of the VC partnership.

Cooperation and Syndication

Syndication frequency. As the increasing size of a portfolio reduces the attention available to each company, the time available to the venture capitalist forms a constraint on the venture capitalist's attention and available time. This limits the number of portfolio companies the venture capitalist can effectively handle. The syndication of investments offers a mechanism for venture capitalists to reduce the time required to manage an individual venture by sharing the workload with syndicate partners.

Venture capital syndicates are typically recurring among partners, with the participants alternating the roles of lead and non-lead investor (Bygrave 1987, 1988; Wright and Lockett 2003). The role of a lead investor is to coordinate the investor group and to act as the managing investor of the investment. On one hand, the existence of a lead investor solves the potential problem of "free-riding" in the investor group, resulting from the fact that the benefits of the efforts contributed to the investment are shared among all participants. On the other hand, the commitment of the lead investor to the investment is frequently secured both by a larger equity stake and the reputation effects implied by the reciprocal syndication relationships (Wright and Lockett 2003). According to Gorman and Sahlman (1989), the lead investor in a syndicate uses 10 times the time the other venture capitalists spend in direct contact with the venture. Participating in syndicates as non-lead investors enables venture capitalists to increase the portfolio size with a lower commitment of resources than acting as a sole investor. Thus, by syndicating investments and delegating a part of the lead investor roles to the syndication partners, the venture capitalist is able to increase the number of investments with a lesser negative effect on portfolio performance, potentially resulting in a higher optimal number of investments.

We hypothesize that VC firms with a higher level of syndication should be able to manage larger portfolios. Accordingly, the point of diminishing total returns on the allocation of attention should be reached with higher portfolio sizes for VC firms with high levels of syndication compared to VC firms syndicating less.

Hypothesis 2: Syndication frequency positively moderates the curvilinear relationship between the attention allocated to the investments and the performance of the VC partnership.

Syndication role. While the co-investor is able to join a syndicate with a significantly lower commitment of managerial resources, the management of the investment is delegated to the lead investor (Gorman and Sahlman 1989, Wright and Lockett 2003). Although syndication is an effective method to share workload and thereby increase the optimal number of investments for the co-investor, for the lead investor syndication requires the amount of attention allocated to the managed investments to be comparable to that of a non-syndicated investment. Furthermore, the workload of a lead investor is increased by the effort invested in the management of the syndicated (Wright and Lockett 2003) Thus, as predicted in Hypothesis 2, syndication should have a positive effect, but this effect should be lower for lead syndication compared to non-lead syndication.

Hypothesis 3: The higher the share of investments syndicated as a lead investor, the lower the positive impact of syndication on the curvilinear relationship between the attention allocated for the investments and the performance of the VC partnership.

METHODOLOGY

Data

To test the effect of the allocation of attention on the performance of the venture capitalists, we used a venture capital firm as the unit of analysis. By focusing on the performance of venture capital firms as the unit of analysis, our research complements the prior research in which the value of venture capitalist attention has been primarily addressed on the level of an individual venture (Barney, et al. 1996; Busenitz, et al. 2004; Gorman and Sahlman 1989; Hellmann and Puri 2002; Macmillan, et al. 1989; Rosenstein, et al. 1993; Sapienza 1992; Sapienza, et al. 1996). Combining the outcomes from the ventures and funds enables us to address the question of the effect of allocation of attention and syndication on the performance of a portfolio of ventures.

We test our hypotheses employing longitudinal data on the largest private U.S. venture capital organizations, defining the size of firms as the number of portfolio companies the firms had invested in cumulatively by the end of the year 2000. This set of venture capital firms includes only those U.S. venture capital partnerships that Venture Economics classifies as "Independent private partnerships" thus excluding investment bank affiliates, corporate investors, endowments, individuals, and other private equity investors. The sample of firms consists of 94 venture capital firms and their investments. Altogether, the data includes 25,009 investments in 6,044 portfolio companies during the years 1986-1998 resulting in 997 firm-year observations. The investments made by the sample firms comprise 48% of all investments recorded in the SDC database for the time period.

The venture capital investment data of this paper is obtained from Securities Data Corporation's (SDC) Venture Economics database. This extensive source has been used also in previous venture capital research (e.g. Bygrave 1987; Gompers 1995; Lerner 1994; Podolny 2001; Sorenson and Stuart 2001). Venture Economics has gathered venture capital investment data since the 1970s using annual reports of venture capital funds, personal contacts with funds' personnel, initial public offering prospectuses, and acquisitions announced in the media. The database contains information on over 210,000 private equity investments (one whole financing round consists of several single investments) and it is widely recognized as a leading source of U.S. venture capital investment data.

Data on the personnel resources of the sample venture capital firms is gathered from the back issues of *Pratt's Guide to Venture Capital Sources*. This widely used publication lists the managing partners, the key personnel, and a variety of other parameters of most of the U.S. venture capital firms each year. The most relevant records for our study are the managing partners of the firms. This data is reported consistently each year with names and positions. Using data from the publication, we tracked the total number of partners and their

names in each venture capital firm each year. To further ensure the validity of the managing partner data, we collected the current resumes of 28% of the partners of our sample firms and backtracked their career years in each venture partnership. We then compared the publication's listings of partners to the sub-sample of resumes without observing significant inconsistencies between these two sources.

Variables

Performance of venture capitalist. A venture capital fund is typically structured as a limited partnership (Sahlman 1990). While the investors of the fund, i.e. limited partners, contribute nearly 99% of the capital (Sahlman 1990), the share of general partners, i.e. venture capitalists, over the profits range from 20% to 25%. Thus, the behavior that maximizes the venture capitalist's personal returns also maximizes the return on the funds invested by limited partners. Although the performance of a venture capital fund can be defined straightforwardly as return on investment, assessing the performance of a venture capital fund is hard for an outsider due to the secretive nature of information relating to venture capitalists' profits. However, as the largest valuations and returns to venture capitalists are most often realized in initial public offerings (Bygrave and Timmons 1992), we can use the number of IPOs (controlling for the number of investments; see control variables below) as a proxy for the venture capitalist's performance. Although only a fraction of venture capital investments reach the IPO, most of the total value to the investors is created in these exits (Bygrave and Timmons 1992; Gompers and Lerner 1999). Thus, we can consider the IPO as the preferred exit vehicle of most venture capital firms.

We measure the performance of the venture capital firm as the number of IPOs generated from the investments in new ventures. We identify the investments made by the venture capitalists and track down the number of IPOs performed by these companies. We observe

the investment activity between the years 1986-1998 and the initial public offerings from these investments until the end of June 2003.

The number of IPOs from new company investments is biased downwards from the actual value towards the end of the time range of our sample. This results from the fact that new company investments require a certain amount of time before the exit is realized. The median time from the first investment of a venture capitalist to the IPO is 4.18 years in the first half of the sample. This indicates that only slightly over half of the investments made in 1998 had reached the potential IPO by June 2003, when we observed the initial public offerings. Thus, we observed too few IPOs in the last years of our sample for all venture capitalists, and especially for those firms who concentrate on early-stage investments. Given that our unit of analysis is the venture capital firm, not a single venture, we cannot use hazard rate models that could be used to measure the likelihood of single ventures to reach an IPO. However, as the bias is downward, the analysis would tend to reject the hypothesis, making the results more significant if the data were complete. In addition, our use of year dummies also partially remedies this problem. As a robustness test, we reran the analyses limiting the time frame to 1993 instead of 1998 and obtained qualitatively identical results.

While the IPOs can be considered as the vehicle to achieve the largest profits, venture capitalists also use many other kinds of exits including trade sales to industrial acquirers, secondary sales to other investors, buybacks, and write-offs (Cumming and MacIntosh 2003). However, of the different exit methods, trade sales are frequently considered as the second best option for the investor bringing in a significant share of returns (Cochrane 2005). While trade sales are generally smaller in size than IPOs, individual trade sales can be substantial and comparable in size to IPOs. Thus, as a further robustness test, we use the number of all positive exits (identified by Venture Economics as IPOs, mergers, acquisitions, and buy-outs)

as an alternative measure for the performance of the venture capitalist. We report the deviations in results for these two performance measures in the following analyses.

Allocation of attention. The personnel structure of a venture capital firm is typically an upside-down pyramid, with a high proportion of upper management and a limited lower level staff (Wasserman 2002). The experience and operations of a venture capital firm are embodied in its partners and due to the knowledge-intensive nature of the work, tasks are generally non-divisible (Wasserman 2002). Managing partners are the key contacts between the venture capital partnership and the portfolio company (Sahlman 1990). According to Gorman and Sahlman (1989), in an average firm, a partner has 8.8 investments to manage, while on an associate level this figure is 3.6. We use the number of partners in a venture capital firm to measure the total amount of attention available for management of the investments. We classified personnel as partners if their position title included the term "partner", "vice president" or "managing director." The number of partners each year is taken from our combination of the records from *Pratt's Guide to Venture Capital Sources* and the resumes of the partner sub-sample. We recognize that the records from the publication represent the situation of the previous year, so we use each year's published data for the previous year's entries. We further assume that the number of partners during a single calendar year remains constant. In rare cases where the partner data is unavailable from both sources for a certain year, we use the data of the previous year.

We measure the size of the portfolio of a venture capitalist as the number of companies the venture capitalist is involved in. We identify the portfolio companies of a venture capitalist using the investment records of Venture Economics, containing information on the dates of the investment as well as whether a company has made an IPO and when. We record the entry date to the portfolio as the date of the initial investment by the venture capitalist. The exit date is recorded either as the date of an IPO or as the date one year after the last

observed investment round. This corresponds to the median interval between investment rounds (Gompers 1995).

We measure the allocation of attention as the size of portfolio relative to the number of partners in each venture capital firm. Thereby, we are able to account for the differences in the sizes of the firms and make the measure comparable across firms. Furthermore, the number of new investments per partner offers a measure for the capacity of an individual venture capitalist to manage the investments.

Syndication frequency. We measure the frequency of syndication as the ratio of syndicated investments to the total number of new investments made within a given year. We record an investment as a syndicated one, if the Venture Economics database records more than one investor for a given investment round. To capture all possible syndication relationships, we first identify all portfolio companies in which the venture capital firms within our sample have invested during the years under investigation. Then we proceed by identifying all investors of these portfolio companies for each investment round. We couple the investors that have invested in a company on the same round, marking them as syndication partners and recording the investment as syndicated.

Syndication role. We further refine the syndication measure by making a distinction between those investments where the investor acts as a lead investor, and those where the investor is one of the co-investors. We identify the lead investor as the one who makes the largest investment in a given round, and the co-investor as the one who makes a smaller investment in the same round. Both lead and non-lead syndication are measured as frequencies, i.e., the ratio of lead or non-lead investments to the total number of new investments made within a given year.

The measures for the lead and non-lead syndication frequency contain a potential downward bias. The measure for lead investor is based on the estimated investments made by investors. When the exact amounts are unknown, the Venture Economics database reports equally sized investments by all investors participating in an investment round. Thus, with equally sized investments we are unable to distinguish the roles within the syndicate, and thus we fail to recognize some of the investments where the investor acts as a lead or non-lead. However, since we were able to identify the lead investor in 66.2% of all investment rounds with more than one investor, the measure should still be powerful enough to capture the effect of lead investing.

Similarly, the measure for the syndication frequency is based on our ability to observe syndicated investments. According to Lerner (1994), investments making up an individual investment round are occasionally recorded on separate dates, and thus using these dates we are unable to observe all syndications. Although the records of the Venture Economics database are continuously augmented and corrected, we acknowledge this potential bias. However, as both the measures for the syndication frequency and the lead syndication frequency are biased downwards, our estimates are more conservative than they would have been with perfect observation.

Control Variables

Syndication frequency (direct effects). We hypothesized that syndication has a moderating role on the optimal portfolio size and hence an effect on performance. Syndication may have also several direct effects on performance. First, the syndication of investments may increase the quality of the investments, both by increasing the amount of information venture capitalists receive concerning potential investment targets (Bygrave 1987; Lerner 1994), and by increasing the geographical reach of the venture capitalist (Lerner

1995; Sorenson and Stuart 2001). Having a larger pool of potential investments may increase the quality of the best proposals received, thus resulting in better investments. Second, the shared decision making of a syndicate is likely to further enhance the quality of investments (Brander, et al. 2002; Lerner 1994). If syndicate partners independently review a proposal and decide to invest upon the approval of all partners, their decision is likely to be of better quality than one made by an individual decision-maker (Sah and Stiglitz 1986; Wilson 1968), thus resulting in better investments. Third, the syndication of investments increases the number of investors of a venture, thus potentially giving it an access to larger pool of resources. A syndicate with multiple venture capitalists provides complementary skills and contacts that contribute to the assistance and governance of the venture (Brander, et al. 2002; Lockett and Wright 2001). Furthermore, the venture capitalist may use later stage syndication as a means of "window dressing," seeking association with successful investments (Lerner 1994). We control these potential direct effects by including the ratio of syndicated investments to all investments as a control to the models. In addition, to control the network effects of syndication, we measure the number of syndication partners of the focal firms (i.e. the number of investors they have syndicated with) in a given year, and include this measure in the models.

Average syndicate size. The size of the syndicate may have an effect on the division of work within the syndicate and on the contribution of the investor group. On average, the larger the investor group, the smaller the share of value-added workload that is left for each investor. Thus, we control for the effects of the syndicate size by measuring the average size of the syndicate at the initial investment.

Investments in new companies. The initial public offerings are generated from the pool of new companies that the venture capitalists invest in yearly. The number of these new companies forms the upper limit for the number of IPOs. Thus, to control the venture

capitalists' yearly potential for IPOs from new investments, we include the number of new portfolio companies in regressions.

Capital under management. The main resources of a venture capital company are the capital to be invested, information on potential investment targets, and the partners managing the firm and its investments (Bygrave 1987). The scarcity or availability of financial resources is likely to have a significant effect on the operations of the firm, and thus they need to be controlled in the model.

When raising funds, venture capitalists negotiate capital commitments from limited partners and invest them gradually over a few years in promising target companies. The total amount of these commitments in a firm is referred to as "capital under management." We calculate the amount as a sum of the non-expired venture capital funds, and exclude funds that are raised for investments in buyouts, for example. We include only funds that Venture Economics classifies as "venture capital" in our sample. We further assume that a fund would expire 10 years after the raising of the fund was completed, which Sahlman (1990) found to be the case in 72% of the funds in his sample. Thus, the total size of a fund is calculated as part of capital under management for 10 years after the fund was raised.

Age of venture capital firm. The age of venture capital firms greatly affects its operations. The older the firm, the more contacts, experience, and prominence it has. Moreover, the younger the firm, the more it tries to establish a reputation by opportunistically striving towards successful exits. This is a phenomenon called "grandstanding" (Gompers 1996). We control for the age effects. We calculate the age of each firm in our sample based on the founding dates in the Venture Economics database. We crosschecked the validity of these records using the back issues of *Pratt's Guide to Venture Capital Sources*. In some rare and ambiguous cases, we found that Venture Economics had allocated venture capital

investments to the firm before the reported founding date. In these cases, we set the founding year of a company equal to the year of its first investment.

Investment stage mix of investments. The nature of an investment target and the stage of the development of a venture affect the risk of investment, the expected time-to-exit, and the nature of involvement required in the investment. To control for these effects, we calculate the percentage of investments made in seed, early, expansion, and later-stage companies as well as in acquisitions and buy-outs for each firm each year according to Venture Economics classifications. In addition, Venture Economics classifies a proportion of investments to the "Other/Unknown" category containing unknown and special situations, mostly later stage and public market investments. We also include this category in the analysis. Furthermore, to differentiate between investment strategies with respect to the stage of investment, we calculate the Herfindahl index for the stage shares. With this stage focus index we are able to control the effects of stage focused investment strategies.

Average round of company at entry. While the investment stage mix captures the effect of the stage of the investments in the portfolio, we measure the average round the venture capitalists entered their portfolio companies in order to control for the investment structure of the portfolio companies. If the initial entry occurs through syndication on a later round, the role of the investor and the interaction between the investors and venture are substantially different from those of first round investors.

Industry mix of investments. We also control for potential industry effects. We use the classification of the Venture Economics database and percentage-of-investments variables for following industry sectors: Communications, Computer Hardware, Computer Software, Semiconductors/Electronics, Internet Communications, Internet/Computer Related, Medical, Biotechnology and Non-High-Technology ventures as recorded by Venture Economics. To

measure the degree of specialization in specific industries, we also calculate the Herfindahl index for the portfolio with respect to the industry sectors.

Time-dependency. As our sample is a time series of cross-sections, it is necessary to control for differences between sample years. In all regressions, we include dummy variables for the sample years.

Methods

We test the hypotheses using longitudinal data from 94 firms over a period of 13 years, with a count variable as the dependent variable. We model the dependent variable, the number of IPOs, as a Poisson model, analyzing the regressions using the generalized estimating equations (GEE) methodology (Liang and Zeger 1986).

Utilizing a Poisson regression is the standard approach to analyze count data models. However, the Poisson regression assumes that the mean count of events equals to the variance of the number of events. We tested this assumption in our data[1], and found the potential effects of overdispersion statistically insignificant. Furthermore, we tested an alternative, negative binomial model that relaxes the assumption of the equality (Cameron and Trivedi 1986, Greene 2000). The analysis did not produce any qualitative differences.

To control for the heterogeneity of individuals, we utilize a population-averaged, i.e. averaged partial effects, approach (Baltagi 1995, Hsiao 1986, Woolridge 2002). We estimate the models using Stata. To control for the expected existence of heteroscedasticity in data, we estimate the GEE models using robust-option, providing White heteroscedasticity consistent estimates.

[1] To confirm this statistically, we calculated the Lagrange Multiplier test for overdispersion. It tests the Poisson assumption of the equality of mean and variance as H_0 against the negative binomial model (Cameron and Trivedi, 1986, Greene 2000). For the test, we estimated the base model in table 2. The $chi^2(1)$-distributed test statistic had a value of 3.593 or the H_0 of $\alpha=0$, thus we were unable to reject the hypothesis with a p-value of 0.058. Therefore, the overdispersion in the data is not significant, making the Poisson model applicable.

RESULTS

Table 1 reports the descriptive statistics and correlations for the variables in the data of 997 observations over 94 firms. The statistics are from the whole sample and, as such, they pool observations across firms and years. This pooling contributes to the reported variation of observations.

The indicators of the size of the venture capital firm – the number of partners and the number of new investments made – reflect both the variation and similarity of firms in the sample. The standard deviation of the number of partners, 2.65, over the mean of 5.54, demonstrates that the size of venture capital firms is relatively homogenous. However, as the range shows, the largest firms have up to 22 partners indicating existence of alternative organizational structures. The number of new investments made yearly shows larger variation with a mean of 18.96 and a standard deviation of 14.76, with the largest number being 95. This reflects both differences in the strategies as well as the variation due to the pooling of firm-year observations. However, as the average number of companies per partner, 6.58, and its deviation, 3.70, show, notably large portfolios are a clear minority. Thus our assumption appears to be valid; venture capitalists typically operate portfolios of a size that allows them to be involved in their portfolio companies.

<== Table 1 approximately here ==>

The mean syndication frequency is 80%, suggesting that venture capitalists cooperate extensively by syndicating their investments. Higher levels of syndication are more common than lower levels. When decomposed to lead and non-lead syndication, the lead syndication ratio, 15%, is slightly more than a third of the non-lead syndication ratio, 43%. This is in line with the average syndicate size of 4.22 investors. The difference between the overall frequency of syndication and the sum of lead and non-lead syndication results both from the

inability to observe roles in all syndicates and the fact that for each lead investor there is typically more than one co-investor.

Performance and Allocation of Attention

Table 2 presents the results of the population-averaged GEE regression analysis on the number of portfolio companies that ultimately reached the initial public offering. The non-standardized regression coefficients are presented with the corresponding standard errors. Although not presented in the table, all regression analyses include year dummy variables to control for potential differences between years.

<== Table 2 approximately here ==>

The first model in Table 2 is the base model testing the effects of the control variables. The sized related controls – the amount of capital under management, the number of partners and the number of new investments – have an expected positive impact on the number of IPOs. Interestingly, the frequency of syndication does not appear to affect the performance directly. In addition, neither the number of syndication partners nor the average size of the syndicates has a significant effect. Expectedly, the average round when the venture capitalists enter their investment has a strong positive effect on the number of IPOs from these investments.

In Hypothesis 1, we suggested that there is a curvilinear relationship between the number of investments per partner and the performance of the venture capital firm. The models 2 and 3 of Table 2 present the analyses testing the hypothesis. The first model includes the linear effect of the number of companies per partner and the second introduces the quadratic effect. The coefficient of the linear term is positive, whereas the coefficient of the quadratic term is negative. Both terms turn out to be highly significant. Thus, the performance of the VC partnership increases as the relative size of the portfolio increases, but the rate of this increase

is diminishing. In order to see whether this deceleration turns the total effect negative in the range of the observed portfolio sizes, we differentiate the model with respect to the number of companies per partner. The first order derivative is zero when the companies per partner ratio is 13 (in model 3 of Table 2). As the centered measure for the range of companies per partner is from -6.33 to 28.41, the model has its optimum within that range. We emphasize that this number is contingent upon the estimated model, the sample and the period under investigation. Thus, the result is merely a validation of the existence of an optimum rather than a prescriptive objective for the size of the portfolio. The importance of the result is that there exists an optimal portfolio size beyond which the inclusion of additional portfolio companies results in negative marginal returns.

Moderating Effect of Syndication

The analysis above demonstrates the inverted U-shaped relationship between the number of companies per partners and the performance of the venture capitalist. In Hypothesis 2, we suggested that the syndication of venture capital investments moderates the optimal number of companies per partner such that as the amount of syndication increases the optimal number of companies per partner increases. In model 4, we include an interaction term of the syndication frequency and the number of portfolio companies per partner. The effect of interaction on the performance is positive and significant.

The effect of interaction term on the optimal number of portfolio companies per partner is two-fold. First, as the syndication frequency increases, the optimum moves to the right on the axis of the number companies per partner, thus increasing the optimal number of companies per partner. Second, the number of IPOs from investments in the optimum increases as the syndication frequency increases. Thus, the increased frequency of

syndication increases both the number of portfolio companies a partner is able manage optimally and the number of IPOs these companies produce.

Although syndication increases both the optimal size and the performance at this optimum, when syndicating as a lead investor, the benefits of work sharing are mitigated by the workload of the lead investor. Thus, in hypothesis 3 we suggested that the amount of investments syndicated as lead investors negatively moderates the optimum, lowering the benefits of syndication. Model 5 tests the hypothesis by including the interaction terms of the companies per partner and the frequency of lead and non-lead syndication.

The interaction between lead syndication frequency and the number of companies per partners does not have a statistically significant coefficient, thus failing to support hypothesis 3. However, the non-lead syndication frequency positively moderates the optimal size of the portfolio on a significant level. The more a venture capitalist syndicates as a non-lead investor, the higher the optimal portfolio size. Thus, it appears that the positive effect of syndication on the portfolio size is mainly due to the benefits of reduced workload when participating in a syndicate in a non-lead role.

Robustness Tests

To test the robustness of our results, we repeated the analyses above using the alternative performance measure of all positive exits resulting from the new investments[2]. While our results on optimal portfolio size were directly supported with the alternative variable, the effects of syndication on the all-positive exits were slightly different, although the qualitative results remained the same.[3] With the all-positive exits as the dependent variable, the moderating effect of syndication was not significant (corresponding to model 4 in Table 2).

[2] We analyzed the number of all successful exits using a negative binomial regression with fixed effects. The population averaged Poisson model was not applicable due to overdispersion of the variable.
[3] Some potential factors explaining the differences include (a) whereas IPOs are most often considered a successful outcome, mergers and acquisitions include unsuccessful exits also, causing investor losses; and (b) due to the statistical properties of this variable, some of the assumptions used in the main analysis were not valid (the assumption concerning overdispersion), forcing us to use an alternative specification (negative binomial instead of Poisson).

However, when we repeated the analyses dividing the syndication between lead and non-lead syndication, the coefficient of lead syndication moderation became statistically significant, having a negative effect on performance, while non-lead syndication was statistically insignificant. Thus, when using this alternative measure, the increased frequency of syndication in the role of a lead investor lowered the optimal size of the portfolio, suggesting a cost for having the lead investor role. These results correspond with our earlier analysis and provide support for the robustness of our results.

In addition to the alternate performance measure, we also tested the robustness of the choice of the moderating effects, as the optimum is determined both by the linear and quadratic term of the portfolio size. Analyzing the number of IPOs, we tested the moderating effect of syndication using an interaction term between the syndication frequency and the number of companies per partner squared. In the case of overall syndication effect, the interaction between the syndication frequency and quadratic term was not significant, indicating that the linear interaction term captures the moderating effect. When we divided the syndication between lead and non-lead syndication, the interaction effects with the number of companies per partner squared were identical to the first-order interactions. That is, the non-lead syndication was positive at a significant level and lead syndication did not have a statistically significant effect. However, when we included both the first-order and second-order interaction effects in the same regression, only the first-order non-lead syndication was significant and negative. Thus, our analyses yield identical results regardless of our choice of interaction terms.

DISCUSSION AND CONCLUSIONS

In this paper, we set out to examine the limitations to the allocation and value of the venture capitalist attention. While earlier research has validated the value of venture

capitalists' involvement in an individual venture, the link between the allocation of attention and the performance of the venture capitalist had not been addressed in prior research.

We argued that the increasing size of the portfolio divides the venture capitalist's attention, producing two countering effects. On one hand, the larger the size of the portfolio, the more firms the venture capitalist will have that can potentially reach desirable outcomes. On the other hand, the larger the size of the portfolio, the less time the venture capitalist has to be involved in portfolio companies, and the smaller the value of this involvement. The overheads created by managing the individual ventures, as well as the diversity of the portfolio, reduce the total time available for managing the portfolio. Based on these arguments, we hypothesized that there exists a curvilinear inverted U-shaped relationship between the performance and the number of companies per partner, and that this relationship is positively moderated by the frequency of syndication. The hypotheses were tested utilizing a data set on the 94 leading U.S. venture capital firms and their investments during 1986-1998.

Our hypotheses are supported by the results of the analysis, suggesting that there exists an optimal portfolio size with respect to the number of companies per partner. First, as the number of companies per partner increases the performance shows a corresponding increase, although with diminishing marginal returns. When the number of investments exceeds the optimum, performance starts to deteriorate and leads to negative total returns. Given the shape of the relationship, there exists an optimal number of investments for a venture capitalist to manage. This optimum is moderated by the syndication activity. The more the venture capitalist syndicates its investments, the higher is the size of the portfolio it can manage optimally. Additional analyses indicated different benefits from syndication depending on the role of the investor in syndicates. Supporting hypothesis 3, our analyses

showed that acting as a non-lead investor is more beneficial compared to acting as a lead investor.

The foremost implication of our results is that the venture capitalist attention is valuable to the portfolio companies. The existence of an optimal portfolio size demonstrates that with a large enough portfolio the marginal return on each additional portfolio company turns negative. Thus, the success of a portfolio company is not independent of the other ventures in the portfolio, but each additional venture affects the outcomes of existing portfolio companies. Should the venture capitalist merely pick and choose the best investment targets with no post-investment contribution, the outcomes would be independent. In this case, we would observe potentially diminishing but not negative marginal returns on the relative portfolio size, resulting from the decreasing quality of the investments.

As the restrictions to the portfolio size stem from the limited attention of the venture capitalist, sharing the workload of managing the investments relaxes these constraints. According to our results, syndication serves as a mechanism to loosen the limitations and to increase the size of the portfolio. The increased portfolio size enables the venture capitalist to diversify its portfolio more widely than when investing alone. The difference in the effects of acting as a lead versus non-lead investor in syndicates suggests that reciprocity between investors, which is commonly observed (Wright and Lockett 2003), is important in the syndication of VC investments.

The theoretical implications contribute to the increasing literature on the optimal size of the portfolio. By confirming the existence of optimal size, it both provides support for earlier theoretical models and an extension to the approaches. By relating the allocation of attention to the outcome of the portfolio, we extend the prevailing theoretical stream that approaches the issue from contracting and incentives (Gifford 1997; Kanniainen and Keuschnigg 2003). As our performance measure is the number of IPOs (controlling for the number of

investments), we are not able to capture the more subtle effects of contracting on the profits of venture capitalists. However, our results indicate a size of portfolio that maximizes the outcomes for the portfolio companies as a group. Thus, our results are complementary to the existing research and also contribute to the empirical studies on the portfolio size and its determinants and variations (Cumming *forthcoming*; Elango, et al. 1995; Murray and Marriott 1998; Sahlman 1990). Furthermore, our findings expand the research by introducing the moderating role of syndication on the optimal size of the portfolio.

Our findings also have important practical implications. The results provide valuable guidance for venture capitalists on successful strategies and resource allocation. Venture capitalists should carefully consider how many companies they can manage and still add value. Too few companies imply that the venture capitalist's value-adding potential is not fully utilized. However, exceeding the optimal number of companies results in deteriorated performance as the venture capitalist's value-adding activities become too fragmented. Syndication can be used to overcome resource constraints. However, given that acting as a lead investor consumes almost as much resources as investing alone, reciprocity should be endorsed and/or taking the lead role compensated in the syndication of venture capital investments.

Similarly, entrepreneurs seeking financing should consider the limitations their investors face. While the results provide further evidence that venture capitalists add value to the ventures beyond the capital, the level of involvement from the venture capitalist affects the value added. Thus, observing and assessing the venture capitalist's ability to manage its investments is of importance also for the ventures. The larger the existing portfolio of the venture capitalist, the less value one can expect from the investor. In addition, the results validate the opportunity cost of venture capitalist attention. As suggested by Gifford (1997), with the opportunity cost of attention, the venture capitalists incentives do not necessarily

match those of the entrepreneur. It is not always optimal for venture capitalist to maximize the value of an individual venture, as this may decrease the value of other portfolio firms. The findings of this research validate the argument of opportunity cost, as they demonstrate the interconnectedness of the outcomes resulting from the limited attention of the venture capitalist.

Although our approach enables us to examine the performance of the venture capitalist, it is both a source of limitations and thus consequently of further research. First, although we measure the performance of venture capital firms in relation to their number of IPOs and capture the optimum for the group of portfolio ventures, some of the finer details remain unresolved. Thus, more sophisticated measures of performance are needed to address the question of division of the proceeds from an IPO. The emerging literature on risk and return in private equity (e.g. Cochrane 2005) can provide new opportunities to examine these aspects in the coming years.

Second, our sample contains the leading U.S. venture capitalists, and thus it may not be representative of the whole venture capital industry. According to Rosenstein, et al. (1993), only the top 20 venture capitalists in their sample seemed to add value to their investments. Although this questions the generalizability of the results regarding the value of venture capitalist involvement, the restrictions the venture capitalist faces in involvement apply even if the involvement would not be as valuable as that of the best venture capitalists.

Third, while our results provide support for the value of the venture capitalist's attention, it leaves open the question of the relative importance of the forms of involvement, as the involvement is both motivated by assistance and governance. The dominant source of value added has implications to both the ventures and venture capitalists. Should the value of involvement stem from governance, the entrepreneur may be better off with less involvement, as this would mean less intense monitoring. The opposite would apply if the value stems from

assistance, which makes involvement would be more desirable. Our results do not differentiate between these two alternatives, and further research on the issue is called for.

To conclude, this paper is one of the first ones to empirically link the organization of investment activities to the performance of venture capital firms. Building on and extending the prior theory, we developed and empirically tested hypotheses arguing that there exists a curvilinear inverted u-shaped relationship between the number of companies per partner and the venture capital firm performance, and that this relationship is positively moderated by the frequency of syndication and the role in syndicates. In so doing, we hope our paper stimulates further research on the strategies and success factors of venture capitalists.

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Table 1. Descriptive statistics

The table reports descriptive statistics and correlations for the dependent and independent variables (94 firms, 997 firm-year observations). All correlations higher than .06 are significant on the level .05. Table excludes industry, stage and location controls as well as dummy variables for years. These variables do not correlate with other variables on level higher than 0.4.

	Mean	Std. dev.	Min	Max	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.	13.	14.
1. Number of IPOs	2.38	2.42	0	14	-													
2. Number of partners	5.54	2.65	1	22	.43	-												
3. #New investments	18.96	14.76	1	95	.69	.51	-											
4. Companies/partner [a]	6.58	3.70	0.25	35.00	.33	-.25	.50	-										
5. Syndication frequency [a]	0.80	0.19	0.00	1.00	.02	-.05	-.01	.01	-									
6. Lead syndication frequency [a]	0.15	0.12	0.00	1.00	.16	.19	.23	.07	-.01	-								
7. Non-lead syndication frequency [a]	0.43	0.21	0.00	1.00	.11	-.02	.11	.18	.54	-.15	-							
8. Capital under management [b]	207.48	198.41	3.40	1929.20	.44	.55	.58	.17	-.08	.22	-.05	-						
9. Age [b]	16.29	9.01	0.50	51.50	.09	.32	.18	.01	.00	-.02	-.12	.27	-					
10. Avg. investment round at entry [b]	1.96	1.20	0.00	11.00	.18	.06	.15	.14	.08	.03	.19	.10	-.03	-				
11. Avg. size of syndicate	4.22	1.75	1.00	13.66	.09	-.05	.03	.12	.66	-.11	.66	-.09	-.09	.20	-			
12. Number of syndication partners	44.62	34.75	0.00	234.00	.59	.37	.81	.48	.30	.16	.42	.41	.08	.24	.51	-		
13. Stage specialization index	0.33	0.15	0.18	1.00	-.30	-.23	-.42	-.29	.04	-.15	-.17	-.32	-.05	-.30	-.08	-.40	-	
14. Industry specialization index	0.31	0.18	0.13	1.00	-.35	-.31	-.48	-.34	.01	-.13	-.22	-.37	-.12	-.32	-.15	-.48	.66	-

Mean, standard deviation and range are reported for non-transformed observations, while correlations are estimated for [a] centered and [b] logarithmic transformations that are used in regressions.

Table 2 The performance of venture capitalists relative to the number of companies per partner and the moderating effect of syndication

The dependent variable is the number of initial public offerings from investments made in new companies each year. The analysis applies a population-averaged Poisson model estimated with generalized estimating equations. Non-standardized regression coefficients and the corresponding standard errors (in parentheses) are presented; year dummies are included in the analysis but not reported. Table excludes industry, stage and location controls as well as dummy variables for years.

	Number of IPOs out of new company investments / year 1986-1998				
	Model 1	Model 2	Model 3	Model 4	Model 5
Companies/partner		.023 *	.052 ***	.048 ***	.048 ***
		(.01)	(.01)	(.01)	(.01)
(Companies/partner)^2			-.002 **	-.002 *	-.002 *
			(.00)	(.00)	(.00)
Synd. freq. x Companies/partner				.112 ***	
				(.04)	
Lead synd. freq. x Companies/partner					.036
					(.06)
Non-lead synd. freq. x Companies/partner					.074 *
					(.03)
Syndication frequency	-.166	-.160	-.173	-.121	
	(.23)	(.22)	(.22)	(.21)	
Lead syndication frequency					-.162
					(.23)
Non-lead syndication frequency					-.006
					(.16)
Number of new investments	.019 ***	.016 ***	.014 **	.016 ***	.016 ***
	(.00)	(.00)	(.00)	(.00)	(.00)
Number of VC partners	.021	.045 **	.061 **	.059 ***	.060 ***
	(.01)	(.02)	(.02)	(.02)	(.02)
Capital under management (log)	.116 +	.111 +	.101	.102 +	.101
	(.06)	(.06)	(.06)	(.06)	(.06)
Avg. investment round at entry	.335 ***	.340 ***	.354 ***	.350 ***	.363 ***
	(.06)	(.06)	(.06)	(.06)	(.06)
Avg. size of syndicate	-.008	-.006	.001	.004	-.011
	(.03)	(.03)	(.03)	(.03)	(.03)
Number of syndication partners	.003	.003	.002	.001	.001
	(.00)	(.00)	(.00)	(.00)	(.00)
Age (log)	-.123 +	-.143 *	-.158 *	-.147 *	-.159 *
	(.06)	(.06)	(.07)	(.06)	(.07)
Stage specialization index	-1.227 ***	-1.236 ***	-1.190 ***	-1.167 ***	-1.261 ***
	(.34)	(.34)	(.34)	(.34)	(.34)
Industry specialization index	-.850 **	-.771 **	-.673 *	-.720 *	-.729 *
	(.30)	(.29)	(.29)	(.30)	(.30)
N	997	997	997	997	997
Wald	923.66	992.27	1090.00	1095.82	1474.42
d.f.	37	38	39	40	42
Prob	0.00	0.00	0.00	0.00	0.00

*** Significant at the .001 level, ** Significant at the .01 level, * Significant at the .05 level,
+ Significant at the .1 level. 1-tailed tests for hypothesized relationships, 2-tailed tests for controls