AN EXAMINATION OF THE DETERMINANTS OF THE INCIDENCE AND SCALE OF SEED CAPITAL INVESTMENTS BY VENTURE CAPITAL FIRMS 1962-2002

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AN EXAMINATION OF THE DETERMINANTS OF THE INCIDENCE AND SCALE OF SEED CAPITAL INVESTMENTS BY VENTURE CAPITAL FIRMS, 1962-2002

Abstract

Employing both behavioural decision making and agency theories, our study seeks to identify those factors that influence a venture capitalist's (VC) initial decision to undertake seed capital investments and then subsequently to determine the scale of seed investment activity. We find investor age, timing of investment, and fund location to be of importance. We also demonstrate that the size of the fund and the existing number of portfolio firms exert opposite influences on the level of seed capital activity of the VC firm. We suggest that seed activity is a valuable source of market intelligence for leading VC firms seeking proactively to identify and invest in novel technologies. Our findings are based on an analysis of 2,9491 VC funds worldwide from 1962 to 2002.

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Since the early 1980s, VC activity[1] has grown rapidly in all major economies and currently billions of dollars of risk capital are allocated annually to high potential enterprises (Denis, 2004). Its popularity among policy makers is underscored by the fact that the investment target for VC funds, namely, radical ideas and the new industries which they may spawn (Gompers, Lerner, and Sharfstein, 2005), hold enormous potential promise at the levels of the economy, the sector and the individual firm. The ready supply, from both public and private sources, of early-stage risk capital to finance high potential but unproven applications of emerging technologies has repeatedly been seen as a major comparative strength of the US economy (Florida and Kenney, 1988; European Commission, 1998; Edwards, 1999).

Yet, a curious paradox has emerged in Europe despite the growing economic importance of the region's venture capital and private equity industries (Manigart *et al*, 2000). Policy makers and entrepreneurs alike argue that the supply of professionally managed risk capital available to nascent enterprises at their earliest and most vulnerable stages of development is persistently inadequate to meet their legitimate demands. Early stage technology enterprises are particularly seen as vulnerable to capital scarcity (Bank of England, 1996; Storey and Tether, 1998; EC, 1998). Thus, an industry that was originally based on the primacy of individual entrepreneurial endeavor – epitomized by the 'garage start-up' – has ended up in rejecting early stage risk capital activity as both too small and uneconomic[2]. Seed capital has become the European VC industry's 'skeleton in the closet'[3].

The theoretical explanation for this phenomenon is based on one widely accepted truism that has remained virtually uncontested, namely: as venture capital firms become larger, their interest and involvement in early-stage investments decreases. Thus, as the industry grows in scale, measured by funds under management, its very success mitigates against a continued involvement in small, early-stage and highly speculative seed investments. The evidence for

this has come from empirical associations of aggregate measures, either in academic studies of venture capital firms (e.g. Elango, Fried, Hisrich, and Polonchek, 1995) or in analytical examination of country level VC industry activity over time (Bank of England, 1996). Yet, where the presumed disconnect between investors and commercially attractive projects has been examined at the micro level, the evidence has not been forthcoming (Hughes 1997; Aston Business School, 1990). Despite these inconsistencies, there have been no studies of the factors that affect whether, and to what degree, a VC fund would engage in seed investment activity. Thus, the hypothesis of a negative relationship between fund size and seed investments, while intuitively appealing, has not been sufficiently nor appropriately tested. Given the difficulties of subjecting seed investment decisions to normative modeling, a determination of the supply and demand factors underlying investors' willingness to make seed investments is important from both theoretical and policy perspectives.

The purpose of this paper is to examine seed investing from the economic interests of a venture capital fund and its investors, and to identify those factors that explain why VC fund managers make more, less, or no seed investments. We point out the importance of high levels of ambiguity to the context of seed investment decisions – namely, the presence of non-quantifiable uncertainty. By integrating behavioral decision making and agency theory arguments, we establish the importance of VC expertise for dealing with such uncertainty. In addition, we consider the implications of a scarcity of experienced, early-stage investment executives (i.e. human capital) available to VC firms and derive implications for the relationship between fund size and seed investing.

We provide support for our hypotheses using data on the investment activity of a sample of 2,951 international VC funds. We find investor age, timing of investment, and fund location to be important in this challenging and increasingly specialist investment activity. Unlike the US, age in European VC firms is negatively associated with seed activity. Portfolio

size is positively associated with the likelihood and scale of seed activity within practicable boundaries although the relationship is ultimately curvi-linear. When fund size is denominated by capital invested, we find a strong and negative relationship for all measures of seed activity. For larger VC firms, an infrastructure enabling many early-stage investment and governance decisions is important. We infer that seed activity is still undertaken by leading VC firms because it is a valuable source of market intelligence for investors seeking proactively to identify and invest in novel technologies. We thus contribute to the entrepreneurial finance literature by extending its theoretical tools and providing a framework for examining early-stage investment decisions under uncertainty. In addition, our findings have important policy implications and suggest that many governments concerned with promoting early-stage equity markets might be pursuing second-best solutions.

THEORETICAL DEVELOPMENT

The Nature of Seed Investments

Seed capital may be defined as the external equity financing provided "before there is a real product or company organized" (NVCA, 2004). The ready availability of seed capital is seen of particular value in the initial and exploratory commercialization of new technologies (Gompers and Lerner, 1999), i.e. that early stage in the innovation cycle where significant time and money has to be invested *before* the creation of a commercially viable product or service[4]. In such uncertain and volatile circumstances, debt is rarely appropriate given that cash flows frequently remain negative for substantial periods of time after the conception of the firm (Berger and Udell, 1998, European Commission, 2000; 2003). External equity, and particularly venture capital, thus may constitute one of the few viable financing options for a knowledge-based new enterprise. It has the added advantage that many professional VC

investors are also experienced in providing managerial guidance to young firms (Sapienza, 1992; Fenn, Liang and Prowse, 1995).

VC firm agents raise specific *funds* from appropriate institutions (Mayer, Schoors and Yafeh, 2005) to invest in portfolio companies. They are frequently focused on a particular market, sector or technology opportunity. These funds are typically structured as fixed-term, limited liability partnerships, with the external finance providers acting as limited partners and the most senior managers of the VC firm raising the funds becoming the general partners (Fenn, Liang, and Prowse, 1995; Sahlman, 1990). Thus, we are interested in the decisions faced by the general partners of a VC fund whether or not to engage in seed investing. For that minority of VC funds having the requisite skills and prepared to consider seed capital, we are similarly interested in the consequent decision of how many seed-stage companies can be supported within the fund's portfolio without negatively affecting overall fund returns. We build our theoretical arguments on this venture capital decision by first outlining the limitations of viewing seed investment allocation solely through the lenses of mainstream financial portfolio theory. We then investigate differences in seed investment decisions by integrating arguments from behavioral decision making and agency theory.

Portfolio Theory and Seed Investing

The Capital Asset Pricing Model (CAPM) has gained near universal acceptance among professional investors and analysts (Fama and French, 2004). Once the volatility of an asset is known, the portion of a portfolio to be allocated to that asset is a function of investors' risk and return aspirations. If we assume that the limited partners of VC funds are relatively homogeneous in their return preferences[5], we would not expect systematic differences between funds in regard to their allocations to seed investments.

The validity of a model rests on the accuracy of its assumptions. Seed investment decisions serve to highlight the limitations of CAPM. Particularly problematic is a presumed

knowledge of future return distributions as estimated from the distribution of prior returns. While this condition is practically met in the domain of actively traded public stocks, the situation becomes more obscure for privately-held investments. Without reference benchmarks, as is frequently the case for early investments in nascent technologies, investors face uncertainty of a *Knightian* nature. A quantitative approach is effectively nullified in such a speculative environment involving multiple sources of uncertainty (Storey and Tether, 1998). These circumstances affect investors' decisions by amplifying their perceived risk components (Einhorn and Hogarth, 1985; Ghosh and Ray, 1997; Kahn and Sarin, 1988). As a result, seed investments may offer the prospect of little confidence of higher returns but with a considerable likelihood of project failure. In such circumstances, investors' abandonment of seed and other early-stage investments in favor of later stage deals is highly rational. Investors' entrenched antipathy to early-stage activity is also supported by empirical evidence of long term, poor fund performance, particularly outside the US (Burgel, 2000; BVCA, 2004; EVCA, 2005).

A further operational problem is that seed investments consume relatively little finance. Even in the rare event of an enterprise being commercially successful, it will take several years to transform the nascent enterprise into a firm capable of being successfully floated or sold to a trade buyer. For a substantial fund with tens or (increasingly) hundreds of millions of dollars to invest and harvest over the course of a ten year fixed term fund, such 'trivial' investments embody a high opportunity cost given their diversion of scarce investment manager talent (Gifford, 1997). Thus, the industry's (seed aversion) behavior is consistent with the theoretical logic of Amit, Brander, and Zott (1998). They argue that venture capitalists generally prefer making later stage investments for reasons of unimpeachable commercial logic.

Factors Affecting Differences in Seed Investment Decisions

Yet, some successful VC firms continue to make seed investments. In order to understand idiosyncratic fund and investor behavior, we need to question if facing non-quantifiable uncertainty universally leads to higher risk perceptions. In the absence of robust estimates of risk, investors may often resort to 'rules of thumb' or routines that are honed by their prior experience (Nelson and Winter, 1982). Given the peculiar nature of VC investing, entailing significant pre- and post-investment involvement (Tyebjee and Bruno, 1984), there are two aspects of risk perception that need to be addressed. The first pertains to dealing with non-quantifiable uncertainty in investors' initial decision making. The second concerns an investor's perceived ability to manage the agency risks associated with a particular portfolio company *after* having made the decision to invest. To explore variations in the former, we resort to behavioral decision making arguments. Then, in order to explain portfolio governance, we refer to agency theory arguments.

Behavioral decision arguments. The managerial perspective on risk outlined by March and Shapira (1987) suggests that the perceived risk in any situation is related to the possibility and magnitude of loss. Managers do not interpret their actions as a gamble. It is a lack of relevant knowledge that makes the decision a gamble in the eyes of the decision maker (Lange, 1982). Heath and Tversky (1991) develop a more elaborate explanation of the role of expertise in choice under uncertainty based on the different ways that credit and blame for the decision outcome are allocated. They argue that experts are more likely than the inexperienced to place a bet (i.e. act) in a situation of uncertainty.

The application of this logic to the context of VCs making seed investments is clear: the attribution of success and failure matter for the investor's reputation. Status is important for continued fundraising, on which the survival of the VC firm critically depends (Gompers, 1996). Before committing additional funds to a partnership, limited partners and their advisers examine the record of the previous fund(s) against industry level performance and judge the

extent to which the VC managers have demonstrated their skill as investors. Their *ex post* assessment of the performance of a fund will, in part, be influenced by the public reputation of the fun's general partners[6]. Thus, for an experienced investor, a seed deal is more likely to be perceived as a 'manageable risk'. If ultimately successful, it stands to enhance the investor's reputation. This idea of manageable risk corresponds well to the presence of an 'over-confidence bias' in the decision making of experienced investors (Zacharakis and Shepherd, 2001).

Agency theory arguments. There are significant agency costs regarding the governance of venture capital investments (Sahlman, 1990). To manage these costs, venture capital firms engage in substantial pre-investment contracting and post-investment monitoring (Gorman and Sahlman, 1989; Gompers, 1995; Lerner, 1995; Hellman and Puri, 2002). Given major information asymmetries, the intensity of governance interactions is even higher for seed and other early-stage ventures (Sapienza and Gupta, 1994; Kaplan and Stromberg, 2001; 2004). Continuing oversight of the enterprise will demand specific business and industry skills that a VC firm may (or may not) possess (Dimov and Shepherd, 2005). Accordingly, the investment selection will also require the investor to make assumptions regarding the level and relevance of his/her competencies – a further source of potential uncertainty.

VC firms may resort to stage, industry or geographical specialization in order to better manage agency risks (Amit *et al.*, 1998; Gupta and Sapienza, 1992). With time, as the VC firm invests in a greater number and range of deals, its executives may learn to interpret better the (warning) signals of (poor) venture performance. As a result of this cumulative learning process, the VC firm develops a pool of experienced investment managers[7]. This intangible and tacit human capital represents a valuable and inimitable source of guidance available to the less experienced founder managers of its portfolio companies. In addition, as a result of this greater operational experience, the network contacts as well as the investors' skills at

conducting due diligence are likely to be improved. Over time, such monitoring expertise may decreases, or at least hold in check, the net costs of post-investment involvement. Accordingly, greater experience may make the VC firm more prepared to engage in challenging but potentially high value seed deals.

Hypotheses related to VC expertise. As these arguments suggest, cumulative experience helps the VC investor both understand and manage better the uncertainty surrounding seed-stage ventures. It also increases the efficacy of post-investment monitoring. Both attributes make seed investments more feasible and attractive. In comparing the investment expertise of VC funds, we first need to determine the nature and location of such expertise. As a starting point, the notion of (decision making) expertise in the behavioral decision making literature pertains to the existence of high-level routines for information processing that have emerged from one's experience as a decision maker (e.g. Newell and Simon, 1972). Similarly, in applying the behavioral perspective to firms, there are well established notions that firms learn from their experience (Levitt and March, 1988); and that the learning outcomes become instilled in routines that facilitate the firm's subsequent decisions and actions (Cyert and March, 1963; Nelson and Winter, 1982). Furthermore, such routines may create externalities (or knowledge spillover beyond the boundaries of the firm) through the development of social institutions that facilitate the flow of ideas and the mobility of individuals (e.g. Almeida and Kogut, 1999).

On this basis, we argue that there are three different, nested levels at which decision making routines may emerge. Comparisons of VC expertise can be made by individual firm (general partnership); by industry across time; and by industry across geography. First, because funds are managed by VC firms which are typically involved with a sequence of over-lapping funds over time, the age of the VC firm is an indication of the extent of its cumulative investment activity. Managing both success and failure enhances the VC firm's

expertise as it becomes instilled in improved routines for making new investment decisions and conducting effective post-investment monitoring. To the extent that these routines contribute to the investment performance of a particular fund, the VC firm can capitalize on this success by raising a subsequent fund. Longevity of a VC firm is positively associated with accumulated VC investment expertise.

Hypothesis 1. The longer a VC firm has been in existence, the higher the seed investing of its latest fund.

Next, funds raised and invested at different points in time, even if managed by VC firms of equal age, are exposed to different externalities given the differences in industry development and maturity across time[8]. Accordingly, a fund that has been more recently established may benefit from a higher degree of cumulative industry development and cohesion. As a national VC industry develops, the quality of its support network including the involvement of successful entrepreneurs, advisers and professional services firms (such as management consultants, IP specialists, lawyers and accountants etc.) and usually the establishment of a national VC industry association. When a high-quality support infrastructure is available, the process of learning and augmenting the industry's core skills may be further accelerated. In addition, the intra-industry mobility of investment executives as well as the advent of industry financed, training programs may further enhance the overall quality of decision processes across firms. Accordingly, when compared to funds established in earlier years, more recently established VC funds can draw from a larger pool of industry knowledge – an 'industry experience effect'. We would therefore expect the complexities of seed investments to be better understood and be perceived as less of a barrier by VC practitioners over time. These time differences in the origins of the individual funds may be

captured by the 'vintage year' of the fund, i.e. the year in which the fund raising was first closed.

Hypothesis 2. The more recent the year of a fund's formation, the higher its seed investing.

Finally, even for funds established in the same year and managed by VC firms of the same age, differences may emerge due to the differential intensity of industry development in the different geographical regions where these funds may operate. We know that technology innovation is particularly sensitive to the positive incubating effect of intense and close networks of complementary resources in spatially distributed nodes or clusters (Porter, 1998; Kenney and von Burg, 1998). Thus, comparing VC industries across countries or regions, we would expect longer established and larger venture capital communities to also have developed a more extensive experience base. VC funds within such better-endowed regions will have access to greater and superior decision resources and expertise. The US VC industry had its roots in post-war America and by the early 1980s the US had become the dominant VC player in, particularly, early-stage technology markets (Bygrave and Timmons, 1992; Fenn, Liange and Prowse, 1995). With the single exception of the UK (Lorenz, 1989; Murray, 1995) it was not until the mid-1980s that recognizable VC industries started to emerge in other national economies. These were initially located in Europe (Martin, Sunley and Turner, 2001). Given the time gap between the emergence of the VC industry in the US and its taking root in other regions of the world, we would expect the accumulated investment experience of the US industry to generate more positive contemporary attitudes towards the potential of seed-stage investments[9].

Hypothesis 3. US venture capital funds will do more seed investing than equivalent, non-US venture capital funds.

Hypotheses related to fund size. While we have established a baseline relationship between VC expertise and seed investing, there may be more pragmatic concerns in the portfolio allocation decisions of VCs which relate to the anticipated size of the VC fund. As highly incentivised agents of their institutional investors (Zider, 1998), VC firms need to ensure that all their drawn down capital is invested in projects capable of generation substantial capital gains. However, given the small size of most VC firms when measured by the number of full-time investment executives, and the relatively large amounts of capital they have under management for a relatively short fixed term, a paramount concern for venture capitalists becomes the optimum utilization of their time (Gifford, 1997). Because of such time restrictions, the marginal effect of a venture capitalist's value-adding efforts decreases with the number of portfolio companies. This implies that, for a given number of investment executives, there is only a limited number of deals they can optimally execute (Jaaskelainen, Maula, and Seppa, 2002; Kanniainen and Keuschnigg, 2000). Considering this time constraint in conjunction with the level of funds raised, there emerges an optimum deal size for a fixed amount of fund capital to be invested by a given number of investment executives.

Furthermore, for a given general partnership, raising larger funds is not necessarily associated with adding new investment executives. Given the relatively high magnitude of fund management fees – 1.5 to 2.5 percent of committed funds per annum (Murray and Marriott, 1998; Sahlman, 1990; Zider, 1998) – there is a clear income incentive for VC firms to raise and manage larger funds without adjusting workforce numbers. Accordingly, when the amount of capital raised by a fund increases, without a commensurate increase in the fund's manpower, average deal size has to increase (Murray, 1999). These structural and operational imperatives for larger average deal sizes make small deals increasingly impracticable. As noted, not only are seed investments small and with highly uncertain

outcomes, but they also absorb a level of investor time that is incommensurate with the proportion of the total fund size they represent.

Hypothesis 4. The greater the amount of finance committed to a fund, the lower its seed investing.

However, one would not expect that all VC firms would yield to the incentive to simply raise larger funds without increasing their manpower. This growth in average deal size may well move the VC executives out of the market sectors where they have their greatest knowledge and competence. Successful VC firms frequently restrict the size of their fund raisings to avoid this threat. Thus, among funds with an equal amount of capital under management, those that employ a higher number of investment executives would be able to execute a greater number of deals and, accordingly, evade the deal size restrictions outlined above. Assuming a constant 'optimal number of deals per partner' ratio across VC funds investing at the same stage, one could deduce that, funds that execute a bigger number of deals will also have higher manpower. In circumstances of high uncertainty, for example in nascent technologies, a seed fund's general partners may adopt a strategy of seeking to maximize their total number of successful investments by maintaining a large portfolio of smaller-value investments. Therefore, the perceived impracticality of seed investments is likely to decrease as the scale and deal making capacity of the VC firm increases.

Hypothesis 5. The higher the number of companies in a fund's portfolio, the higher its seed investing.

DATA

From the *VentureXpert* database published by Thomson Financial, we collected multi-country data on venture capital funds[10] that have invested in at least 10 companies over the period from 1962 to 2002 – a total of 2,949 funds. These dates represent the widest available

spectrum of data collection. Before 1962, negligible information is available. The threshold of 2002 represents the latest date at which statistics collected can indicate the investment preferences of the sampled VC firms. The reason for selecting a cut-off point of at least 10 portfolio companies is that we wanted to study funds that have already realized a specific and identifiable, early-stage investment strategy. Only when a certain minimum number of investments are made does the intended portfolio allocation become clear. In addition, because of our cut-off date of 2002, selecting a lower threshold for the number of investments per fund could result in right-sensoring of currently active funds, i.e. ignoring the investments they still intend to undertake in the time after 2002 and thereby under- or over-stating their seed capital investment preferences.

The funds in our sample represent 30 countries worldwide, with the majority based in the US (81%), followed by UK (4%), South Korea (2.1%), Germany (1.9%), and France (1.7%). Table I presents a detailed description of our sample by the funds' country of origin. In terms of their investment focus, 43.7% of the funds had a balanced focus, while 36.4% had an early-stage focus. Table II presents a detailed description of our sample by the funds' stated investment focus. As is evident from both tables, there is large variation in the number of seed investments both by country of origin and investment focus. This warrants a more detailed analysis of the factors that could account for such variation. Finally, Table III presents a description of the sample funds based on the year the new fund raising was completed. As is evident from the table, 44% of the funds have been raised over the period 1996-2000.

Insert Tables I, II, and III about here

We examined the incidence of seed investing in two ways – measuring both (1) the proportion and (2) the number of seed investments made by a particular VC fund. This

allowed us to examine the robustness of our results as well as facilitating their interpretation. Because a change in a ratio can be driven both by the numerator (number of seed investments) and the denominator (total number of all investments), the statistical association of the ratio variable to other variables may be more difficult to interpret. Repeating the analysis with the count measure of seed investing thus allowed a less ambiguous investigation of the factors that influence the demand, supply, and thus the impact of seed capital activity. In creating these two dependent variables, we counted for each fund the number of 'first-time' investments in seed-stage companies in their portfolios. First-time investments indicate a fund's earliest involvement with a particular portfolio company. Our reason for this restriction is that uncertainty attitudes are likely to be signaled most clearly at the time of a fund's initial involvement with a portfolio company. Any follow-on investment or syndication in other VC firms' portfolio companies (Lerner, 1994; Lockett and Wright, 2001) incorporates shared information that represents some resolution of the uncertainties present at the time of the initial investment decision.

From the data available in the *VentureXpert* database for each selected fund, we derived several variables to test the relationship of interest. For each fund, we calculated the age of the VC firm managing it, i.e. from the year in which the VC firm had been founded to the year in which the raising of the particular fund was closed to investors. This variable represented the cumulative investment experience of the VC firm and we thus expected it to have a positive association with seed investing. We also recorded the vintage (calendar) year of the fund to capture the learning curve effect of the VC industry as a whole – more recently raised funds were expected to engage in more seed investing. Two indicator variables represented whether a fund was located in the US or in Europe. Given that the US VC industry is older and better established, we expected a US location to have a positive effect on the level of seed investing. Finally, we measured two aspects of fund size – the number of

companies in which the fund had invested and the total amount invested in all of its portfolio companies. As elaborated in the previous section, we expected these both to have opposite effects on the fund's seed investing. In order to explore possible curvi-linear relationships between fund size and the number of seed investments, indicating the possibility of optimal scale effects, we also calculated the squared terms for the two variables representing fund size.

Achieving an unbiased estimation of the above effects was contingent upon ruling out various alternative explanations for the level of seed investing of a particular fund. We therefore included a broad set of control variables, to account for such explanations. The first set of control variable captured other relevant fund characteristics, while the second set captured the factors affecting the demand for seed investing. Given that funds are often promoted to investors with an explicit investment mandate – as evidences by their stated focus – we included an indicator variable for whether or not the fund had a seed or early-stage focus. We expect funds with such focus will do more seed investing. In addition, given the arguments on the distinctive nature of 'independent'[11] venture capital firms (Manigart *et al.*, 2002; van Osnabrugge and Robinson, 2001), we included an indicator variable for whether the fund was independently managed. Further, because the institutional investors in a fund have different liquidity requirements – with bank-owned funds needing higher liquidity for regulatory requirements and thus avoiding early-stage investments (Mayer, Schoorsb, and Yafeh, 2005) – we included an indicator for whether the fund's management was owned or controlled by a financial institution. We also included an indicator for whether the fund was corporately managed, based on the expectation that such funds tend to follow the independent VC investors and thus invest at later stages (Birkinshaw, Murray and van Basten Batenburg, 2002). Finally, given the pivotal roles of Silicon Valley and Route 128 in the development of the US venture capital industry (Florida and Kenney, 1988), we included indicator variables

for whether or not a fund was located in the well established venture capital/new technology clusters of California or Massachusetts.

Our set of demand-side control variables sought to capture the different demand for seed capital that the funds in our sample could be facing. Such demand is essentially deemed to be driven by a country's entrepreneurial environment, as represented by its number of start-ups and innovation output. In times of rapid economic growth, the incidence of start-up activity is higher, creating more demand for investments at early stages (Storey, 1994; Audretsch, 2002). Similarly, higher innovation output also generates a higher demand for seed investments as new inventions or applications embark on the path to commercialization. To capture these two conditions, we included the GDP growth rate of the country in which each fund was based and for the year it was established as well as the total number of patent applications in that country for that year[12]. We also included several stock market indices in order to capture the possibility that capital market conditions also affected the demand environment for seed investing. Because our fund coverage was global, we included indices from different regions – the S&P from the US, the FTSE from the UK, and Nikkei from Japan. Our general expectation was that the returns of these indices would be positively associated with the level of seed investing. The logic behind this expectation is that because stock markets represent a major avenue for exiting VC investments, such exits are more likely when stocks represent an attractive investment opportunity as signaled by current stock market returns (Lerner, 1994).

In addition, given that the above indices may cover the more 'traditional' economic sectors and not necessarily the high-technology innovation sectors that create the bulk of demand for seed investing, we also included the NASDAQ index in order to account for developments in the high-technology space. For each index and each fund year, we calculated the return to that index over the year before. In addition, to account for the fact that the

relationship between economic environment and the demand for seed capital may be lagged, we also calculated the index performance over a broader period around the raising of each fund. We chose a 5-year window, beginning two years prior to the fund raising and ending two years after the fund has been raised. This measure thus captures not only the initial investment period of a fund, but also the environment during its fundraising period.

ANALYSIS AND RESULTS

Table IV presents the descriptive statistics and bivariate correlations of the variables used in our analyses. Some of the high correlations (e.g. among variables reflecting fund size) suggested that multi-collinearity might be an issue in our analyses. Although it does not lead to biased estimation, it does affect inference by inflating the standard errors of some of the affected variables. In the cases where it was possible to do so, our diagnostics revealed this not to be an issue – the higher VIF value in our OLS estimation was 5, which is well within the acceptable range. For the remaining cases, the procedure for maximum likelihood estimation used in the "Stata" statistical software program checks for multi-collinearity beforehand and removes any variables affected by it from the subsequent estimation. To the extent that no variables were removed from our estimation, we could conclude that multi-collinearity was not an issue in our results.

In order to verify the robustness of our results as well as their sensitivity to particular intervening factors, we ran all our analyses on several subsets of the data. First, because some of our independent variables (VC firm age, fund vintage year) were time related, we had to account for the possibility that the surge in VC investment activity in the late 1990s, largely driven by the rapid development of internet-related technologies, could confound some of our results. In essence, the seed investments made over the period 1996-2000 – i.e. from the time following the IPO of Netscape Communications (August 1995) until the rapid reversal in investor attitudes in April 2000 – accounted for 42.5% of all seed investments. Thus, given

that the funds raised after 1995 represented 46.4% of our sample, there was a real possibility that the effect of this occurrence of intense investment activity could overpower some of the time trends related to earlier periods. Therefore, we ran our estimation on the subset of funds raised prior to 1995, excluding all seed investments made after 1995[13]. Second, given that the majority of funds were based in the US with the second largest contingent being European countries, we ran the analyses on the subsets of US and European funds seeking to establish whether both the direction and strength of the relationships held in these contexts. Finally, given that the explicit investment focus could present issues of endogenous self-selection into the various fund categories, we ran our analyses on three subsets of our data: early-stage funds, balanced funds, and late-stage funds.

We started our analysis with the proportion of seed investments made by the VC funds in our sample. Given that nearly half of our funds (44%) did not make seed investments, our dependent variable contained a large number of zeros. We therefore used a Tobit model in order to account for this large number of zeros. The Tobit estimation is shown in Table V. Model 1 contains only the control variables; the variables for VC firm age, fund year, US or European location, and fund size are added in model 2. Models 3 through 8 contain the estimations on the different subsets of the data in order to establish the robustness and sensitivity of our results.

Among the control variables, the effects for seed and early-stage focus and location in California were all positive as expected. While the independent status of a fund mattered only in the context of funds with early-stage focus (a significant positive effect), corporate and financial institution funds had a consistently lower proportion of seed investments across the various contexts. This was again in line with our expectations. The yearly performance of the stock market indices showed varying effects – positive for the S&P and Nikkei returns and negative for the NASDAQ and FTSE returns – whereas their 5-year performance had largely

positive effects on the proportion of seed investments. We were initially puzzled by the negative effect of NASDAQ returns, yet on reflection we inferred that when exit conditions are positive, funds are likely to focus more on companies that are closer to achieving exits. Finally, contrary to our expectations, both GDP growth and country patent applications had negative effects on the proportion of seed investments. While positive in the base model, the patent application effect turned negative once the fund characteristics were accounted for. Similar to the effect of NASDAQ returns, it is plausible that when the entrepreneurial dynamics within a country are high, experienced professional investors seek businesses that are more developed and thus closer to their investment exits.

The results for VC firm age are mixed. While its effect was positive and significant for the subset of funds raised prior to 1995, it was negative in the other subsets, and marginally significant in the European and balanced-focus subsets. These results suggest that there may be several underlying processes at work simultaneously. While there may be a general experience effect for the VC firm managing the fund, this effect may be diluted post-1995 due to the entry of many new VC firms and the large number of seed investments made in the ICT space during the technology bull market post 1995. In addition, for European and balanced-stage funds, the accumulation of VC firm investment experience seems to work to the effect of directing the fund away from seed investing. This finding is supported by European VC industry statistics showing a progressive smaller share of early stage investments in total industry activity over time. This trend has raised considerable policy concerns regarding the future funding of innovation activity (HM Treasury & Small Business Service, 2003; European Commission 2005). The effects for fund year are positive in all the models (except for late-focus funds) and significant in the full, US-only, early-focus, and balanced-focus models. This is consistent with the observation that the incidence of seed investing has

increased in recent years, possibly again due to the technology investing effect of the mid to late 1990s.

The effect for US location was consistent and strong across all the models (except for late-focus funds) and suggests that US-based funds make more seed investments. The effects for European location were negative across the models and significant in the full and early-focus models. This further reinforces the notion that funds located in Europe are less attracted to seed investing, even if having an explicit early-stage focus. Finally, the effects for fund size were significant and consistent across all the models. The number of portfolio companies was positively associated with the proportion of seed investments, while the amount of funds available exhibited the opposite, negative effects.

Because the Tobit analysis combines both the generation of zeros and the generation of positive ratios, we also ran separate analyses for whether a fund made seed investments and, given that it has made such investments, for the proportion of these investments. This helped us disentangle whether the Tobit effects were due to a fund's propensity to make at least one seed investment or due to its propensity to make a high proportion of seed investments. Table VI presents a Probit estimation of whether or not a fund has made seed investments. In model 1 the estimation was done on the entire data, while in models 2 to 7 the estimations were done on the different subsets of the data as specified above. The results for the control variables were consisted with those in the Tobit model. Also consistent with the Tobit estimation, the effect for VC firm age was positive and significant for the funds raised prior to 1995, suggesting that as the VC firm accumulated more experience it was more likely to make seed investments. In addition, the negative effect for European funds was also upheld, albeit at marginal significance. For such funds, the more experienced their management firm the less likely they are to make seed investments. The effects for fund year, US location, and fund size were also consistent with those derived from the Tobit estimation,

except that the positive effect of US location on funds raised prior to 1995 was no longer significant. These results suggest that much of the variation in the proportion of seed investments is explained by whether or not funds make at least one seed investment.

Table VII presents an OLS estimation of the proportion of seed investments for all funds that have made such investments. This allowed us to explore the intensity of seed investing for the funds so engaged. The full estimation is presented in model 1, while models 2 through 7 present the estimation results for the different subsets of the data. The effects for VC firm age are negative across all (but not significant for European and early-focus funds), suggesting that for more experienced VC firms the allocation to seed investments in their fund portfolios decreases. Fund year had a positive effect across all models (not significant for European funds), thereby reinforcing the argument of an industry experience effect increasing the intensity of seed investing. Unlike the previous models, there was no effect for US location here. This suggests that while US-based are more likely to make seed investments, they do not necessarily have higher allocations to such investments. The effect of a European location was negative across all models and significant in the full (marginally) and early-focus funds. Combined with the Probit results, this suggests that European funds are no more likely to make seed investments than funds located in other regions. However, when European funds invest in seed activity, they do so more cautiously (i.e. with lower intensity). Finally, the effects for both measures of fund size were negative in all models (and significant in most cases). This suggests that, except for funds located in Europe or with early-focus, as the number of portfolio companies increases, the number of seed investments increases but at a slower pace. We also observe the same effect when the fund's available capital increases but in this case with only the balanced and late focus coefficients failing the significance test.

In our final set of analyses, we used the number of seed investments made by the VC funds in our sample as our dependent variable. Because there was over-dispersion in our data

– the mean and standard deviations for the number of seed investments were 1.81 and 3.20 respectively – we used a negative binomial (rather than Poisson) regression which better accommodates such a dispersion. A useful feature of this model is that its estimation contains a Poisson model nested within it, thereby allowing for a more formal test of its better suitability. In particular, the model estimates a parameter (alpha), which reflects a comparison of the conditional mean and variance in the model. If alpha were zero, the conditional mean and variance would be equal and the model would thus reduce to a Poisson distribution (Cameron and Trivedi, 1998). In our estimation, the null hypothesis of alpha equaling zero was rejected ($p < .001$), suggesting that a negative binomial model was indeed better suited for the data at hand.

Because of the large number of zeros for the number of seed investments across the funds in our sample, we had to account for the possibility that these zeros were generated by a qualitatively different process. Although the unobserved heterogeneity that causes the over-dispersion can also cause the excess zeros (Cameron and Trivedi, 1998), one might consider the possibility that they are driven by different processes. This was reinforced by the significance of the Probit models presented in Table VI. In our case, whether or not a fund makes seed investments may be a result of a strategic decision by the fund's managers. Therefore, it is plausible and, indeed probable, that there are different processes involved in the funds' decisions whether or not to make seed investments. And, for those that have decided to do so, in the subsequent and separate decisions of how many seed investments to make. In order to account for this possibility, we included a correction for each fund's endogenous self-selection into making or not making seed investments[14]. We used the probit estimations above to determine the hazard of making (or respectively not making) seed investments for each fund by calculating the inverse Mills ratios – $\varphi(.)/\Phi(.)$ for those making seed investments and $-\varphi(.)/[1-\Phi(.)]$ for those not making seed investments – where $\varphi(.)$ is the

normal density and Φ(.) the cumulative normal distribution. The results from the negative binomial regression are shown in Table VIII. Model 1 includes all control variables, model 2 adds the main effects of VC firm age, fund year, location, and fund size, and in model 3 we added the square terms for the number of portfolio companies and the amount of fund capital. Model 4 through 9 represented the robustness and sensitivity analyses run in the different subsets of the data. The effects of the control variables were consistent with those in the Tobit estimation. The effect for VC firm age was again positive in the subset of funds raised prior to 1995 and negative for European funds. This is consistent with the results in the previous estimations. Similarly, the effects for fund year and US location were positive and significant across all models, thereby reinforcing the previous results. The effect of European location, while negative across all models, was significant only in the full and early-focus models. This was consistent with the Tobit and OLS estimations. The effects for the two measures of fund size were consistent with the Tobit and Probit results above – positive for the number of portfolio companies and negative for the amount of fund capital. Of the two square terms, only the one for the number of portfolio companies was significant. Its negative sign suggests an inversed-U-shaped relationship with the number of seed investments. Thus, as the number of companies in the portfolio grows, the number of seed investments increases before reducing beyond a certain total portfolio size. This effect is consistent with the negative effect for number of portfolio companies in the OLS estimation in Table VII[15]. However, the low effect size for the square term compared to the effect of the linear term suggests that the maximum number of seed investments is reached for a portfolio size, i.e. 270 companies, that is beyond those observed in practice.

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DISCUSSION AND CONCLUSION

In this paper we have sought to understand of the determinants of seed investments, testing our predictions on a large and international sample of venture capital funds across a forty year period (1962-2002). As the empirical results suggest, the theoretical perspectives we offer in this paper lead to some interesting and counter-intuitive results in arguably the least understood area of venture capital investment activity.

Summary of Findings

We find a mixed picture on the effect of greater funds' age (and experience) on their likelihood of engaging in, and intensity of, seed investing. On one hand, we found a positive overall effect for funds raised prior to 1995. This supports our theoretical reasoning that VC investment expertise facilitates dealing with the non-quantifiable uncertainty inherent in seed-stage investments. More specifically and from a reputation point of view, when compared to young VC firms, more established firms are able to extract higher benefits from making seed investments. Their success could be attributed to greater expertise. In addition, more established firms have better and more efficient processes in place to engage in the more intensive post-investment monitoring and governance associated with seed and early-stage companies. But this result also highlights the difficulty of looking for systematic relationships driving seed investing post-1995, i.e. from the time the internet bubble started gathering momentum (Howcroft, 2001; Sohl, 2003).

On the other hand, we have some evidence that VC firm age is negatively associated with the likelihood and number of seed investments for European funds. We speculate here that, given the strong focus in Europe on management buyout (rather than early-stage, venture capital) investments, as VC firms become older and thus more experienced they become more aligned with the institutional context of the dominant European private equity industry. Thus, European venture capitalists increasingly focus on later-stage investments. Given published

fund performance details (EVCA 2005) there is little doubt that such a choice of later-stage, private equity type investments has financially benefited both limited partners and fund managers incentivised to share in the resultant capital gains.

We have consistent evidence that fund year is positively associated with both the proportion and number of seed investments. It is also a discriminating factor for whether or not a fund will make seed investments. In addition, among the funds that do make seed investments, those raised more recently make a higher number of seed investments. This suggests that over time seed investing becomes a more specialist activity – an interpretation supported by the diminishing relative number of VC firms prepared to engage in such activities.

The finding that US funds make both a higher number and proportion of seed investments, even after controlling for the cluster effects of California and Massachusetts, should come as no surprise. This is a result that we attribute to the greater development of the US VC industry and its close association with sources of leading-edge scientific and technological innovation from both world-class universities and corporate research laboratories. The importance of California (Florida and Kenney, 1988; Saxenian, 1994) demonstrates the effect of a self-reinforcing cycle of technology production and its commercial exploitation largely contained within dense networks or clusters (Shane and Stuart, 2002; Porter and Ackerman, 2001). With time, a small number of other regions in the US have successfully managed to replicate (albeit to a lesser degree) the Silicon Valley experience, notably the North Carolina Triangle and Dallas Texas. This has raised the overall level of early-stage VC investment expertise in the US. Seed stage enterprises require demanding skill sets from their investment managers in addition to patient money from their limited partners. Few, if any, national venture capital industries outside the US can point to such a strategy successfully producing exceptional returns for their investors[16]. It may well be

that only US venture capitalists, given their historical investment performance, are as yet able and prepared to make the larger and longer term 'bets' needed to finance an emerging but unproven technology. Similarly, it may only be US venture firms that are also allowed to make such speculative investments by their limited partners. Investors willingness is likely to be linked to the number of highly visible 'home runs' that US equity investors have enjoyed through their very early involvement in major VC backed, start-up successes over decades including DEC, Compaq, Apple, Amgen, Netscape, eBay and Google, Skype etc. In line with our proposed link between expertise and seed investing, the occurrence of so many exceptional investment successes has been a prime ground for learning and thus further honing of the available investment expertise. This consistency, not replicated outside the US, has also made their institutional investors tolerant of the inevitable and occasional investment failures of such funds.

In contrast to US-based funds, funds located in Europe were lower in terms of both the proportion and number of seed investments. This effect was particularly acute for early-stage funds. When considered together with the negative effect of VC firm age in seed investing in Europe, this reinforces the idea that the investment environment in Europe is less conducive to seed-stage investing. Perhaps the factors that enable seed investing in the US, as discussed in the preceding paragraph, are still absent or under-developed in Europe, given the relative immaturity of European VC industry (US Department of Commerce and European Union, 2005).

We find strong evidence that the number of portfolio companies is positively associated with the likelihood and number of seed investments. On one hand, this should not be surprising – bigger portfolios allow for more diversification across investment stages. On the other hand, this effect holds even after accounting for the explicit investment focus of the fund. Surprisingly, it also holds true even for balanced- and late-focus funds. This suggests

that having a larger portfolio enables a fund to bet speculatively on the establishment of new industries as they pursue the super-normal returns available to successful innovators. In this context of seeking out novel and exceptional enterprises as well as prospecting for the dominant technologies of the future, we deduce that seed capital activity represents an important *intelligence mechanism* for large funds. For the successful venture capital firm, a seed capital facility may not be the peripheral investment activity that its scale of investment would suggest. On the contrary, seed capital may be central to the VC firm's continuing relevance as a prescient investor influential in identifying early in the cycle the next generation of key technologies.

Yet, the commitment to seed investments is not without limits. Our results also suggest a negative relationship between the number of portfolio companies and the proportion of seed investments described by an inverse-U shaped relationship between the number of portfolio companies and the number of seed investments. This finding suggest the existence of a maximum efficient scale in making seed investments. We attribute this to the manpower limitations inherent in VC investment teams exacerbated by the significantly longer 'nurturing' commitments that seed investments require. While maintaining a constant proportion of deals invested at the seed stage may make sense from a fund diversification point of view, VC fund managers face additional burdens of post-deal monitoring and the need to provide follow-on rounds of investments when deciding to expand their portfolio numbers. Thus, while diversification may reduce portfolio risk, it simultaneously increases the costs of governance. This implies that, given the primary constraint of VC management's time in making allocation decisions, the fund cannot keep increasing its number of seed investments without limit. Also, within the limit of the financial resources of the fund, seed investors are obliged to participate in the subsequent (and larger) funding rounds of their successful companies. This follow-on financial commitment is necessary in order to protect

their fund's initial equity stake from being severely diluted and future returns being prejudiced (Admati and Pfeiderer, 1994). Therefore, in contemplating whether or not to embark on seed investments, VC fund managers need to make complex and uncertain decisions regarding future commitments of both financial and managerial resources. These decisions have consequences that will necessarily extend across multiple rounds of financing for their most attractive portfolio companies. These considerations thus impose an upper ceiling on the number of seed deals that a fund can sensibly execute.

In regard to the other aspect of fund size – the amount of capital available – we find a strong and consistent negative relationship with the likelihood, number, and proportion of seed investments. We interpret this finding in the light of holding the number of portfolio companies constant. The greater the availability of capital per portfolio firm, the less attractive the allocation of finance to more seed investments. This suggests that, while seed investing may be more affordable to large VC funds, it will not occur unless a fund has the management infrastructure to accommodate the simultaneous management of many portfolio companies. We acknowledge that the strength of these claims is somewhat weakened by the lack of detail in the data on the degree to which investments are staged over time or, conversely, made as one single capital transfer[17]. Nevertheless, these results suggest the existence of an important relationship with major policy implications. VC funds making seed investments require some minimum portfolio size. Yet, with an increasing number of portfolio companies in the fund, the 'interest' in seed investments is correspondingly reduced. This finding is consistent with the idea that VC funds with a seed focus have a minimum scale of efficiency given their fixed cost structures (Murray, 1999).

Limitations

There are inevitably limitations to our study. The first pertains to the nature of the data contained in the *VentureXpert* database. While the database is one of the most comprehensive

sources of data on venture capital investment activity, it does have some potential drawbacks. First, it is predominantly US-focused. While the coverage of non-US venture capital activity has significantly increased in the 1990s, one should make inferences based on earlier periods with care (only 15% of the non-US funds in the sample were raised prior to 1990, compared to 47% for US funds). Second, it is generally accepted that the coverage of activity prior to 1980 is not as comprehensive as in subsequent periods. Given that our study extends across a forty year time horizon, one should treat the inferences with care. Nevertheless, because we have only focused on more active funds, i.e. those making at least 10 investments, there is a better chance that the coverage of such funds in the database is more extensive. In addition, given our large sample and a fund vintage year representation that follows the general development of the VC industry, we feel confident that our inferences do not suffer from material bias.

Second, although we refer to the initial decision to make seed investments as a strategic one, being driven by a separate process to the subsequent decision determining the number of seed investments in a fund's portfolio, we have lacked the variables to comprehensively estimate it. Our analysis has been limited to fund characteristics. These are at best merely proxies for complex internal processes and as a result do not go deep enough into the making of strategic decisions. As a consequence, only a few of the variables employed show significant effects in distinguishing between funds that make seed investments and those that do not. Thus, an important avenue for future research is to bring the seed-investment decision closer to its more immediate antecedents, namely top management teams' characteristics and processes.

Third, we did not control for the degree of syndication that may occur with the seed investments. Syndication, the joint participation of VC firms in the investment in a particular portfolio company is a common occurrence in the VC industry and serves an important

uncertainty-reducing and risk management functions (Bygrave, 1987; Lerner, 1994; Lockett and Wright, 2001). For a focal VC firm that may not have sufficient knowledge to improve the odds of success in seed investing, its ability to attract more informed and experienced co-investors may be a critical success factor. Accounting for syndication effects may make a significant contribution to the literature. However, there is a counter argument that suggests syndication at the earliest stage of a seed investment is inefficient from a managerial control perspective. Venture capitalists often have to act quickly and decisively to resolve the myriad crises to which nascent firms are especially vulnerable. In such circumstances the VC managing partners need a considerable degree of autonomy to make rapid and sometimes painful decisions. Such decisions are invariably delayed by the consensus forming processes common in syndication activity. Accordingly, the general partners of a VC firm may prefer to leave syndication until there is a need for follow-on finance for the more proven portfolio businesses.

Finally, governments' concern with the deleterious effect of a continuing and expanding equity gap on a country's ability to support innovative young firms has drawn the state increasingly into the early-stage capital markets (Murray, 1999). The willingness of several governments to intervene directly as a principal and 'special' limited partner in early stage funds with the specific intent of changing the nature of the economics of seed and early-stage financing is a factor of growing salience in many developed economies (Jääskeläinen et al, 2004). While acknowledging government's possible future role, we have ignored this complexity in our modeling.

Future Research Directions

In addition to the research possibilities arising from addressing the limitations of our current data and analysis, there are several other, explicit directions that we would like to outline. The adverse effects of 'excessive exuberance' up to the year 2000 is still working

itself through the investment system. We would suggest that there is a continuing need to obtain reliable longitudinal data at investment, fund, and country levels for this important but ill defined and operationally challenging investment activity. We have some understanding of how investors accommodate risk but we remain much less informed on how they manage decisions given the very high levels of uncertainty involved with new science, emerging technologies and their innovative consequences. Expanding and further validating our investment decision models to include and accommodate the more tacit effects of knowledge, experience – both educational and professional – and social interactions will likely help us continue from where the power of normative decision models ends. In addition, given governments' increasing influence and involvement in private seed activities, their actions and consequences represent a fruitful additional stream of work again with both theoretical and policy implications. Finally, seed capital remains a strategic innovation activity that appears to be successfully undertaken only in a few US locations. Thus, it remains a Gordian Knot worthy of serious interest.

Our findings also raise some important issues that could potentially inform policy decisions in the areas of financing innovation and growing government support for nascent entrepreneurial firms (Gilbert, Audretsch and McDougall, 2004). Government policy has generally addressed equity gap issues by creating and supporting *new* funds with a *specialist focus* on equity investment at the earliest investment stages. That governments feel obliged to intervene at all is based on a key assumption that existing, private incumbents in the risk capital industry are not interested in undertaking investments in (unattractive) categories such as seed and start-up investments. Our present research suggests that the "unattractive" nature of such investments may be systematically related to particular fund characteristics; investment expertise, vintage year, location, and size account for variation in seed investing above and beyond the effects of the fund's explicit investment focus, ownership structure, or

general economic environment. Further understanding and reinforcement of these relationships may well suggest policy solutions that ascribe bigger roles to larger and more experienced funds.

Concluding Comments

The studying of investment behavior has long been a secure domain for financial economists. Accordingly there has been a tremendous increase in the number and sophistication of highly quantitative models that seek to predict future asset prices largely on historic data. However, at the intersection of finance and entrepreneurship, as in the context of early-stage venture capital investments, one needs to balance competing pressures for order and disorder. Institutional investors appreciate the positivistic 'comfort' of econometric models. Yet, such investors would be wise to reflect that entrepreneurial activity, with its constant push towards innovation and rule breaking, cannot easily be circumscribed by such models. The huge potential value of such enterprises is precisely their intractability to either modeling or prediction.

We have sought to caste light on this most difficult stage of VC investment by introducing theories of decision making based on a more behavioral perspective. We see their use as complementary to more quantitative modeling particularly in areas where there is little appropriate historic data with which to model contemporary or future patterns. Our analysis of seed capital activity has led us to findings and possible policy prescriptions that currently run counter to received wisdom and widespread governmental practice. We hope that we have made a modest step in introducing perspectives that can further enlighten the study of seed capital and other early-stage investment behavior.

Notes

[1] The term venture capital is used throughout this paper in its US interpretation. It refers to the financing of new and young, high potential enterprises. It does not refer to management buy-outs or any other financial restructuring of established and mature businesses.

[2] On the 3rd February 2005, Apax Partners, a leading international venture capital management company and one of the first VC firms in the UK to invest in early-stage businesses, announced that it no longer would consider new investments of less than £10 million. Apax is unusual in publicly acknowledging this policy. (see TimesOnline http://www.timesonline.co.uk/newspaper/0,,173-1468073,00.html)

[3] In practice, the constrained supply of seed capital is a global phenomenon with a small number of US technology clusters being very much the exception.

[4] While seed capital does not necessarily have to deal with technological products or services, a majority of venture capitalists' interests are focused exclusively on technology derived innovations which have the potential for disruptive change and, potentially, very large commercial rewards.

[5] This homogeneity is likely to be encouraged by the increasingly informed, investment performance demands of institutional investors.

[6] Long term investors in a successful VC managing partnership will generally be tolerant of the occasional poorly performing fund.

[7] An important role of 'carried interest' is to lock-in experienced and highly valuable partners and managers to the VC management company over the life of a fund.

[8] Here we operate under the assumption that most VC funds are of predetermined fixed life of usually ten years. Accordingly, they are obliged to complete most of their investment selection activity within a short time period (<5years) of their establishment. While we acknowledge that "evergreen" funds without a fixed fund life do exist, albeit less commonly, we point out that for such funds the effect vintage year would be subsumed under VC firm age.

[9] Such an attitude will also be materially influenced by US venture funds consistent ability to achieve higher returns from early-stage technology investments.

[10] We used the VentureXpert classification of funds as 'venture capital' or 'buyout' and included in our sampling frame only those classified as 'venture capital.'

[11] VC firms are loosely characterized as independent or captive depending on whether or not the VC management company is autonomous or owned by a corporate parent, respectively.

[12] The data on the countries' patent applications was collected from the World Intellectual Property Organization. Where data on individual years was missing, we inferred the values while keeping the trends implied by the preceding and subsequent values. Although patent applications do not necessarily result in granted patents, there was a high correlation (.89, $p < .001$) between patent applications and granted patents. We therefore used the number of applications in order to represent a more comprehensive set of innovation activity as well as to eliminate the effects associated with the processing time and complexity of patent approval.

[13] Branscomb and Auerswald (2002) in an analysis of US funding for early-stage technology similarly compensate for the possible confounding effect of 'dot.com' investments in their selection of time series data.

[14] The effect of including the endogenous self-selection correction was the same as if running a zero-inflated negative binomial regression in which the generation of zeros is estimated separately by a logit or probit model. The Vuong statistic was 0.00 if the self-selection correction was included in the zero-inflated negative binomial regression.

[15] Given that the proportion of seed investments has the number of seed investments in its numerator and the total number of portfolio companies in its denominator, a negative relationship between this ratio and the number of portfolio companies is equivalent to a negative relationship between the number of seed investments and the number of portfolio companies.

[16] Some industry observer might suggest Israel as a second example. However, it is difficult to see Israel as a genuinely independent VC industry separate from the US if the sources of institutional money and the exit behavior of successful portfolio companies are examined.

[17] In practice, seed capitalists normally require a series of 'milestones' to be passed as a condition of further investment. It is unlikely that many very early and speculative investments would have received all their finance as a single *ex ante* payment.

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TABLE I
Description of the Sample Funds by Country of Origin
(Standard deviations are shown in parentheses)

	Number of funds	Average number of seed investments	Average number of investments	Average Fund size ($mln)		Number of funds	Average number of seed investments	Average number of investments	Aver Fund ($n
Australia	31	1.6	13.4	31.7	Italy	1	1.0	14.0	1
		(2.9)	(3.6)	(21.3)					
Austria	2	0.5	11.0	8.3	Japan	21	0.6	19.1	8
		(0.7)	(1.4)	(10.0)			(1.2)	(12.4)	(11
Belgium	9	1.1	27.6	87.8	Luxembourg	2	0.5	24.5	1
		(1.2)	(23.2)	(125.9)			(0.7)	(9.2)	(
Canada	36	0.8	24.9	82.8	Netherlands	18	0.6	20.8	8
		(1.1)	(21.8)	(112.1)			(0.9)	(12.0)	(15
China	2	1.0	10.0	11.1	Poland	2	0.5	13.5	3
		(0.0)	(0.0)	(14.4)			(0.7)	(0.7)	(4
Czech Republic	3	0.7	15.0	32.5	Russia	2	0.5	33.5	2
		(1.2)	(3.0)	(21.5)			(0.7)	(19.1)	(2
Denmark	6	1.8	15.3	29.6	Singapore	14	0.4	16.3	9
		(1.5)	(6.7)	(12.4)			(0.6)	(7.2)	(14
Finland	11	3.5	21.6	19.0	South Korea	63	0.2	19.6	1
		(9.5)	(23.3)	(12.7)			(0.6)	(11.7)	(1
France	51	0.7	19.6	62.9	Spain	3	1.7	19.7	3
		(1.3)	(11.2)	(113.7)			(2.1)	(10.8)	(4
Germany	57	1.4	22.7	74.5	Sweden	16	0.7	15.8	2
		(2.8)	(19.2)	(181.1)			(1.0)	(6.1)	(2
Hong Kong	15	0.2	18.3	146.8	Switzerland	16	0.6	21.8	10
		(0.4)	(14.7)	(192.1)			(1.0)	(9.9)	(12
Iceland	1	0.0	12.0	10.7	Taiwan	19	0.3	20.0	3
							(0.9)	(9.7)	(4
India	23	2.0	21.2	27.6	Thailand	1	1.0	12.0	
		(4.7)	(17.4)	(21.8)					
Ireland	5	0.6	19.4	42.8	United Kingdom	118	0.6	20.1	5
		(0.9)	(6.5)	(16.7)			(1.4)	(13.9)	(9
Israel	18	1.3	15.8	51.4	United States	2383	2.0	29.4	9
		(1.1)	(7.0)	(26.3)			(3.4)	(27.8)	(17

TABLE II
Description of the Sample Funds by Investment Focus
(Standard deviations are shown in parentheses)

	Number of funds	Average number of seed investments	Average number of investments	Average Fund size ($mln)
Early-stage Focus				
Seed stage	121	3.9	19.8	33.0
		(5.1)	(10.8)	(43.3)
Early stage	947	2.4	24.8	72.7
		(3.6)	(21.7)	(96.5)
Other	4	3.0	48.3	163.4
		(4.0)	(37.3)	(193.2)
Balanced focus				
Balanced stage	1259	1.7	32.1	92.3
		(2.9)	(31.6)	(192.1)
Other	31	1.2	15.7	41.2
		(1.5)	(8.2)	(40.1)
Late-stage focus				
Development	22	0.4	17.1	57.8
		(1.0)	(9.2)	(113.0)
Expansion	241	0.8	20.6	80.4
		(2.5)	(15.4)	(126.1)
Later stage	315	0.7	27.5	116.3
		(1.4)	(21.9)	(227.3)
Other	9	0.1	15.4	44.4
		(0.3)	(8.8)	(53.4)

TABLE III
Description of the Sample Funds by Vintage Year
(Standard deviations are shown in parentheses)

Fund year	Number of funds	Average number of seed investments	Average number of investments	Average Fund size ($mln)
prior to 1965	35	3.3	75.9	197.7
		(4.6)	(62.0)	(317.2)
1966 to 1970	79	3.1	56.1	119.0
		(7.1)	(65.7)	(240.2)
1971 to 1975	81	2.4	44.1	92.3
		(5.0)	(38.3)	(211.9)
1976 to 1980	159	1.9	35.2	57.4
		(3.2)	(24.0)	(120.8)
1981 to 1985	560	2.3	31.2	55.9
		(3.3)	(24.4)	(117.6)
1986 to 1990	326	2.6	27.2	64.5
		(3.5)	(24.0)	(165.6)
1991 to 1995	340	2.2	27.2	91.3
		(3.4)	(24.0)	(154.4)
1996 to 2000	1295	1.2	21.7	97.3
		(2.2)	(17.6)	(166.5)
2001 to 2002	74	0.8	16.7	85.6
		(1.3)	(7.5)	(120.5)

TABLE IV
Descriptive Statistics and Correlations
(p-values for the bivariate correlations shown in parentheses)
N=2949, except for Country patent applications (N=2,930) and Amount of capital (N=2,944)

	Mean	S.D.	1	2	3	4	5	6	7	8	9	10	
1 Number of seed investments	1.81	3.20	1.00										
2 No. seed investments prior to 1995	1.04	2.54	0.82	1.00									
			(0.00)										
3 Proportion of seed investments	0.06	0.10	0.68	0.53	1.00								
			(0.00)	(0.00)									
4 Prop.seed investments prior to 1995	0.03	0.07	0.56	0.74	0.74	1.00							
			(0.00)	(0.00)	(0.00)								
5 Seed focus	0.04	0.20	0.13	0.14	0.27	0.27	1.00						
			(0.00)	(0.00)	(0.00)	(0.00)							
6 Early-stage focus	0.32	0.47	0.13	0.06	0.19	0.08	-0.14	1.00					
			(0.00)	(0.00)	(0.00)	(0.00)	(0.00)						
7 Private fund	0.67	0.47	0.11	0.07	0.18	0.12	0.07	0.19	1.00				
			(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)					
8 Corporate fund	0.10	0.30	-0.10	-0.09	-0.10	-0.08	-0.02	-0.08	-0.48	1.00			
			(0.00)	(0.00)	(0.00)	(0.00)	(0.19)	(0.00)	(0.00)				
9 Financial fund	0.10	0.31	-0.09	-0.07	-0.11	-0.07	-0.04	-0.11	-0.49	-0.11	1.00		
			(0.00)	(0.00)	(0.00)	(0.00)	(0.04)	(0.00)	(0.00)	(0.00)			
10 Located in California	0.26	0.44	0.16	0.14	0.15	0.13	-0.03	0.10	0.16	-0.04	-0.10	1.00	
			(0.00)	(0.00)	(0.00)	(0.00)	(0.11)	(0.00)	(0.00)	(0.02)	(0.00)		
11 Located in Massachussetts	0.11	0.31	0.00	-0.02	-0.02	-0.01	-0.03	0.00	0.11	-0.06	-0.03	-0.21	
			(0.86)	(0.29)	(0.29)	(0.71)	(0.06)	(0.84)	(0.00)	(0.00)	(0.06)	(0.00)	
12 S&P 500	0.15	0.15	0.06	-0.02	0.07	-0.04	-0.01	-0.03	0.04	-0.02	-0.03	0.05	-0
			(0.00)	(0.33)	(0.00)	(0.03)	(0.55)	(0.10)	(0.03)	(0.28)	(0.13)	(0.01)	(
13 S&P 500, 5-year	0.53	0.53	0.07	-0.02	0.10	-0.01	-0.03	-0.04	0.09	-0.06	-0.04	0.02	0
			(0.00)	(0.25)	(0.00)	(0.42)	(0.14)	(0.02)	(0.00)	(0.00)	(0.02)	(0.21)	(
14 NASDAQ	0.17	0.35	0.00	-0.07	0.00	-0.11	-0.01	0.02	0.01	0.05	-0.04	0.04	-0
			(0.91)	(0.00)	(0.93)	(0.00)	(0.54)	(0.38)	(0.73)	(0.01)	(0.02)	(0.02)	(
15 NASDAQ, 5-year	0.99	1.14	0.02	-0.10	0.05	-0.11	-0.03	0.00	0.06	-0.04	-0.05	-0.01	0
			(0.35)	(0.00)	(0.00)	(0.00)	(0.11)	(0.97)	(0.00)	(0.04)	(0.01)	(0.67)	(
16 FTSE	0.12	0.18	0.06	0.06	0.03	0.03	-0.01	-0.08	-0.01	-0.01	0.00	0.03	-0
			(0.00)	(0.00)	(0.08)	(0.09)	(0.43)	(0.00)	(0.77)	(0.47)	(0.86)	(0.12)	(
17 FTSE, 5-year	0.65	0.56	0.12	0.16	0.09	0.16	-0.02	-0.15	0.01	-0.03	0.01	0.00	0
			(0.00)	(0.00)	(0.00)	(0.00)	(0.27)	(0.00)	(0.46)	(0.08)	(0.46)	(0.80)	(
18 Nikkei	0.05	0.24	0.09	0.13	0.04	0.12	0.02	-0.10	-0.04	0.01	0.03	0.03	-0
			(0.00)	(0.00)	(0.04)	(0.00)	(0.23)	(0.00)	(0.02)	(0.49)	(0.08)	(0.07)	(
19 Nikkei, 5-year	0.26	0.80	0.15	0.26	0.07	0.27	0.02	-0.20	-0.05	-0.03	0.08	-0.02	0
			(0.00)	(0.00)	(0.00)	(0.00)	(0.35)	(0.00)	(0.00)	(0.08)	(0.00)	(0.40)	(
20 GDP growth	0.04	0.02	-0.04	-0.06	-0.01	-0.05	0.04	0.04	-0.02	0.05	0.04	-0.02	-0
			(0.04)	(0.00)	(0.52)	(0.01)	(0.03)	(0.05)	(0.24)	(0.00)	(0.06)	(0.32)	(
21 Country patent applications ('000)	148.89	81.87	-0.03	-0.11	0.03	-0.08	-0.09	0.11	0.19	0.05	-0.14	0.23	0
			(0.08)	(0.00)	(0.13)	(0.00)	(0.00)	(0.00)	(0.00)	(0.01)	(0.00)	(0.00)	(
22 VC firm age	5.96	8.58	0.04	0.03	-0.02	-0.02	-0.08	0.04	0.14	-0.14	-0.06	0.07	0
			(0.02)	(0.11)	(0.42)	(0.39)	(0.00)	(0.03)	(0.00)	(0.00)	(0.00)	(0.00)	(
23 Fund year	1990.89	9.13	-0.17	-0.27	0.00	-0.19	0.04	0.24	0.11	0.04	-0.14	0.01	-0
			(0.00)	(0.00)	(0.99)	(0.00)	(0.03)	(0.00)	(0.00)	(0.03)	(0.00)	(0.59)	(
24 Located in US	0.81	0.39	0.15	0.14	0.11	0.14	-0.09	-0.03	0.17	-0.04	-0.06	0.29	0
			(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.13)	(0.00)	(0.03)	(0.00)	(0.00)	(
25 Located in Europe	0.11	0.31	-0.10	-0.10	-0.08	-0.10	0.05	0.07	-0.09	-0.01	0.00	-0.21	-0
			(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.75)	(0.89)	(0.00)	(
26 Number of companies	27.54	26.02	0.53	0.43	0.01	0.05	-0.06	-0.07	-0.06	-0.03	0.02	0.06	0
			(0.00)	(0.00)	(0.49)	(0.00)	(0.00)	(0.00)	(0.00)	(0.08)	(0.39)	(0.00)	(
27 Amount of capital ($mln)	84.31	161.59	0.20	0.06	-0.06	-0.08	-0.07	-0.05	-0.05	0.03	-0.02	0.03	0
			(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.01)	(0.00)	(0.08)	(0.34)	(0.16)	(

TABLE IV (cont.)

	13	14	15	16	17	18	19	20	21	22	23	24	25
13 S&P 500, 5-year	1.00												
14 NASDAQ	0.27	1.00											
	(0.00)												
15 NASDAQ, 5-year	0.77	0.19	1.00										
	(0.00)	(0.00)											
16 FTSE	0.31	0.52	0.20	1.00									
	(0.00)	(0.00)	(0.00)										
17 FTSE, 5-year	0.61	0.14	0.46	0.35	1.00								
	(0.00)	(0.00)	(0.00)	(0.00)									
18 Nikkei	0.01	0.57	-0.24	0.41	0.21	1.00							
	(0.73)	(0.00)	(0.00)	(0.00)	(0.00)								
19 Nikkei, 5-year	0.14	-0.18	-0.09	0.11	0.60	0.37	1.00						
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)							
20 GDP growth	0.06	-0.02	0.02	-0.06	-0.06	0.12	-0.03	1.00					
	(0.00)	(0.34)	(0.32)	(0.00)	(0.00)	(0.00)	(0.10)						
21 Country patent applications ('000)	-0.08	0.05	-0.01	-0.12	-0.30	-0.15	-0.36	0.01	1.00				
	(0.00)	(0.00)	(0.62)	(0.00)	(0.00)	(0.00)	(0.00)	(0.74)					
22 VC firm age	0.02	-0.03	0.04	-0.08	-0.09	-0.13	-0.15	-0.02	0.24	1.00			
	(0.35)	(0.08)	(0.04)	(0.00)	(0.00)	(0.00)	(0.00)	(0.31)	(0.00)				
23 Fund year	-0.01	0.11	0.12	-0.18	-0.45	-0.39	-0.71	0.15	0.43	0.21	1.00		
	(0.47)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)			
24 Located in US	0.09	0.02	-0.01	0.09	0.19	0.16	0.22	-0.07	0.61	0.14	-0.26	1.00	
	(0.00)	(0.20)	(0.78)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)		
25 Located in Europe	-0.06	-0.02	0.01	-0.07	-0.12	-0.12	-0.15	-0.15	-0.53	-0.07	0.18	-0.72	1.00
	(0.00)	(0.26)	(0.65)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	
26 Number of companies	0.01	-0.01	-0.03	0.04	0.10	0.13	0.19	-0.03	-0.08	0.07	-0.33	0.14	-0.10
	(0.56)	(0.67)	(0.16)	(0.04)	(0.00)	(0.00)	(0.00)	(0.13)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00
27 Amount of capital ($mln)	0.00	0.04	0.01	-0.02	-0.07	0.03	-0.07	0.03	0.11	0.14	0.03	0.08	-0.05
	(0.89)	(0.03)	(0.66)	(0.28)	(0.00)	(0.17)	(0.00)	(0.17)	(0.00)	(0.00)	(0.13)	(0.00)	(0.01

TABLE V
Tobit Estimation for the Proportion of Seed Investments

	Model 1 Base	Model 2 Full	Model 3 Until 1995	Model 4 US	Model 5 Europe	Model 6 Early focus	Model 7 Balanced
Seed focus	0.189 ***	0.190 ***	0.220 ***	0.204 ***	0.133 ***		
	(0.013)	(0.013)	(0.017)	(0.015)	(0.041)		
Early-stage focus	0.078 ***	0.078 ***	0.070 ***	0.081 ***	0.066 **		
	(0.006)	(0.006)	(0.008)	(0.006)	(0.024)		
Private fund	0.009	0.013	0.015	0.014	0.042	0.056 **	0.00
	(0.009)	(0.009)	(0.011)	(0.009)	(0.027)	(0.020)	(0.010
Corporate fund	-0.037 **	-0.028 *	-0.009	-0.033 **	-0.008	-0.003	-0.03
	(0.012)	(0.012)	(0.016)	(0.013)	(0.041)	(0.028)	(0.013
Financial fund	-0.044 ***	-0.041 ***	-0.029 *	-0.033 **	0.004	-0.006	-0.04
	(0.012)	(0.012)	(0.014)	(0.012)	(0.041)	(0.029)	(0.013
Located in California	0.038 ***	0.028 ***	0.047 ***	0.026 ***		0.015	0.02
	(0.006)	(0.006)	(0.008)	(0.006)		(0.012)	(0.008
Located in Massachusetts	0.000	-0.009	-0.009	-0.008		-0.016	-0.01
	(0.009)	(0.009)	(0.011)	(0.008)		(0.017)	(0.010
S&P 500	0.101 *	0.092 *	0.033	0.068 +	0.124	0.128	0.08
	(0.041)	(0.041)	(0.082)	(0.040)	(0.212)	(0.084)	(0.046
S&P 500, 5-year	0.017	0.015	-0.026	0.010	-0.057	0.005	0.02
	(0.011)	(0.011)	(0.025)	(0.011)	(0.052)	(0.021)	(0.013
NASDAQ	-0.069 ***	-0.066 ***	-0.053	-0.044 *	-0.069	-0.100 **	-0.05
	(0.018)	(0.018)	(0.056)	(0.018)	(0.090)	(0.037)	(0.022
NASDAQ, 5-year	0.001	0.002	-0.016	0.005	0.016	0.002	0.00
	(0.004)	(0.004)	(0.011)	(0.004)	(0.018)	(0.008)	(0.005
FTSE	-0.026	-0.033	0.003	-0.032	-0.282	0.041	-0.05
	(0.022)	(0.022)	(0.022)	(0.021)	(0.188)	(0.053)	(0.025
FTSE, 5-year	0.023 **	0.014	0.024 **	-0.005	0.088	0.010	0.00
	(0.009)	(0.009)	(0.009)	(0.010)	(0.060)	(0.021)	(0.009
Nikkei	0.081 ***	0.074 ***	0.036 +	0.048 *	0.152	0.114 *	0.04
	(0.020)	(0.021)	(0.021)	(0.021)	(0.131)	(0.047)	(0.024
Nikkei, 5-year	0.010 +	0.004	0.014 *	0.003	0.022	0.006	0.00
	(0.006)	(0.006)	(0.007)	(0.006)	(0.038)	(0.014)	(0.007
GDP growth	-0.407 **	-0.503 ***	-0.090	-0.123	-1.094	-1.052 ***	-0.20
	0.143	(0.153)	(0.191)	(0.172)	(0.729)	(0.320)	(0.171
Patent applications	0.0001 ***	-0.0002 **	-0.0001	-0.001 ***	-0.001	-0.001 ***	-0.000
	0.000	(0.000)	(0.000)	(0.000)	(0.001)	(0.000)	(0.000

TABLE V (cont.)

	Model 1 Base		Model 2 Full		Model 3 Until 1995		Model 4 US		Model 5 Europe		Model 6 Early focus		Model 7 Balanced	
VC firm age			-0.0004		0.001	**	-0.0003		-0.003	+	-0.001		-0.00	
			(0.000)		(0.000)		(0.000)		(0.002)		(0.001)		(0.000	
Fund year			0.002	***	0.001		0.004	***	0.005		0.009	***	0.00	
			(0.001)		(0.001)		(0.001)		(0.003)		(0.002)		(0.001	
Located in US			0.0724	***	0.0659	**					0.229	***	0.07	
			(0.017)		(0.025)						(0.052)		(0.019	
Located in Europe			-0.030	*	-0.003						-0.066	**	-0.01	
			(0.014)		(0.027)						(0.026)		(0.021	
Number of companies			0.001	***	0.001	***	0.001	***	0.003	**	0.001	***	0.00	
			(0.000)		(0.000)		(0.000)		(0.001)		(0.000)		(0.000	
Amount of capital			-0.0001	**	-0.0001	***	-0.0001	**	-0.0001		-0.0002	**	-0.0000	
			(0.000)		(0.000)		(0.000)		(0.000)		(0.000)		(0.000	
Constant	-0.059	***	-4.427	***	-2.624		-8.418	***	-10.746		-18.408	***	-4.87	
	(0.011)		(1.239)		(1.693)		(2.069)		(6.862)		(3.574)		(1.341	
Model _se	0.130		0.129		0.117		0.120		0.152		0.152		0.10	
Generalized R2	0.180		0.203		0.252		0.213		0.136		0.165		0.12	
Log-likelihood	160.329		205.494		160.294		368.019		-40.405		80.802		257.02	
Chi-square	580.190	***	664.260	***	456.060	***	571.070	***	46.770	***	192.250	***	174.15	
N	2930		2926		1574		2383		320		1069		127	

*** $p < 0.001$, ** $p < 0.01$, * $p < 0.05$, + $p < 0.10$

TABLE VI
Probit Estimation for Whether Funds Made Seed Investments
Standard errors adjusted for clustering on VC firm.

	Model 1 Full	Model 2 Until 1995	Model 3 US	Model 4 Europe	Model 5 Early focus	Model 6 Balanced focus	Mo La
Seed focus	0.943 ***	1.104 ***	1.160 ***	0.624 +			
	(0.135)	(0.215)	(0.188)	(0.320)			
Early-stage focus	0.622 ***	0.518 ***	0.679 ***	0.492 *			
	(0.062)	(0.087)	(0.070)	(0.197)			
Private fund	0.114	0.136	0.086	0.379 +	0.544 **	-0.012	
	(0.087)	(0.116)	(0.101)	(0.218)	(0.181)	(0.116)	
Corporate fund	-0.171	-0.100	-0.285 *	0.158	0.366	-0.393 *	
	(0.117)	(0.163)	(0.132)	(0.281)	(0.240)	(0.164)	
Financial fund	-0.375 ***	-0.316 *	-0.383 **	-0.019	0.104	-0.546 ***	
	(0.109)	(0.137)	(0.126)	(0.293)	(0.244)	(0.150)	
Located in California	0.186 **	0.284 ***	0.178 *		0.130	0.221 *	
	(0.071)	(0.088)	(0.072)		(0.115)	(0.106)	
Located in Massachusetts	-0.095	-0.153	-0.100		0.004	-0.259 +	
	(0.101)	(0.123)	(0.102)		(0.175)	(0.138)	
S&P 500	0.726 +	0.791	0.643	0.567	0.180	0.765	
	(0.402)	(0.926)	(0.441)	(1.510)	(0.852)	(0.564)	
S&P 500, 5-year	0.114	-0.225	0.109	-0.203	0.264	0.264 +	
	(0.106)	(0.276)	(0.124)	(0.372)	(0.211)	(0.158)	
NASDAQ	-0.480 **	-0.691	-0.350 +	-0.552	-0.732 *	-0.401	
	(0.179)	(0.619)	(0.200)	(0.634)	(0.362)	(0.260)	
NASDAQ, 5-year	-0.014	-0.146	0.000	0.034	-0.103	0.022	
	(0.042)	(0.127)	(0.049)	(0.143)	(0.081)	(0.065)	
FTSE	-0.455 *	-0.315	-0.440 *	-1.983	1.039 +	-0.841 **	
	(0.201)	(0.217)	(0.215)	(1.385)	(0.553)	(0.292)	
FTSE, 5-year	0.215 *	0.335 ***	0.106	0.568	0.151	0.122	
	(0.090)	(0.103)	(0.109)	(0.414)	(0.232)	(0.119)	
Nikkei	0.565 *	0.343	0.394	1.009	0.762 +	0.325	
	(0.222)	(0.221)	(0.242)	(0.965)	(0.453)	(0.310)	
Nikkei, 5-year	0.018	0.084	0.021	0.237	-0.047	0.047	
	(0.064)	(0.068)	(0.068)	(0.267)	(0.150)	(0.087)	
GDP growth	-4.593 **	-2.522	-1.443	-9.859 +	-9.672 **	-3.136	
	(1.553)	(2.071)	(1.850)	(5.863)	(3.170)	(2.143)	
Patent applications	-0.002 +	-0.0003	-0.004 *	-0.007	-0.010 ***	-0.002 +	
	(0.001)	(0.002)	(0.002)	(0.005)	(0.002)	(0.001)	

TABLE VI (cont.)

	Model 1 Full		Model 2 Until 1995		Model 3 US		Model 4 Europe		Model 5 Early focus		Model 6 Balanced focus		Mo La
VC firm age	-0.002		0.020	***	-0.001		-0.020	+	-0.006		-0.006		
	(0.004)		(0.005)		(0.004)		(0.012)		(0.006)		(0.006)		
Fund year	0.014	*	0.000		0.026	*	0.039		0.082	***	0.025	**	
	(0.007)		(0.010)		(0.012)		(0.024)		(0.017)		(0.010)		
Located in US	0.597	**	0.419						2.203	***	0.724	***	
	(0.197)		(0.315)						(0.406)		(0.243)		
Located in Europe	-0.145		-0.086						-0.309		-0.112		
	(0.147)		(0.261)						(0.237)		(0.254)		
Number of companies	0.027	***	0.024	***	0.027	***	0.037	***	0.045	***	0.030	***	
	(0.003)		(0.004)		(0.003)		(0.008)		(0.007)		(0.004)		
Amount of capital	-0.001	***	-0.002	*	-0.001	***	-0.001		-0.002	**	-0.001	***	
	(0.000)		(0.001)		(0.000)		(0.001)		(0.001)		(0.000)		
Constant	-29.616	*	-1.554		-51.141	*	-78.311		-163.504	***	-49.656	**	
	(14.061)		(19.198)		(23.377)		(48.152)		(34.219)		(18.901)		
(Pseudo) R2	0.170		0.185		0.163		0.138		0.199		0.179		
Log likelihood	-1663.235		-886.581		-1335.568		-184.512		-537.009		-716.028		
Chi-square	431.830	***	268.870	***	342.920	***	54.560	***	178.660	***	196.890	***	
N	2926		1574		2383		320		1069		1275		

*** $p < 0.001$, ** $p < 0.01$, * $p < 0.05$, + $p < 0.10$

TABLE VII
OLS Estimation for the Proportion of Seed Investments for Funds that Have Made Such Investments
Standard errors adjusted for clustering on VC firm

	Model 1 Full	Model 2 Until 1995	Model 3 US only	Model 4 Europe	Model 5 Early focus	Model 6 Balanced focus	Model Late fo
Seed focus	0.151 ***	0.176 ***	0.153 ***	0.087			
	(0.025)	(0.035)	(0.030)	(0.057)			
Early-stage focus	0.041 ***	0.044 ***	0.043 ***	0.019			
	(0.005)	(0.007)	(0.006)	(0.021)			
Private fund	0.001	-0.005	0.008	-0.002	-0.009	0.002	0.0
	(0.009)	(0.008)	(0.008)	(0.020)	(0.027)	(0.009)	(0.0
Corporate fund	-0.024 *	-0.005	-0.017 +	-0.036	-0.067 *	-0.005	-0.0
	(0.010)	(0.011)	(0.010)	(0.031)	(0.027)	(0.011)	(0.0
Financial fund	-0.014	-0.015	-0.006	0.022	-0.032	-0.015	0.0
	(0.011)	(0.012)	(0.011)	(0.043)	(0.032)	(0.013)	(0.0
Located in California	0.019 **	0.032 ***	0.018 *		0.009	0.014 *	0.0
	(0.007)	(0.009)	(0.007)		(0.013)	(0.007)	(0.0
Located in Massachusetts	-0.003	-0.009	-0.004		-0.019	0.001	0.0
	(0.007)	(0.008)	(0.007)		(0.014)	(0.007)	(0.0
S&P 500	0.055 +	-0.013	0.035	0.092	0.124 +	0.041	0.0
	(0.032)	(0.069)	(0.034)	(0.178)	(0.073)	(0.034)	(0.0
S&P 500, 5-year	0.000	-0.039 +	-0.001	-0.054	-0.013	0.001	-0.0
	(0.008)	(0.022)	(0.009)	(0.039)	(0.014)	(0.013)	(0.0
NASDAQ	-0.044 **	-0.026	-0.032 *	0.003	-0.067 +	-0.039 *	-0.0
	(0.015)	(0.048)	(0.016)	(0.076)	(0.035)	(0.019)	(0.0
NASDAQ, 5-year	0.005	-0.001	0.006	0.016	0.009	-0.001	0.0
	(0.004)	(0.010)	(0.004)	(0.016)	(0.007)	(0.004)	(0.0
FTSE	0.005	0.045 *	0.007	-0.131	-0.020	0.024	-0.0
	(0.014)	(0.021)	(0.014)	(0.122)	(0.028)	(0.021)	(0.0
FTSE, 5-year	-0.003	-0.001	-0.012 +	0.045	0.002	-0.011	-0.0
	(0.006)	(0.008)	(0.007)	(0.031)	(0.019)	(0.008)	(0.0
Nikkei	0.034 *	0.014	0.031 *	0.042	0.071 +	0.015	0.0
	(0.015)	(0.015)	(0.015)	(0.085)	(0.039)	(0.016)	(0.0
Nikkei, 5-year	0.002	0.009	0.001	0.005	0.011	-0.001	0.0
	(0.005)	(0.006)	(0.005)	(0.020)	(0.015)	(0.004)	(0.0
GDP growth	-0.067	0.121	-0.064	0.126	-0.354	-0.014	-0.0
	(0.122)	(0.160)	(0.133)	(0.685)	(0.275)	(0.143)	(0.3
Patent applications	-0.0001	-0.0001	-0.0004 *	-0.001	-0.0003	-0.0002	-0.00
	(0.000)	(0.000)	(0.000)	(0.001)	(0.000)	(0.000)	(0.0

TABLE VII (cont.)

	Model 1 Full	Model 2 Until 1995	Model 3 US only	Model 4 Europe	Model 5 Early focus	Model 6 Balanced focus	Model Late fo
VC firm age	-0.001 *	-0.001 +	-0.001 *	-0.001	-0.001	-0.001 **	-0.0
	(0.000)	(0.000)	(0.000)	(0.001)	(0.001)	(0.000)	(0.0
Fund year	0.002 **	0.003 ***	0.003 ***	0.002	0.004 *	0.002 *	0.0
	(0.001)	(0.001)	(0.001)	(0.003)	(0.002)	(0.001)	(0.0
Located in US	-0.003	0.025			0.011	0.023	-0.0
	(0.020)	(0.022)			(0.066)	(0.016)	(0.0
Located in Europe	-0.043 +	-0.002			-0.080 *	-0.019	-0.0
	(0.023)	(0.018)			(0.039)	(0.034)	(0.0
Number of companies	-0.0003 **	-0.0003 **	-0.0002 *	-0.0002	-0.0001	-0.0003 *	-0.0
	(0.000)	(0.000)	(0.000)	(0.001)	(0.000)	(0.000)	(0.0
Amount of capital	-0.00003 **	-0.00003 *	-0.00003 **	-0.0002 *	-0.0002 **	-9.1E-06	-5.0E-
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.0
Constant	-3.080 **	-5.355 ***	-5.319 ***	-4.504	-7.016 *	-3.635 *	-4.4
	(1.059)	(1.390)	(1.430)	(5.867)	(3.314)	(1.649)	(2.1
R2	0.212	0.320	0.221	0.183	0.101	0.099	0.2
F-value	9.530 ***	8.330 ***	10.270 ***	1.880 *	3.760 ***	3.740 ***	2.3
N	1647	833	1451	125	727	725	1

*** $p < 0.001$, ** $p < 0.01$, * $p < 0.05$, + $p < 0.10$

TABLE VIII

Negative Binomial Estimation for the Number of Seed Investments

Endogenous self-selection correction used for funds' choosing to make or not to make seed investments.
Standard errors adjusted for clustering on VC firm

	Model 1 Base	Model 2 Main	Model 3 Full	Model 4 Until 1995	Model 5 US	Model 6 Europe	Model 7 Early focus	Model 8 Balanced focus	Model 9 Late focus
Seed focus	1.224 ***	1.917 ***	2.090 ***	2.407 ***	1.951 ***	2.710 ***			
	(0.147)	(0.116)	(0.112)	(0.133)	(0.125)	(0.412)			
Early-stage focus	0.811 ***	1.071 ***	1.150 ***	1.146 ***	1.121 ***	1.573 ***			
	(0.095)	(0.055)	(0.054)	(0.069)	(0.056)	(0.180)			
Private fund	-0.333	0.136	0.182 *	0.108	0.164	0.391 **	0.136	0.126	0.334 *
	(0.223)	(0.096)	(0.093)	(0.135)	(0.106)	(0.145)	(0.158)	(0.116)	(0.169)
Corporate fund	-0.981 ***	-0.485 ***	-0.461 ***	-0.425 *	-0.457 ***	-0.524 *	-0.667 ***	-0.359 *	-0.224
	(0.291)	(0.131)	(0.121)	(0.170)	(0.139)	(0.239)	(0.167)	(0.165)	(0.229)
Financial fund	-0.933 **	-0.711 ***	-0.709 ***	-0.839 ***	-0.726 ***	-0.535 *	-0.624 **	-0.795 ***	-0.608 *
	(0.331)	(0.151)	(0.152)	(0.176)	(0.176)	(0.223)	(0.244)	(0.179)	(0.241)
Located in California	0.623 ***	0.388 ***	0.389 ***	0.643 ***	0.376 ***		0.239 **	0.386 ***	0.763 ***
	(0.116)	(0.061)	(0.059)	(0.075)	(0.058)		(0.092)	(0.071)	(0.153)
Located in Massachusetts	0.247	-0.077	-0.080	-0.365 ***	-0.080		-0.241 *	-0.006	0.150
	(0.165)	(0.091)	(0.085)	(0.103)	(0.087)		(0.117)	(0.110)	(0.220)
S&P 500	1.298 *	1.387 ***	1.531 ***	0.426	1.323 ***	2.460	1.793 ***	1.164 **	2.052 +
	(0.595)	(0.331)	(0.308)	(0.806)	(0.320)	(1.533)	(0.488)	(0.436)	(1.091)
S&P 500, 5-year	-0.006	0.213 **	0.195 **	-0.630 **	0.131	-0.155	0.116	0.239 *	-0.017
	(0.137)	(0.079)	(0.074)	(0.219)	(0.081)	(0.380)	(0.114)	(0.113)	(0.292)
NASDAQ	-0.776 ***	-0.881 ***	-0.901 ***	-0.761	-0.810 ***	-1.342 *	-1.056 ***	-0.669 **	-1.781 ***
	(0.241)	(0.147)	(0.142)	(0.593)	(0.148)	(0.658)	(0.248)	(0.236)	(0.479)
NASDAQ, 5-year	0.055	-0.018	-0.010	-0.354 ***	-0.003	0.081	0.033	-0.094 *	0.046
	(0.053)	(0.036)	(0.034)	(0.100)	(0.036)	(0.103)	(0.051)	(0.046)	(0.095)
FTSE	-0.066	-0.281	-0.296	0.336	-0.296	-0.522	-0.521 *	-0.064	-0.667 *
	(0.416)	(0.209)	(0.207)	(0.320)	(0.206)	(0.958)	(0.263)	(0.353)	(0.316)
FTSE, 5-year	0.174	0.284 ***	0.264 ***	0.411 ***	0.127	0.855 **	0.287 *	0.251 **	0.330 +
	(0.121)	(0.081)	(0.077)	(0.096)	(0.080)	(0.311)	(0.144)	(0.095)	(0.186)
Nikkei	1.048 ***	0.903 ***	0.850 ***	0.476 **	0.702 ***	1.781 *	1.193 ***	0.663 **	1.313 *
	(0.326)	(0.181)	(0.182)	(0.179)	(0.181)	(0.861)	(0.322)	(0.239)	(0.529)

TABLE VIII (cont.)

	Model 1 Base	Model 2 Main	Model 3 Full	Model 4 Until 1995	Model 5 US	Model 6 Europe	Model 7 Early focus	Model 8 Balanced focus	Model 9 Late focus
Nikkei, 5-year	0.293 ***	-0.011	0.015	0.169 **	-0.009	0.183	0.077	-0.011	-0.011
	(0.086)	(0.049)	(0.047)	(0.059)	(0.047)	(0.146)	(0.103)	(0.058)	(0.146)
GDP growth	-5.787 **	-5.938 ***	-5.324 ***	-0.941	-3.917 **	-5.281	-8.783 ***	-4.502 **	-6.657 *
	(1.878)	(1.276)	(1.201)	(1.529)	(1.364)	(5.295)	(1.826)	(1.708)	(3.302)
Patent applications	-9.2E-06	-0.004 ***	-0.004 ***	-0.004	-0.008 ***	-0.005	-0.004 *	-0.005 ***	-0.004 *
	(0.001)	(0.001)	(0.001)	(0.003)	(0.002)	(0.003)	(0.002)	(0.001)	(0.001)
VC firm age		0.002	-0.003	0.025 ***	-0.003	-0.016 +	-0.002	-0.005	-0.001
		(0.003)	(0.003)	(0.004)	(0.003)	(0.009)	(0.005)	(0.004)	(0.008)
Fund year		0.027 **	0.031 ***	0.037 ***	0.048 ***	0.082 **	0.047 ***	0.032 ***	0.038 **
		(0.009)	(0.007)	(0.011)	(0.011)	(0.029)	(0.014)	(0.009)	(0.012)
Located in US		1.169 ***	1.215 ***	1.188 **			0.918 *	1.563 ***	1.294 ***
		(0.209)	(0.189)	(0.417)			(0.438)	(0.193)	(0.367)
Located in Europe		-0.336 *	-0.345 *	-0.417			-0.736 ***	-0.2056	-0.310
		(0.159)	(0.153)	(0.286)			(0.222)	(0.247)	(0.286)
Number of companies		0.036 ***	0.058 ***	0.054 ***	0.054 ***	0.096 ***	0.059 ***	0.053 ***	0.076 ***
		(0.003)	(0.003)	(0.003)	(0.003)	(0.016)	(0.004)	(0.003)	(0.010)
Amount of capital		-0.001 ***	-0.001 ***	-0.003 ***	-0.001 *	-0.004 **	-0.004 ***	-0.0003	-0.001 *
		(0.000)	(0.000)	(0.001)	(0.000)	(0.002)	(0.001)	(0.000)	(0.001)
Number of companies ^2			-0.0001 ***	-0.0001 ***	-0.0001 ***	-0.0002 *	-0.0001 ***	-0.0001 ***	-0.0002 **
			(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Amount of capital ^2			2.8E-08	-3.4E-07	-1.4E-07	2.6E-06	1.9E-06	-4.5E-07 *	9.8E-08
			(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Endogeneity correction	1.637 ***	2.343 ***	2.622 ***	2.717 ***	2.545 ***	3.807 ***	2.315 ***	2.482 ***	3.191 ***
	(0.048)	(0.069)	(0.065)	(0.080)	(0.068)	(0.334)	(0.076)	(0.078)	(0.145)
Constant	-0.266	-55.351 **	-65.077 ***	-77.538 ***	-97.276 ***	-169.942 **	-95.228 ***	-66.871 ***	-79.784 ***
	(0.252)	(18.432)	(14.516)	(22.621)	(20.939)	(57.255)	(27.177)	(17.785)	(23.903)
Model alpha	0.855	0.368 ***	0.256 ***	0.261 ***	0.248 ***	0.057	0.300 ***	0.232 ***	0.113 *
Generalized R-square	0.382	0.530	0.515	0.638	0.549	0.734	0.790	0.699	0.890
Log-likelihood	-4400.454	-3554.618	-3392.968	-1732.678	-3023.862	-205.701	-1630.403	-1445.791	-328.245
Wald Chi-square	1406.090 ***	2211.320 ***	2119.310 ***	1600.490 ***	1899.850 ***	423.810 ***	1668.650 ***	1530.450 ***	1283.150
N	2926	2926	2926	1574	2383	320	1069	1275	582

*** $p < 0.001$, ** $p < 0.01$, * $p < 0.05$, + $p < 0.10$