the Autonomous Management School of
Ghent University and Katholieke Universiteit Leuven

Vlerick Leuven Gent Working Paper Series 2008/08

HIGH-TECHNOLOGY VCS: A DISTINCT SPECIES ON THE INVESTMENT MARKET

MIRJAM KNOCKAERT
Mirjam.Knockaert@vlerick.be
BART CLARYSSE
Bart.Clarysse@vlerick.be

D/2008/6482/11

HIGH-TECHNOLOGY VCS: A DISTINCT SPECIES ON THE INVESTMENT MARKET

MIRJAM KNOCKAERT

Vlerick Leuven Gent Management School

BART CLARYSSE

Vlerick Leuven Gent Management School

Contact:

Mirjam Knockaert

Vlerick Leuven Gent Management School

Tel: +32 09 210 98 70

Fax: +32 09 210 97 00

Email: Mirjam.Knockaert@vlerick.be

ABSTRACT

Over the last decades, venture capital investment management has considerably become interested in high-tech investing. Despite this higher interest, no clear analysis exists of who these high-tech VCs are, and how they differ from traditional VCs. Studying selection behaviour of VCs using a conjoint methodology, we identified 28 high-tech investors in a unique sample of 68 European early stage investors. These VCs emphasize high-tech related criteria during the selection process. A further analysis of this group of high-tech investors compared to traditional investors showed that high-tech VCs are to a larger extent publicly funded than traditional VCs. Besides, they tend to be more prominent in biotech investing. We found no indication that specific or general human capital with respect to high-tech investing affects selection behaviour. This research has important implications for public policy, aiming at resolving the market failure for high-tech investments, high-tech entrepreneurs looking for VC funding, and VC funds.

INTRODUCTION

It is commonly agreed that over the last decades, venture capital investing management has to a large extent diversified into high-technology investing. The extent to which and the speed at which this has happened however are different across the world.

In the US and Canada, nowadays, approximately 90% of all venture capital investments are made in technology investments (Cumming, 2007). Until the early 1990s, there was very little venture capital activity in Europe, but this has substantially grown in the second half of the decade (Bottazzi and Da Rin, 2002). The venture capital industry that existed at the start of the 1990s in the UK and continental Europe was largely non-technology focused and dominated by management buy-outs and other later-stage development activity (Lockett et al., 2002). The share of early stage and high-tech investments has also increased over time, moving closer to the US pattern (Da Rin et al., 2006), but showing a fall in fund-raising and investments at the turn of the century (Knockaert, 2005). Moreover, venture capital firms remain considerably less numerous than in the US, despite a reduction in the gap during the mid 1990s (Da Rin et al., 2006). Murray and Lott (1995) and subsequently Lockett et al. (2002) indicate that in the EU, by the year 2000, the venture capital industry has evolved to a robust and highly international, specialist investment community. Both studies however indicate that venture capital firms in the UK have a bias against investment in new technology based firms.

It is therefore clear that the European venture capital industry has only recently evolved, and besides has, over a relatively short time frame, become increasingly involved in high-tech investments, but is still more reluctant than the US VC industry to invest in early stage high tech ventures. This study aims at understanding what the drivers for high-tech investing are and aims at understanding what distinguishes high-tech investors from the more traditional VCs.

In order to distinguish high-tech investors from traditional ones, this paper takes a study of selection behaviour of early stage VCs as a starting point. Selection behaviour of VCs has been studied over many decades, using different techniques and different angles. Researchers studying investment behaviour of VCs have to a large extent focused on selection behaviour of VCs, and have discovered that important criteria on which VC investors base their investment selection decisions are the human capital of the entrepreneur and the entrepreneurial team, the market environment, the characteristics of the product and service and the financial criteria.

Interestingly, to our knowledge, no research has focused on what distinguishes high-tech investors from the more traditional VCs, even though many authors, including Lockett et al. (2002); Murray and Lott (1996); Baum and Silverman (2004), have pointed out that high-tech investing is different from non-tech investing. Even though many researchers (f.i. Avnimelech and Teubal, 2006) have used the term high-tech investing, no clear insight has been provided into what makes high-tech investors distinct from traditional investors.

This research aims at understanding what makes high-tech VCs different from traditional VCs by assessing selection behaviour of a set of 68 European early stage VCs, and by, in supplement to other studies, adding tech-related selection criteria during the assessment. By adding such criteria, we are able to analyze the extent to which VCs that focus on high-tech characteristics of a business proposal during the selection process are different from traditional VCs. In line with the newest research techniques studying decision processes, we carried out face-to-face interviews with VCs, employing conjoint methodology to assess the selection procedure used. Besides, these interviews enabled us to capture information on the fund characteristics, human capital characteristics of the investment manager, and information on the portfolio companies selected and managed by this investment manager. In contrast to previous research on VC selection behaviour, we do not assume that the selection behaviour exhibited by one single investment manager is representative for the fund's selection behaviour, and take both fund level and human capital characteristics into account throughout the analysis.

First, this paper provides an overview of VC selection behaviour literature and illustrates how, by adding specific high-tech selection criteria a taxonomy of high-tech investors can be built. Second, the paper provides a theoretical framework for differences between high-tech investors and traditional investors, and offers hypotheses on these differences. Third, methodology and data collection are described. Fourth, the results of the analyses are discussed. The paper ends with conclusions and directions for further research.

TOWARDS A TYPOLOGY OF HIGH-TECH INVESTORS

Existing research has identified a number of important criteria on which VC investors base their investment selection decisions. First, the “human capital” of the entrepreneur and the entrepreneurial team, which includes: (a) the ability of management, whether it is management skill, quality of management, characteristics of the management team or the management track record (Shepherd and Zacharakis, 1998); (b) the management skills of the entrepreneur (Tyebjee & Bruno, 1984; MacMillan et al., 1985; 1987); and (c) the heterogeneity of the entrepreneurial team (Keeley and Roure, 1989). Second, the market environment, which includes the characteristics of the market/industry (Hisrich and Jankowitz, 1990), environmental threats to the business (Tyebjee and Bruno, 1984; Meyer et al., 1993), the level of competition (Hutt and Thomas, 1985; Kahn, 1987; Muzyka et al., 1996) and the degree of product differentiation (Tyebjee and Bruno, 1984; Hutt and Thomas, 1985; Kahn, 1987; Hisrich and Jankowitz, 1990). Third, are characteristics of the product / service (Macmillan et al., 1987). Fourth, are financial criteria and exit opportunities (Macmillan et al., 1987).

The methodology that has been used to study selection behaviour has evolved over the last decades. So far, the most common approach to study selection behaviour has been a post hoc methodology which consisted effectively of asking why investment managers had invested in certain business proposals. This method, however, is problematic as it can potentially generate biased results because people are poor at introspection (Shepherd and Zacharakis, 1998), are often motivated to bias results in a post hoc rationalisation (March and Feldman, 1981), and have limited capacity to recall what has happened (Fischhoff, 1982). As a reaction to these post hoc methods, researchers started to experiment with real time methods such as verbal protocol analysis. For example, Hall and Hofer (1993) presented four venture capitalists six protocols for assessment. They found that VCs screen and assess business proposals very rapidly which makes it unlikely that they can persistently evaluate their decisions post hoc. In a further development, the subjectivity of analysis and interpretation involved in verbal protocol techniques, without being supplemented with other techniques such as computer algorithms, has been questioned by Riquelme and Rickards (1992). They argue that verbal protocol analysis is more an art than a science; suggesting instead the use of conjoint analysis as a technique for the analysis of VCs’ decision making.

For an overview of studies into selection criteria and the methodology used, we refer to Shepherd and Zacharakis (1999). They bring forward that, in order to overcome the weaknesses of post hoc methodologies and real time methods, conjoint analysis is highly suitable.

Consistent with Muzyka et al. (1996), we analyze the investment behaviour of VCs by investigating the trade offs made by them at the moment they take the decision as to whether or not to further investigate an initial proposal, using conjoint methodology. This research however starts from the premise that high-tech investing is different from non high-tech investing. Besides, in contrast to Muzyka et al. (1996), this research takes into account that early stage investing was found to be different from late stage investing (Elango et al., 1995; Sapienza et al., 1994), and focuses on early stage VCs only. Furthermore, it takes into account that, also in Europe, a new breadth of VC investors has emerged that can be called high-tech investors, and therefore includes a set of high-tech related selection criteria to the traditional set of selection criteria outlined above.

Based on the conjoint analysis results, we call those VCs that emphasize the high-tech related selection criteria during the selection procedure “high-tech investors”. Subsequently, we look at the differences that exist between early stage high tech and early stage traditional investors. In order to do so, we assess fund characteristics and human capital characteristics of the interviewed investment manager. In the next section, we offer the theoretical background and hypotheses for differences between high-tech and traditional early stage VCs.

THEORY AND HYPOTHESES

Theory provides a number of indications of how high tech VCs could differ from others. Below, we build on agency theory, and related market imperfections, human capital theory and exit mechanisms.

Imperfections in capital markets and public intervention

Early stage high tech firms are seen as important to an economy, given that they are offering a significant potential contribution in four cardinal areas of economic activity: innovation, new employment creation, export sales growth and regional development (Freeman, 1983; Oakey et al., 1988). Many of these companies however find it difficult to get started and grow (Gill et al., 2002; Martin et al., 2002), especially in Europe.

The dominant view is that this is due to the nature of capital markets and the problems of raising finance for small risky businesses (Martin et al., 2002).

Di Giacomo (2004) and Lerner (1999) indicate that public intervention in the equity market is justified mainly by the existence of market failures in the financing of some categories of firms, such as high-tech small firms, young enterprises and firms located in depressed areas. According to this market failure hypothesis, asymmetric information explains the existence of financial gaps: high tech start-ups do not have access to funding by banks, VC firms, or other private financing institutions because they are considered too risky and have little collateral. Therefore, VCs are often viewed as the primary source for inventive high-tech start-ups companies (Gompers and Lerner, 1999, 2001). Many researchers have pointed out that venture capital is a form of financial intermediation particularly well suited to support the creation and growth of early stage high tech companies (Hellmann and Puri, 2000, 2002; Kortum and Lerner, 2000).

From an agency theory perspective, VCs may however be reluctant to invest in early stage high-tech companies. Entrepreneurs, by virtue of being intimately involved in their venture, are likely to possess greater information about it than are VCs who may find it difficult to access this information even with extensive due diligence. This information asymmetry leads to agency conflicts (Gompers, 1995). Agency theory suggests that although the entrepreneur can autonomously take certain decisions, part of the costs resulting from these decisions will be borne by the remaining shareholders, giving rise to problems of moral hazard. Agency costs may be especially important in high tech companies, where investors usually cannot evaluate the technology and have difficulties in assessing the commercial implications of strategic choices (Knockaert et al., 1996).

Governments can rectify market imperfections that exist with respect to the provision of early stage high tech financing by using a large number of instruments, ranging from the establishment of public funds to providing financing to private funds, over refinancing and guarantee schemes to the provision of fiscal incentives and incubation schemes (Wright et al. , 1996). Given the high suitability of venture capital financing for early stage high tech companies, governments have to a large extent either provided VC financing directly by setting up private funds, or indirectly, by investing in private VC funds (Cumming, 2007).

Building on agency theory, there is a clear indication that market failures take place in the case of early stage high-tech investments. Given that policy makers strive to provide adequate funding for these high-tech ventures, assuming their importance for achieving economic growth and job creation, we offer the following hypothesis:

H1: High-tech VCs will to a larger extent be publicly funded than traditional VCs

Human capital theory

Previous studies on VC selection behaviour have mainly studied responses provided by one investment manager, and drawn conclusions for the VC fund's selection behaviour based on these responses. Human capital theory however provides a rationale of why individual responses may deviate from a fund's selection behaviour, and provides insight into how high-tech investors may differ from traditional investors.

Two key demographic characteristics, education and experience, underlie the concept of human capital (Becker, 1975). Applying the human capital concept in a VC context, Dimov and Shepherd (2004) distinguished between general and specific human capital. General human capital refers to overall education and practical experience, while specific human capital refers to education and experience with a scope of an application limited to a particular activity or context (Becker, 1975; Gimeno et al., 1997). In a VC context, Dimov and Shepherd define specific human capital as education and experience that is directly related to the tasks of the VC. In the context of this study, focusing on high-tech investing, we define specific human capital as experience or education in high-tech domains.

Second, we build on self-efficacy theory and the "similar-to-me" hypothesis (Byrne, 1971) to explain how the human capital of investment managers may influence their selection behaviour. Self-efficacy theory suggests that people who think they can perform well at a task do better than those who think they will fail (Gist and Mitchell, 1992). Subsequently, people perform activities and pick social environments they judge themselves capable of managing (Wood and Bandura, 1989). According to the "similar-to-me" hypothesis (Byrne, 1971), individuals rate other people more positively the more similar they are to themselves. A rationale for this hypothesis can be found in three different theoretical backgrounds, namely learning theory, self-categorization theory and social identity. According to learning theory, similarity is perceived as rewarding and dissimilarity works as a negative reinforcement (Lefkowitz, 2000).

Self-categorization theory implies that a person's self-concept is based on the social categories he puts himself or herself in and that each person strives for a positive self-identity (Jackson et al., 1991). According to social identity theory (Tajfel, 1982), people strive to belong to a group as this leads to the positive feeling of social identity. The assignment to a specific group allows for in-group/out-group comparisons which are biased towards the own group. The impact of the "similar to me" hypothesis has been demonstrated in many management fields, such as buyer-seller relationships (Lichtenthal and Tellefsen, 2001) and employment selection interviews (Anderson and Shackleton, 1990).

Building on self-efficacy theory, we can hypothesize that those investment managers that are most familiar with high technology, and have thus generated specific human capital with respect to high tech investing, will emphasize high-tech criteria in the selection process. Subsequently, the "similar-to-me" hypothesis indicates that investment managers who possess specific human capital with respect to high tech investing, will have a bias during the selection process, and will be more positive towards high-tech entrepreneurs who have a similar background. Specific human capital in this context is defined as technical education and experience in a high tech research environment. General human capital in this high-tech VC context is defined as education in humanities, and experience in finance, consulting or investment management.

Based on self-efficacy theory and the "similar-to-me" hypothesis, we offer the following hypotheses:

H2: The degree of specific human capital of the investment manager with respect to high-tech investing will be higher in the case of high-tech investors

H3: The degree of general human capital of the investment manager with respect to high-tech investing will not distinguish high-tech investors from traditional investors

Accessibility of complementary assets and exit scenarios for VCs

There are a number of ways in which VCs can exit their investments. For VCs, an IPO represents an attractive exit mechanism (Black and Gilson, 1998) and contributes greatly to the upside potential of a fund's performance. An alternative exit route is a trade sale, during which the portfolio company is sold to another investor or commercial party. Finally, VCs exit the portfolio company through liquidation or bankruptcy.

There are two main routes to valorize the knowledge or technology built within an early stage company. Building on Teece (1986)'s seminal work, Gans and Stern (2003) define two types of markets that companies can play on: the market for ideas and the market for products. In the first case, the company collaborates with a partner that holds power in the value chain and that markets the product. In the latter case, the company develops all complementary assets that are necessary to bring the product to market, such as production, marketing and distribution facilities and complementary technologies. In this case, the company enters into competition with the existing parties on the market and offers a product or service on the market. The extent to which this occurs is highly dependent on the appropriability regime of the technology and the accessibility of complementary assets in the value chain.

In the case the company plays on the market for technology, it will enter in collaboration with an existing party on the market. This collaboration can take many forms, and has been studied in large extent by technology management literature (for an overview, see Williamson, 1985; Hart, 1995; Aghion and Tirole, 1994). One of these forms is acquisition, by which the technological innovator is acquired by an incumbent (Gans and Stern, 2003; Tellis, 2006).

According to Gans and Stern (2003), the extent to which a start-up company will either play on the market for technology or products is dependent on the importance of the protectability regime and the accessibility of complementary assets. Besides, they stress that the impact of these two factors will be highly dependent on the sector the company is in. Gans, Hsu and Stern (2002) showed that the probability of cooperation is highest in the biotechnology industry, where patents are relatively effective in protecting IPR and firms face high relative investment costs. They indicate that, in contrast, when investment costs for the entrant are relatively low and the technological innovation is not protected by patents, as in the disk drive industry, the disclosure threat tends to foreclose the ideas market.

Also Orsenegio (1989) and Lerner (1999) and Merges (1998) indicated that cooperation between start-up innovators and more established firms is the norm (whether through licensing, strategic alliances, or outright acquisition) in biotechnology. In this way, start-up innovators avoid duplicating of sunk assets in biotechnology, such as regulatory expertise and distribution channels of established pharmaceutical companies (Gans, Hsu and Stern, 2002). Gans and Stern (2003) indicated that the majority of new products approved by the FDA are based on discoveries developed with the tools of biotechnology, and that are in most cases innovative outputs of research-oriented biotechnology firms in collaboration with an incumbent pharmaceutical firm in the commercialization process. Therefore, we can hypothesize that a biotechnology start-up firm will most probably play on the market of ideas and the exit focus of the VC investor will be on a trade sale scenario. However, in order to make this trading of developed technology possible, it is important that the appropriability regime of the developed technology is sufficiently strong. Therefore, the VC will stress characteristics of the developed technology during the selection process to a large extent in the case of a biotechnology proposal. In the case of potential ICT investment, the VC may pay less attention to technology characteristics in the business proposal. Indeed, as Mann and Sager (2007) and Gans et al. (2002) indicate, protectability of developed technology in the ICT sector is less straightforward and appropriability regimes are weaker for this type of technology. Besides, ICT innovators in more often engage in creative destruction, earning their innovation rents through product market entry and competition with more established firms (Christensen, 1997). The weak appropriability regime of ICT developments and the accessibility of complementary assets therefore make it less likely that an ICT start-up will play on the market for ideas. Therefore, the VC investor will less emphasize characteristics of the developed technology during the selection process in the case of an ICT proposal, but will focus on those characteristics in the business proposal that determine whether or not the start-up can enter in competition with existing players on the market. Therefore, we offer the following hypothesis:

H4: High-tech investors will be most prominent in biotech investing

RESEARCH METHODOLOGY

The sample

Given that none of the publicly available databases and information sources on VC activity in Europe, such as VentureEconomics or VentureOne could provide sufficiently detailed information on the level we required, namely fund characteristics and investment management characteristics, we constructed our own dataset of European early stage VCs.

A stratified sample of 68 VC investors was drawn from different regions across Europe. As our research focus is on early stage VC investors, we needed to obtain an international dataset because the number of potential respondents within any one country, outside of the US, would have been too small. We selected the seven regions across Europe that had the highest R&D intensity and venture capital presence. The seven regions were: Cambridge/London region (UK), Ile de France (France), Flanders (Belgium), North Holland (the Netherlands), Bavaria (Germany), Stockholm region (Sweden), Helsinki region (Finland). In each region, we wanted to have a representation of small and large funds with various degrees of public funding. A random sample based upon the most widespread available sample frame, i.e. the EVCA-filings, would have resulted in a sample biased towards the larger private venture capital firms. Therefore, we created our own sample frame, collating the directory information from EVCA with those of the various regional venture capital associations and information obtained through contacts we had with academics specific regional expertise and contacts. This resulted in a population of 220 funds across the 7 regions. These were all funds that are investing early stage. The sample frame was stratified into different groups or subpopulations according to the scale of the funds (small funds versus mega funds) and their institutional investors. In terms of scale, 33 funds were small, 21 were large and 14 were mega funds[1]. With respect to institutional investors, 6 funds were private equity arms of banks, 9 funds were public funds, 12 were public/private partnerships and the others are private funds.

---

[1] Venture funds having a fund size between 100 million Euro and 250 million Euro are considered to be large funds for venture investments. Mega funds are those funds having a size of more than 250 million Euro, small funds have less than 100 million Euro under management (EVCA definition)

Research design

The interviews were conducted from January to December 2003. Each interview lasted on average 90 minutes, and provided information on selection behaviour, human capital characteristics of the investment manager and portfolio companies.

Using a conjoint method we presented the venture capitalists with a number of fictitious business proposals that differ across a range of attributes. The first stage of the analysis was to identify the different attributes that would be at the heart of the fictive business cases. The attributes were selected as follows. First, we synthesized the criteria that had been used in previous research, namely human capital characteristics, financial criteria and product/technical characteristics. Second, we drew on the insights of two VC and one business angel investors active in the early stage high tech sector and in addition three VC experts in order to draw up a list of criteria that were important to them, in order to make sure that high-tech selection criteria were included. The high-tech selection criteria that were included are protectability and platform. Protectability was defined as the ability to protect the technology by patents or trade secrets. Platform technology was defined as a broad technology with lots of different applications.

Finally we synthesized the two lists into a set of criteria that we then pre-tested with the experts, which they agreed were the criteria that are employed when selecting investments. As a result of this process we identified twelve different attributes which included: team, entrepreneur, contact with the entrepreneur, uniqueness of the product, protection of the product, market acceptance, platform technology, location, size and growth of the targeted market, time to break-even and return on investment.

These twelve attributes were used to construct a range of possible events that would form the basis of the fictitious business proposals. In line with the conjoint analysis philosophy, and consistent with Muzyka et al. (1996), potential events were matched to the different attributes, as shown in Table 1. Thirty events (or levels) were developed conceptually based upon the twelve attributes. For instance, team complementarity and experience are two important characteristics of the attribute “team”. Business start-up teams can thus be categorized into three attributes: not complementary but having business experience; complementary with experience; or having neither complementarity nor business experience. For other attributes such as uniqueness, only two events are allowed: either it is unique or not.

Insert Table 1 About Here

The possible events associated with the twelve attributes summarized in the table can then be combined into 'business proposals' (or profiles). Theoretically any combination of 12 (number of attributes) out of 29 potential events is possible. This would result in more than 1000 theoretically feasible business proposals or profiles. The total number of profiles resulting from all possible combinations of the levels would become too great for respondents to score in a meaningful way. Therefore, a fractional factorial design using Addelman's basic plans (Addelman, 1962) for designing an orthogonal main effects plan was chosen. This resulted in 27 business proposals that were presented to the respondents (VC investment managers). The 27 proposals were printed on cards that were used during the interviews. Respondents were asked to judge the proposals on a five-point Likert scale (from 1= bad investment opportunity I would certainly not invest; to 5= major investment opportunity, large chance of investing). Using a conjoint analysis these scores were then translated into derived utility scores for each attribute. Utility scores are measures of how important each characteristic is to the respondent's overall preference of a product.

Measures

A binary logistic regression model was used in order to assess differences between high-tech VCs and traditional VCs. The measures used are described below.

Dependent variable

Using the output of the conjoint analysis, namely the utility scores on the attributes and its levels as a starting point, we identified high-tech investors as those investors that were either in the top quartile of the sample for the utility attached to protectability of technology or in the top quartile of the sample for the utility attached to the fact that the technology was a platform technology. In this way, 28 of the 68 VCs were labelled "high-tech VCs".

Independent variables

Percentage public capital. This variable ranges between 0% and 100%, with 100% indicating that the fund is entirely funded by public means. 46 out of 68 funds were not funded by public means, 10 were 100% publicly funded, and the other funds were partially publicly funded.

Specific human capital. In order to capture the extent to which the investment manager disposes of human capital that relates to high tech investing specifically, we constructed two variables. The first measures whether or not the investment manager has experience with high-technology through means of a PhD (labelled "academic experience") and takes the form of a dummy. The second measures whether or not the investment manager has a technical education, and takes the form of a dummy. 7 investment managers had academic experience, and 37, or the majority had a technical background.

General human capital. In order to capture the general human capital, i.e. human capital not related to high-tech investing, 5 variables were created. Financial experience is measured as the number of years of experience in banking and audit. The investment managers interviewed had on average 2.23 years of financial experience. Consulting experience is measured as the number of years in consulting, which is on average 1.02 years for the investment managers in the sample. Management experience is measured as the number of years in general management, on average 4.55 years in our sample. Investment management relates to the number of years experience in investment management, which is on average 4.68 years in this sample. Finally, education in business administration is measured by a dummy variable. 46 of the 68 interviewed investment managers had had this education.

Exit orientation. Given the importance of the sector of investment on exit orientation, and the hypothesized relation between the biotechnology focus of the investment manager and the emphasis on high-tech selection criteria, we constructed a variable to measure the biotech focus. We classified an investment manager as "biotech investor" if he or she indicated to consider biotech investments. The degree of focus on biotech was then determined by using the function biotech investor (0/1)/number of investment sectors. The investment manager indicated whether or not he or she would consider investing in each of the investment sectors, which were defined using the EVCA industry classification in 8 sectors[2]. Therefore, investment managers that would only consider biotech investments would score high on the measure for biotech focus. Investment managers involved in a diversified set of sectors would score low. The average score for biotech focus was .26.

---

[2] Communications, computer related, other electronics related, biotech, medical/health related, energy, chemicals and materials, industrial automation

Control variables

Fund age. First, we controlled for the age of the fund, on average 8.06 years in our sample

Fund size. Second, we controlled for the fund size, measured as the total capital managed, on average 269.49 million Euros in our sample.

RESULTS

Table 2 provides an insight into the descriptives of variables used and the correlation between these variables. Correlations between independent variables were all below 0.6. In order to make sure that multicollinearity was not an issue, VIF factors were calculated, and were found to be below 3.0, suggesting that multicollinearity was not an issue (see Hair et al, 1998).

Insert Table 2 About Here

Table 3 presents the results of the binary logistic regression analysis, with as dependent variable a dummy (0/1) indicating whether or not the investor was classified a high-tech investor or not. This classification was based upon the utility of high-tech selection criteria for investment managers during the selection process.

Insert Table 3 About Here

However, given that researchers studying selection behavior of VCs taking cognitive learning processes as point of departure have noted that the selection procedure and criteria put forward by investment managers during their research is different from the actual procedure and criteria used, we deemed it necessary to additionally test whether or not classification used matched with the in use decision policy of the investment manager. As Shepherd (1999) puts it, there is a gap between “In Use” and “Espoused” decision policies used by VCs. First, this gap is caused by the fact that it is difficult for VCs to truly understand their intuitive decision process because of all the noise caused by information overload (Zacharakis and Meyer, 1998). Second, investment managers suffer from overconfidence.

As Zacharakis and Shepherd (2001) point out, more information should enable the VCs to assess any potential pitfalls, however, it also makes the decision more complex. Thus, more information creates greater confidence, but it also leads to lower decision accuracy.

In order to test whether the observed selection behavior using conjoint methodology matched the in use decision policy, we asked the 68 investment managers to provide us with a list of portfolio companies for which they had been involved in the selection process. 37 investment managers provided us with this list, resulting in 168 portfolio companies. For these investee companies, we looked up the number of patents before and after investment. The number of patents post-investment correlated significantly positive with the utility the investment managers attached to protectability of technology (correlation of .40, $P<.05$). No significant correlation was found for the number of pre-investment patents (correlation of .13, $P>.10$). This is not surprising, given that we only surveyed early stage funds and that it takes a number of years before a patent is granted, which however does not prohibit the investment manager from assessing the patentability of technology. Therefore, we find an extra indication that the observed selection behavior is in line with the in use selection behavior by the investment managers interviewed.

The base model for the binary logistic regression was not statistically significant ($R^2=0.060$, $P>.10$), and neither was the base model including the variable for public funding ($R^2=0.091$, $P>.10$). The base models including human capital characteristics and exit orientation were statistically significant. So was the full model ($R^2=.473$; $P<.01$). In the full model, positive significant coefficients were found for the percentage public capital ($B=.015$, $P<.10$), the experience of the investment manager in investment management ($B=.217$; $P<.10$) and the biotech focus of the investment manager ($B=3.27$, $P<.01$). A negative significant coefficient was found for the fund age ($B=.114$; $P<.10$).

Therefore, we can conclude that we find **support for H1**: high-tech VCs are to a larger extent publicly funded than traditional VCs. We do **not find support for H2** or **H3**, hypothesizing that specific and human capital characteristics will be different between high-tech investors and traditional investors. We do find that it are those investment managers that have the most experience in investment management that have a higher probability of being classified as high-tech investor, which is contrary to the expectations. We do find **support for H4**: high-tech investors are more prominent in biotech investing than in other sectors.

CONCLUSIONS

So far, many researchers have used the term high-tech investing and have indicated that high-tech investing is different from traditional investing, however without providing a definition to high-tech investing, nor providing an indication for the differences between high-tech and traditional investors. Using a hand collected, unique dataset of early stage European VCs, for which information on selection behavior using a conjoint methodology and their fund characteristics and human capital characteristics were available, we were able to distinguish high-tech investors from traditional investors based on the emphasis investment managers placed on high-tech selection criteria, such as protectability and platform technology. First of all, we found that high-tech investors dispose to a higher extent of public funding. This higher degree of public intervention may be explained by the fact that it is commonly accepted that market failures for financing of high-tech ventures in their early stages of development exist. Given that high-tech ventures are however esteemed important for innovation and employment generation, governments may want to correct this market failure by providing funding for high-tech investors. Second, we do not find that the human capital of investment managers is significantly different between high-tech investors and traditional ones. Only the experience in investment management seems to differ, with high-tech investors having a higher degree of investment management experience. It therefore seems to be the most experienced investment managers that turn into high-tech investing. Clarysse et al. (2007) indicate that the valuation of patents or tacit knowledge at the early stage of product development is quite uncertain and poses particular problems for traditional venture capital firms. This problem is exacerbated since there is typically little information about the acceptability of the product in the market or the size of the market (Manigart et al., 2000). Therefore, it may be that only the most experienced investment managers, who know how to deal with market uncertainty and team related uncertainty, have the capacity to deal with technological uncertainty. We do not find any indication that investment managers emphasize high-tech selection criteria given their technical background, or are more positive towards the evaluation of high-tech entrepreneurs, since they are similar to their own background. Most probably, the investment criteria that are put forward by the fund, and that are checked during the selection process, for instance in investment committees, have more impact than the personal affinity of the investment manager with the investment proposal and the entrepreneur. Finally, we find that high-tech investors are much more focused on biotech investing than traditional investors are.

This may have to do with the fact that, in biotech investing, the exit routes are often limited to trade sales, requiring a considerable strength of high-tech criteria. Without for instance protectability of technology, the investee company would find it very difficult to enter the market for ideas, and cooperate with existing players, and would have to build its own value chain and market product and services based on the idea, which is extremely difficult in biotechnology, given the need for high regulatory expertise and specialized distribution channels.

IMPLICATIONS AND DIRECTIONS FOR FURTHER RESEARCH

This paper has a number of important implications for policy makers, VC funds and investment managers and entrepreneurs.

First, this research indicates that policy makers are indeed succeeding in their attempt to alleviate a market failure with respect to high-tech financing. The funds that receive public funding tend to a larger extent to invest their funds in high-tech investments. Given the belief that high tech ventures are important for stimulation of innovation and subsequently employment generation, it is of great importance to policy makers to gain insight into the deployment of government resources and to ascertain that the resources employed reach their intended goals. Besides, this research clearly shows that human capital has little impact on the extent to which investment managers select high-tech deals. It shows that it is mainly experienced investment managers who turn to high-tech investing. Even though, at first sight, this indicates that the selection process for high-tech deals will be in experienced hands, it has to be noted that high-tech investing has only recently emerged in Europe, and therefore, even the most experienced investment managers will only be experienced in traditional investing. As Lockett et al. (2002) indicate, high-tech investing requires specialist technology skills. This research does not indicate that people with specialist technology skills are the ones investing in high-tech deals. More cumbersome even, Knockaert et al. (2006) show that human capital highly affects the involvement of investment managers post investment. Therefore, policy makers should focus on how, apart from selecting high-tech proposals, investment managers can be recruited that have specialist technology skills on the one hand and investment management skills on the other.

Second, this research has a number of implications for VC funds. It indicates that investment managers are not biased by their own technical background while analyzing high-tech proposals.

This may indicate that they align to a large extent to the investment policy set by the VC fund. It also clearly indicates that investment managers focusing on biotech investing understand the importance of high-tech criteria during the selection procedure for the exit routes and potential returns for the fund. It should be mentioned though that this research did not attempt to analyze the results from the employed selection procedure. It therefore does not indicate whether or not the fact that technical knowledge and experience does not lead to a higher focus on high-tech selection criteria has a positive or negative impact on fund performance. Research by Dimov and Shepherd (2004) however indicates that, in a broad sample of US traditional and high-tech investors, over all stages of investment, human capital affects the chances of reaching a “home run” or IPO and the chances of “strike outs” or bankruptcy of the investee company. Further analysis should indicate whether or not specific human capital with respect to high-tech investing results in better or worse investment decisions.

Third, this research has a number of implications for entrepreneurs looking for VC financing. From this research it is clear that high-tech investors, who stress strong technological criteria in the business plan, exist. This may be of interest to many early stage high tech companies, often lacking first customer contracts, a well-established entrepreneurial team or clearly identifiable financial prospects. Besides, these high-tech investors can especially be found at public funds or funds that are partially publicly funded. Besides, entrepreneurs operating in the biotech industry should be aware of the importance attached by investment managers responsible for biotech investing to high-tech criteria such as protectability of technology.

To conclude, further research should indicate to which extent the emphasis on high-tech criteria in the business proposal are beneficiary to the fund’s objectives and leads to positive investment returns. Besides, further research should indicate whether differences in selection behavior between investment managers within one fund exist, and should shed light on the extent to which the fund’s selection procedure is the primary focus of the investment manager, hereby overruling any human capital-related selection behavior.

REFERENCES

Addelman S. (1962). Orthogonal Main-Effect Plans for Asymmetrical Factorial Experiments. *Technometrics*. 4(1): 21-46.

Aghion P., Tirole J. (1994). The management of innovation. *Quarterly Journal of Economics*. 109(4), pp. 1185-1210.

Anderson N., Shackleton V. (1990). Decision Making in the Graduate Selection Interview: A Field Study. *Journal of Occupational Psychology*. 67, pp. 63-77.

Avnimelech G., Teubal M. (2006). Creating venture capital indusstries that co-evolve with high-tech: Insights from an extended industry life cycle perspective of the Israeli experience. *Research Policy*. 35, pp. 1477-1498.

Baum J.A.C., Silverman B.S. (2004). Picking winners or building them? Alliance, intellectual and human capital as selection criteria in venture financing and performance of biotechnology. *Journal of Business Venturing*. 19(3): 411-425.

Becker G.S. (1975). Human capital. Chicago University Press, Chicago, IL.

Black B.S., Gilson R.J. (1998). Venture capital and the structure of capital markets: banks versus stock markets. *J. Financ. Econ*. 47, 243-277.

Bottazzi L., Da Rin M. (2002). Venture capital in Europe and the financing of innovative companies. *Economic Policy.* 34: 231-269.

Byrne D. (1971). The Attraction Paradigm. New York.

Christensen C.M. (1997). The Innovator’s Dilemma: When New Technologies Cause Great Firms to Fail. Harvard Business School Press. Boston, MA.

Clarysse B., Wright, M., Lockett A. and Mustar P. (forthcoming), « Academic Spin-offs, Formal Technology Transfer and Capital Raising”, *Industrial and Corporate Change*

Cumming D. (2007). Government policy towards entrepreneurial finance: Innovation investment funds. *Journal of Business Venturing*. 22, 193-235.

Da Rin M., Nicodano G., Sembenelli A. (2006). Public policy and the creation of active venture capital markets. *Journal of Public Economics*. 90, 1699-1723.

Di Giacomo M. (2004). Public Support to Entrepreneurial Firms: An Assessment of the Role of Venture Capital in the European Experience. *The Journal of Private Equity*, 22-38.

Dimov P.D., Shepherd D.A. (2005). Human capital theory and venture capital firms: exploring "home runs" and "strike outs". *Journal of Business Venturing.* 20: 1-22.

Elango B., Fried V.H., Hisrich R.D., Poloncjek A. (1995). How Venture Capital Firms Differ. *Journal of Business Venturing*.10: 157-179.

Fischhoff B. (1982). For those condemned to study the past: heuristics and biases. In. Hindsight, Judgement under uncertainty: heuristics and biases. Cambridge University Press.

Freeman C. (1983). The economics of industrial innovation. Cambridge, MA: MIT Press.

Gans J.S., Hsu D.H., Stern S. (2002). When does start-up innovation supr the gale of creative destruction? *RAND Journal of Economics*. 33(4), pp. 571-586.

Gans J.S., Stern S. (2003). The product market and the market for „ideas": commercialization strategies for technology entrepreneurs. *Research Policy*. 32, pp. 333-350.

Gill D., Martin C., Minshall T., Rigby M. (2000). Funding Technology: Lessons from America. London: Wardour Publications.

Gimeno J., Folta T.B., Cooper A.C., Woo C.Y. (1997). Survival of the fittest? Entrepreneurial human capital and the persistence of underperforming firms. *Administrative Science Quarterly*. 42(4): 750-784.

Gist, M.E. and Mitchell, T.R (1992) 'Self-efficacy: a theoretical analysis of its determinants and malleability', *Academy of Management Review*, Vol. 12 (2), pp. 183-211.

Gompers (1995). Optimal Investment, Monitoring, and the Staging of Venture Capital. *Journal of Finance*. 50(5): 1461-1489.

Gompers P., Lerner J., (1999). The Venture Capital Cycle. MIT Press. Cambridge.

Gompers P., Lerner J. (2001). The Venture Capital Revolution. *Journal of Economic Perspectives*. 15(2): 145-168.

Hair J.F., Anderson R.E., Tathum R.L., Black W.C. (1998). Multivariate data analysis with readings. Macmillan, New York.

Hall, J., Hofer, C.W. (1993). Venture Capitalists' Decision Criteria in New Venture Evaluation. *Journal of Business Venturing*. 8: 25-42.

Hart O. (1995). Firms, contracts and financial structure. Oxford University Press, Oxford.

Hellmann T., Puri M. (2000). The interaction between product market and financing strategy: the role of venture capital. *The Review of Financial Studies*. 13(4): 959-984.

Hellmann T., Puri M. (2002). Venture capital and the professionalization of start-up firms: Empirical evidence. *The Journal of Finance*. 57(1): 169-198.

Hisrich, R.D. and Jankowitz, A.D. (1990). Intuition in venture capital decisions: an exploratory study using a new technique. *Journal of Business Venturing*. 5: 49-62.

Hutt, R.W. and Thomas, B. (1985). Venture capital in Arizona. *Frontiers of Entrepreneurship Research*. 155-169.

Jackson S.F., Brett J.F., Sessa V.I., Cooper D.M., Julin J.A., Peyronnin K. (1991). Some Differences make a Difference: Individual Dissimilarity and Group Heterogeneity as Correlates of Recruitment, Promotion and Turnover. *Journal of Applied Psychology*. 76, pp. 675-689.

Kahn, A.M. (1987). Assessing venture capital investments with noncompensatory behavioural decision models. *Journal of Business Venturing*. 2: 193-205.

Keeley R.H., Roure J.B. (1989). Determinants of new venture success before 1982 and after a preliminary look at two eras. Frontiers of Entrepreneurship Research. 274-287.

Knockaert M., 2005, Unpublished Ph.D. Dissertation University of Gent.

Knockaert M., Lockett A., Clarysse B., Wright M. (2006). Do human capital and fund characteristics drive follow-up behaviour of early stage high-tech VCs? *International Journal of Technology Management*, 34(1/2), 7-27.

Kortum S., Lerner J. (2000). Assessing the contribution of venture capital to innovation. *The Rand Journal of Economics*. 31(4): 674-693.

Lefkowitz J. (2000). The Role of Interpersonal Affective Regard in Supervisory Performance Ratings: a Literature Review and Proposed Causal Model. *Journal of Occupational and Organizational Psychology*. 73, pp. 67-85.

Lerner J. (1999). The Government as Venture Capitalist: The Long-Run Impact of the SBIR Program. *Journal of Business*, 72(3), 285-318.

Lichtenthal J.D., Tellefsen T. (2001). Toward a Theory of Business Buyer-Seller Similarity. Journal of Personal Selling and Sales Management. 1, pp. 1-14.

Lockett A., Murray G., Wright M. (2002). Do UK venture capitalists still have a bias against investment in new technology firms. *Research Policy*. 31, 1009-1030.

MacMillan, I.C., Siegel, R., Subbanarashima, P.N. (1985). Criteria used by venture capitalists to evaluate new venture proposals. *Journal of Business Venturing*. 1: 119-128.

MacMillan, I.C., Zemann, L., Subbanarashima, P.N. (1987). Criteria distinguishing successful from unsuccessful ventures in the venture screening process, *Journal of Business Venturing*. 2: 123-137.

Manigart S., De Waele K., Wright M., Robbie K., Desbrieres P., Sapienza H., Beekman A. (2000). Venture capitalists, investment appraisal and accounting information: a comparative study of the USA, UK, France, Belgium and Holland. 6(3), pp. 389-404.

Mann R., Sager T.W. (2007). Patents, venture capital and software start-ups. *Research Policy*. 36(2), 193-208.

March J.G., Feldman, M.S. (1981). Information in organisations as signal and symbol. *Administrative Science Quarterly*. 26: 171-186.

Martin R., Sunley P., Turner D. (2002). Taking risks in regions: the geographical anatomy of Europe's emerging venture capital market. *Journal of Economic Geography*. 2(2): 121.

Merges R. (1998). The control of strategic alliances: an empirical analysis of the Biotechnology industry. *Journal of Industrial Economics*. 46, pp. 125-156.

Meyer G.D., Zacharakis A.L., De Castro J. (1993). A post-mortem of new venture failure: an attribution theory perspective. Frontiers of Entrepreneurship Research. 256-269.

Murray G., Lott J. (1995). Have venture capitalists a bias against investment in new technology firms? *Research Policy*. 24, 283-299.

Muzyka, D., Birley, S., Leleux, B. (1996). Trade-offs in the investment decisions of European Venture Capitalists, *Journal of Business Venturing*, 11: 273-287.

Oakey R.O., Rothwell R., Cooper S. (1988). Management of innovation in small firms. London: Francis Pinter.

Orsenegio L. (1989). The emergence of Biotechnology: Institutions and Markets in Industrial Innovation. New York, St. Martin's Press.

Riquelme H., Rickards T. (1992). Hybrid conjoint analysis: an estimation probe in new venture decisions. *Journal of Business Venturing*. 7: 505-518.

Sapienza H.J., Amason A.C., Manigart S. (1994). The level and nature of venture capitalist involvement in their portfolio companies: a study of three European countries. *Managerial Finance*. 20(1): 3-17.

Shepherd D.A., Zacharakis A. (1998). Conjoint analysis: a new methodological approach for researching the decision policies of venture capitalists, *Venture Capital*. 1(3): 197 – 217.

Shepherd D.A. (1999). Venture capitalists' introspection: A comparison of "In Use" and "Espoused" Decision Policies. *Journal of Small Business Management*. 37(2), pp. 76-87.

Tajfel H. (1982). Social Identity and Intergroup Relations. New York.

Teece D.J. (1986). Profiting from technological innovation: implications for integration, collaboration, licensing, and public policy. *Research Policy*. 15, pp. 285-305.

Tellis G.J. Disruptive Technology or Visionary Leadership? (2006). Journal of Product Innovation Management. 23(1), pp. 34-38.

Tyebjee T.T., Bruno A.V. (1984). A model of VC investment activity. *Management Science*. 30: 1051-1066.

Williamson O.E. (1985). The Economic Institutions of Capitalism. Free Press, New York.

Wood, R., and Bandura, A. (1989). 'Social Cognitive Theory of Organizational Management', *Academy of Management Review*, Vol. 14 (3), pp. 361-384.

Wright M., Lockett A., Clarysse B., Binks M. (2006). University spin-out companies and venture capital. *Research Policy*, 35(4), 481-501.

Zacharakis A.L., Shepherd D.A. (2001). The nature of information and overconfidence on venture capitalists' decision making. *Journal of Business Venturing*. 16, pp. 311-332.

Zacharakis A.L., Meyer G.D. (1998). A lack of insight: do venture capitalists really understand their own decision process? *Journal of Business Venturing*. 13, pp. 57-76.

TABLE 1

Trade-off table conjoint analysis

Characteristics of…	Attribute	Levels (potential events)
A) Team	1) Team	1) non complementary and no business experience
		2) complementary and business experience
		3) non complementary and business experience
B) Entrepreneur	2) Entrepreneur	4) leader: yes
		5) leader: no
		6) perseverance: yes
		7) perseverance: no
	3) Contact	8) contact with VC: good
		9) contact with VC:bad
C) Proposed product or service	4) Uniqueness	10) product is unique
		11) product is not unique
	5) Market acceptance	12) product is accepted by the market
		13) product is not accepted by the market
D) Technology	6) Protection	14) protection is possible
		15) protection is not possible
	7) Platform	16) it is a platform technology
		17) it is no platform technology
E) Targeted market	8) Geography	18) the market is regional
		19) the market is global
	9) Size	20) it is a niche market
		21) it is a mainstream market
	10) Growth	22) the market is seemingly high growth
		23) the market is low growth
F) Financial forecast	11) Time to break-even	24) expected time to breakeven is less than 1,5 years
		25) expected time to breakeven is more than 3 years
		26) expected time to breakeven is between 1,5 and 3 years
	12) Return on investment	27) expected return is less than 30%
		28) expected return is more than 50%
		29) expected return is between 30 and 50%

TABLE 2

Descriptive statistics and correlations

	Mean	S.D.	1	2	3	4	5	6	7	8
1. Percentage public capital	21.68	36.57	1.00							
2. Financial experience	2.23	4.65	.27*	1.00						
3. Consulting experience	1.02	2.03	-.04	-.02	1.00					
4. Management experience	4.55	6.07	.02	-.23	-.04	1.00				
5. Investment management experience	4.86	3.83	.08	-.06	-.23	-.03	1.00			
6. Biotech focus	.26	.36	-.03	-.13	-.07	.20	-.03	1.00		
7. Fundage	8.06	9.45	.04	-.02	.01	.01	.25*	.11	1.00	
8. Fund capital (million Euro)	269.49	649.36	.17	-.13	.05	-.03	-.09	.02	.41*	1.00

Note: Pearson correlation for continuous variables, *correlations are significant at p>0.05, n=68

TABLE 3: binary logistic regression analysis (0=traditional investor; 1=high-tech investor)

	Base model	Base model + public intervention	Base model + human capital	Base model + exit orientation	Full model
Public intervention					
Percentage public capital		.009			.015*
		(.007)			(.009)
Specific human capital					
Academic experience			2.338*		.780
			(1.214)		(1.302)
Technical education			.236		-.004
			(.723)		(.816)
General human capital					
Financial experience			-.115		-.123
			(.112)		(.111)
Consulting experience			.067		.110
			(.143)		(.149)
Management experience			.051		.029
			(.046)		(.052)
Investment management experience			.158*		.217*
			(.087)		(.111)
Business administration education			.753		.880
			(.730)		(.856)
Exit orientation					
Biotech focus				2.888***	3.274***
				(.906)	(1.153)
Control variables					
Fund age	-.037	-.052	-.065	-.047	-.114*
	(.001)	(.045)	(.052)	(.044)	(.068)
Fund capital	.001	.002	.001	.001	.003
	(.041)	(.001)	(.001)	(.001)	(.002)
Constant	-.338	-.516	-1.881*	-1.015**	-2.994**
	(.335)	(.370)	(1.132)	(.426)	(1.407)
Model					
Chi-Square	3.109	4.736	17.631**	16.745***	29.373***
Concordant Ratio	61.8%	63.2%	73.5%	73.5%	76.5%
-2Log Likelihood	89.03	87.40	74.508	75.394	62.766
Cox & Snell R^2	.045	0.067	.228	.218	.351
Nagelkerke R^2	.060	0.091	.308	.294	.473

Note: Levels of significance: *=0.10; **=0.05; ***=0.01; ****=0.001; n=68