The risk and return of venture capital

Historical return, alpha, beta and individual performance drivers (1983-2009)

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April 2014

Abstract

We analyse the returns and the risk profile of venture capital based on a sample of 1,953 funds raised between 1983 and 2009. In a historical perspective, we first show that the strong returns during the dotcom era are followed by a decrease and a convergence of returns. However, we find strong evidence of outperformance compared to public markets, with a PME of 1.26 (vs. S&P500) and 1.08 (vs. Nasdaq). In a second time and in order to assess the risk profile and the risk-adjusted returns of venture capital, we focus on the beta and alpha of this asset class. Beta stands between 1.0 and 1.8 and the quarterly CAPM alpha between 0.3%-5.1%, revealing a clear positive risk-adjusted performance. Lastly, we focus on individual fund characteristics as potential drivers of performance. If we find no evidence of size driving overall returns, we show that location (US) is a strong determinant of performance. Stage-focus does not influence returns, unless the fund is a general fund, in which case returns are driven downwards. Finally, we confirm the negative relationship between IRR and duration, and show that funds whose payback period is shorter are likely to outperform.

Keywords: venture capital, private equity, performance, return.

Acknowledgements: I would like to first thank Mr. Christophe Spaenjers for supervising this research paper. I am also very grateful to Mr. Amaury Bouvet for helping me to understand the different databases and collect data.

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1 Introduction

This paper examines the performance of venture capital as an asset class. By definition, venture capital is a component of private equity, the act of investing in the equity of a private, non-listed, company. Among private equity, venture capital funds seek returns by investing in young companies whereas buyout funds target mature and established companies. Despite the dramatic growth in private equity investments over the last twenty years, the very basic characteristics of venture capital remain controversial: if an extensive research already exists on the subject, the studies have reached different findings and no consensus exists on questions such as the risk and return of this asset class. For Gompers and Lerner (2000), the risk-return profile is precisely "what we don't know about venture capital".

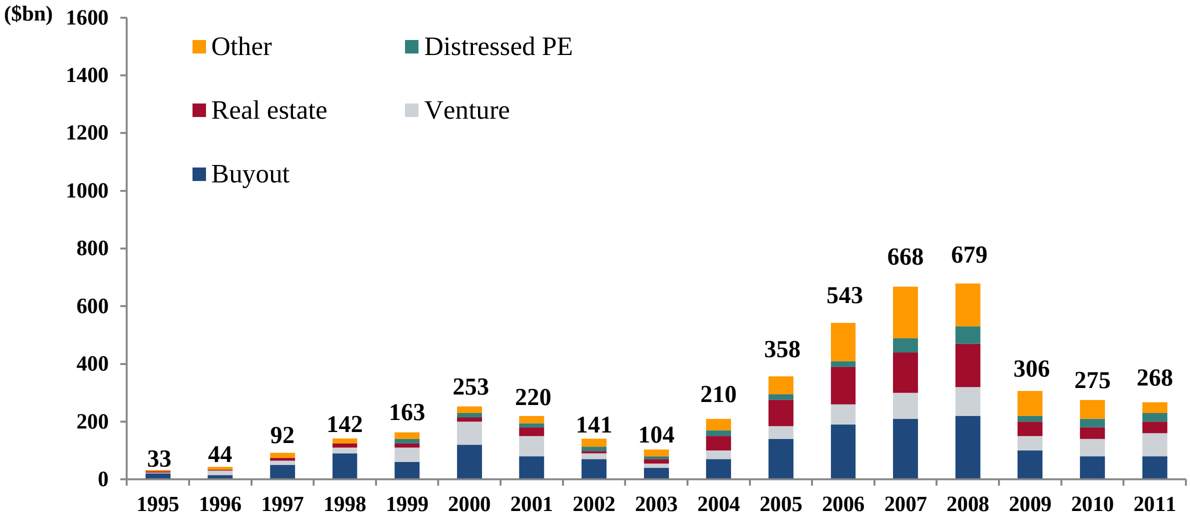
The main goal of this paper is therefore to get a better understanding of the returns of the venture capital asset class. First, what is the historical performance of venture capital investments, and how this performance compares to public equities? Do they yield larger risk-adjusted returns than publicly traded securities? The existing research emphasizes the different cycles in the performance of venture capital, with increasing returns for funds raised in the 80s and the 90s (Ljungqvist and Richardson (2003)) and a reversed pattern after 1999 and the Internet bubble (Harris, Jenkinson and Kaplan (2013)), however the average return during these cycles and whether or not funds have outperformed public markets remains controversial. Second, we would like to understand the specificity of venture capital investments and therefore estimate the alpha and beta of such investments[1]. From a theoretical standpoint, the illiquidity of such investments in private companies should lead to a premium and consequently to high returns in comparison to the overall market. Moreover, venture capital firms often keep around two percent of the invested capital (see Gompers and Lerner (1999), Lerner, Schoar and Wongsunwai (2007)) to compensate for their monitoring role within portfolio companies, which should normally result in a high performance (Admati and Pfleiderer (1994)). Finally, we would like to characterize the type of fund which outperforms and underperforms in terms of size, geography and stage specialisation. This will be the last focus of this paper.

[1] The beta, defined more precisely later in this paper, represents the degree of correlation between an asset and the overall market. The alpha measures how effectively an asset has outperformed or underperformed the theoretical performance. It depends on the model used to forecast asset returns.

1.1 Why the performance of venture capital funds matters

The private equity asset class, made mainly of buyout and venture capital funds, has grown importantly since 1990, with institutional investors dedicating more and more capital to private equity in their tactical allocation. A good example is given by the Harvard endowment, allocating 0% to private equity in 1980, 7% in 1984 and 16% in 2013[1]. Within this asset class, venture capital has increased significantly as well, from $3bn flowing into venture funds in 1990 to around $100bn in 2012. Venture capital has consequently been the fastest growing segment among private equity, with a 1995-2011 CAGR of 20%.

Figure 1: Global private equity capital raised by fund type



Source: "Global Private Equity Report", *Bain & Company*, p.25.

One of the reasons of the success of the private equity segment among asset managers is probably its hedging property. Many invest heavily in private equity with the belief that the returns of private equity investments are largely uncorrelated with public markets and business cycles. As an example, the Yale endowment reports that such funds "can generate incremental returns independent of how the broader market will be performing[2]", something interesting given the current context in public markets. This belief, discussed later in this paper, has already received attention from previous research. According to Gottschalg, Phalippou and Zollo (2003), the performance of venture funds strictly follows business cycles and consequently the beta for such investments should be around one, as documented by Lerner and Schoar (2005).

[1] "Harvard Management Company", *An evolving view of asset classes: Creating the optimal mix of investments*.
[2] *The Yale Endowment 2010*.

Moreover, venture capital is interesting from a macro perspective. It enables young and innovative companies to receive financing from outside investors to finance their growth. Given the uncertain prospects, it is difficult for start-ups to receive bank financing and venture capital can often be an efficient way to grow and professionalize young companies, as evidenced by Hellman and Puri (2002). A company like Sequoia Capital, one of the biggest venture capital firms specialized in technology companies, has helped Cisco, Nvidia, Apple or Youtube grow and become strong established companies. According to Hege and Palomino (2003), the strong economic growth in the US in comparison to Europe can partly be attributable to the emphasis put on venture capital and contractual differences such as the greater use of control rights. It is therefore clear that venture capital plays an important role as a catalyst for economic growth and knowing more about the risk and return of these investments is of primary importance.

1.2 Overview of the research paper

In this paper, we analyse the performance of funds based on the IRR measure traditionally used in private equity. However, this measure is imperfect for at least two reasons, described into more details in section 3. Firstly, it assumes that all the proceeds are reinvested at the IRR, which of course is not the case. Secondly, it does not take into account the return on public markets. Bradley, Mulcahy and Weeks (2012) recommend "rejecting performance marketing narratives that anchor on internal rate of return" and "adopt public market equivalent as a consistent standard for VC performance reporting" instead. This is why we build another measure, the public market equivalent (PME), based on the methodology developed by Kaplan and Schoar (2005). This metric compares the return one gets by investing all the money into the fund, basically the IRR, and the return obtained by investing everything into public markets, using for example the return of the S&P500.

This paper answers three questions that previous research has not answered yet or for which there is not a clear consensus: firstly, whether venture capital funds have historically outperformed public equities and whether its performance help justify the dramatic growth of this asset class; secondly, define the alpha and beta of this asset class; finally, whether size, geography and stage specialisation are explanatory variables of a fund performance.

We show that historically venture capital funds have yielded an average IRR of 9% and have significantly outperformed public markets, with a PME of 1.26 using the S&P500 and 1.08 using the Nasdaq Composite index. Especially, funds raised between 1993 and 1996 have had a very strong performance. However, it seems that the overall performance of VC funds is being less and less volatile and is converging both in the US and Europe, because of a maturing market.

Using three different venture capital indices from VentureXpert, Cambridge Associates and Sand Hill Econometrics, we estimate the beta and alpha of venture capital. We also test for sensitivities using two benchmarks: the S&P500 index and the Nasdaq Composite Index. We find that the beta lies between 1.0 and 1.8, close to the findings of previous literature. This result is consistent with both the S&P500 and the Nasdaq Composite Index and proves that venture capital tends to overreact to public markets. However, this beta is calculated using lagging market returns, which shows that venture capital returns are linked to current and past market returns. We document a positive quarterly alpha between 0.3% and 5.1% revealing a strong risk-adjusted return for venture capital.

Finally, we find evidence that location can be considered as a performance driver. Funds in the US significantly outperform European funds. Additionally, we confirm the theoretical negative relationship between the lifetime of a fund and its return, suggesting for practitioners to focus on general partners showing a strong ability to exit investments quickly. However, this conclusion is to be mitigated by the difference between US and Europe, where this relationship is weaker. Eventually, if non-specialized funds slightly underperform the venture capital industry, stage specialisation and size have little explanatory power over the return of a fund.

The rest of the paper proceeds as follow. Section 2 provides some theoretical background on venture capital, describing the typical structure of a private equity investment. Section 3 surveys and summarizes the relevant literature. In section 4, we present our research questions and lay out our hypotheses. Section 5 presents the dataset obtained from VentureXpert and warns the reader about potential biases. It also describes the variables that will be used in our empirical analysis. Section 6 presents the key findings of the empirical analysis. Section 7 concludes.

2 Theoretical background on venture capital

2.1 The emergence of venture capital

Gompers (2004) situates the emergence of venture capital in the early 80s in the US, after changes in the Employee Retirement Income Security Act (ERISA). Before, this act largely prohibited pension funds from allocating large amounts of money to high-risk assets including venture capital. After 1979, they were allowed to invest up to 10% of their capital into venture funds.

However, as early as the 19th century, the ancestors of venture capital began to look for risky, high-return investments in diverse industries, as described by David Lampe and Susan Rosegrant: "The city's great fortunes, including those of the Vanderbilts, Whitneys, Morgans and Rockefellers, were based on such ventures as railroads, steel, oil and banking. Although not all investors were so well-known, it was wealthy families such as these that bankrolled Boston's earliest high tech entrepreneurs. When the young Scot Alexander Graham Bell needed money in 1874 to complete his early experiments on the telephone, for example, Boston attorney Gardiner Green Hubbard and Salem leather merchant Thomas Sanders helped out, and later put up the capital to start the Bell Telephone Co. in Boston"[1].

After the 80s, venture capital became more and more important and reached a peak at the end of the 90s with the high-tech bubble. It is documented that even some buyout funds allocated part of their investments to start-ups during this period.

2.2 Types of private equity investments

Private equity is made of 5 main classes: venture capital, growth capital, mezzanine financing, leveraged buyout and distressed buyouts, investing at distinct stages of development:

- Venture capital firms typically invest in start-ups at an early stage of development with a negative cash-flow generation. The investment is generally a minority stake characterized as high-risk/high-return.
- Growth capital is made of equity or debt investments in growing companies that require additional financing for their working capital, capital expenditures or acquisitions.

[1] "Route 128: Lessons from Boston's High-Tech Community", 1993.

- Mezzanine funds invest in mezzanine debt or preferred equity, i.e. all the instruments between traditional equity and senior debt on the balance sheet.
- Leveraged buyout (LBO) is the biggest class among private equity. LBO funds seek returns from the acquisition of mature companies with a significant amount of debt or borrowed funds.
- Distressed buyout funds purchase distressed companies below market value looking for example for a corporate restructuring.

A private equity firm is generally specialized into one of these investment strategies. Moreover, there is often a geographical focus, either at a country (United States) or a regional level (Western Europe, South-East Asia, etc.) as well as an industry focus (real estate, retail, healthcare, technology, media & telecom, etc.).

2.3 Private equity investment structure and definition of terms

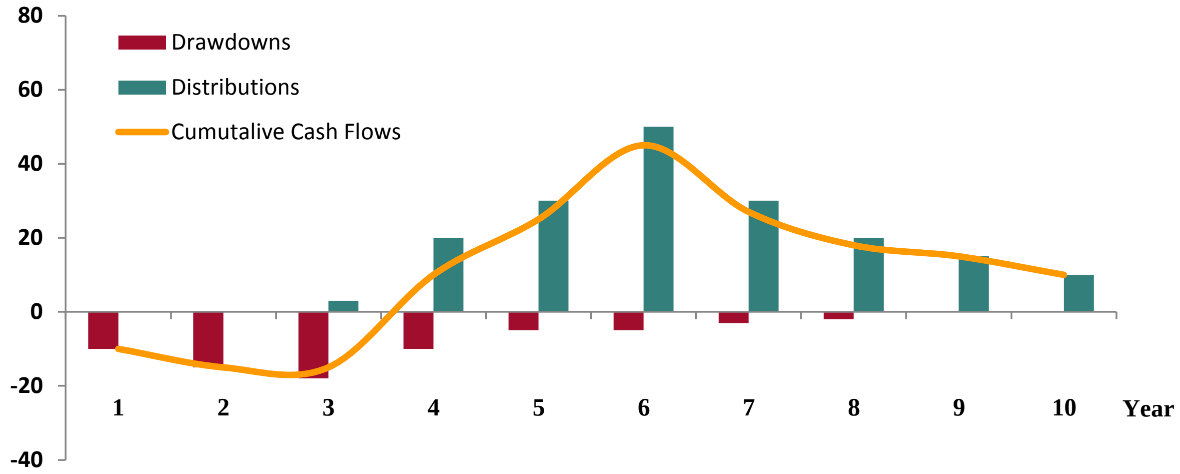
A private equity firm, known as the *general partner* (GP), is traditionally made of several investment teams raising capital from outside investors, the *limited partners* (LPs). Limited partners are typically endowments, pension funds, high net worth individuals or any other type of institutional investor. Once the fund is created, the GP is the manager, whereas LPs are only passive investors. In this paper, we will call *capital commitment* every amount of money flowing from a limited partner to the fund, basically the amount of money that investors have agreed to subscribe to the fund. It is important to note that the capital is flowing to the fund only once the GP has found an interesting project to invest in. Consequently, the committed capital is gradually invested into different projects, what we define as a *draw-down*. The capital committed that the fund has not drawn down is called *undrawn commitment* whereas the part invested by the fund is characterized as *assets under management*. The sum of these two items – assets under management and undrawn commitments – minus the net debt[1] used for financing gives the *net asset value*. The GP is required to invest the capital generally between 3 to 5 years and has then another 5 to 7 years to exit its investment and give back the money to the LPs, what we call a *distribution*.

A private equity investment is therefore nothing else than a stream of cash inflows and cash outflows, usually described as the "J-curve". The J-curve is precisely what makes the valuation of private equity investments difficult, as we need to estimate the whole net asset

[1] Net debt equals total debt minus cash, which can be used to pay back the debt.

value at any point in time, or every quarter as reported by VentureXpert, which means knowing the value of the undrawn and the invested capital. The actual return is known only at exit, when the fund is liquidated and when we can observe the cash-flows that are given back to investors.

Figure 2: J-curve description



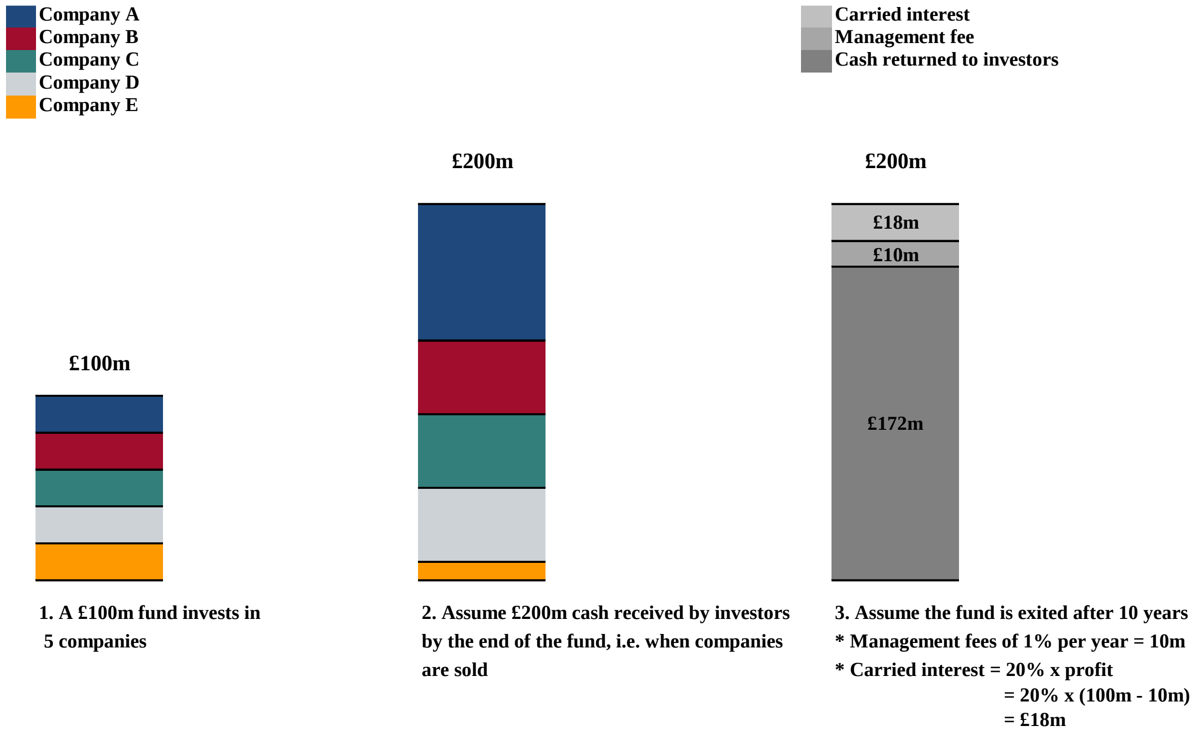
Source: "Investment Banking: Valuation, Leveraged Buyouts, and Mergers & Acquisitions", J. Rosenbaum and J. Perella, *John Wiley & Sons*, 2009.

To remunerate the general partner for its expertise and management of investments, venture capital firms generally charge a 2% interest based on asset under management. Then, if the fund has reached a minimum return known as the *hurdle rate*, generally 8%, it takes an additional 20% performance fee called *carried interest* from exited investments (Gompers and Lerner (1999), Lerner, Schoar and Wongsunwai (2007)). Figure 3 below should clarify the traditional fee structure of any private equity firm.

2.4 Overview of venture capital funds

Actors in the venture capital landscape are extremely diversified. First, venture capital funds are bigger in the United States than somewhere else and the industry is somehow maturing. In Europe and Asia, the industry is growing importantly and venture capital is still much less established than in the US. Structural differences also exist between the US and Europe, such as "the more frequent use of convertibles in the US and the replacement of the entrepreneur", as studied by Hege, Palomino and Schwienbacher (2003).

Figure 3: Private equity fee structure



Source: 3i 2007 annual report.

Differences also appear in the specialisation, with firms focusing on different stages. The first stage in VC investing is *seed*, targeting companies with not yet established operations. The next stage is the *early* stage for companies able to begin operations but needing to boost sales. Finally, the *late* stage provides capital to well-established companies generally before an initial public offering.

3 Literature review

In this section, we review the existing literature about the performance of venture capital funds, keeping in mind the 3 objectives of this paper:

- Understand the average historical performance of venture capital and determine whether or not this asset class has outperformed public markets.
- Study the risk-adjusted return of venture capital, focusing on the alpha and beta of this asset class.
- Focus on individual characteristics of funds such as size, geographic focus and stage specialisation and see how they help explain the overall performance of a fund.

We have focused primarily on papers which analyse the performance at a fund level, which corresponds to our approach, some research studying the return of each investment. Moreover, all the data below is net of fees, i.e. after management fees and carried interest have been paid out to the fund. Beyond our three questions, a first part will be dedicated to performance measurement. The two last subsections will deal with the persistence in performance and the problem of success bias in the sample selection.

3.1 How to measure the performance of a private equity investment

The first measure one naturally think about when speaking of private equity is the internal rate of return (IRR), as this is the most commonly used measure in this industry. By definition, the internal rate of return is the discount rate that makes the net present value of a stream of cash flows equal to zero, i.e.:

$$-\mathrm{CF}_0 + \frac{\mathrm{CF}_1}{1+\mathrm{r}} + \frac{\mathrm{CF}_2}{(1+\mathrm{r})^2} + \cdots + \frac{\mathrm{CF}_\mathrm{n}}{(1+\mathrm{r})^\mathrm{n}} = 0$$

In the case of a private equity investment and referring to the previously described J-curve, the equation looks like:

$$-Draw_0 + \frac{Dist_1 - Draw_1}{1+\mathrm{r}} + \frac{Dist_2 - Draw_2}{(1+r)^2} + \frac{Dist_3}{(1+r)^3} + \cdots + \frac{Dist_\mathrm{n}}{(1+r)^n} = 0$$

where *Draw* represents the draw-downs from the LPs to the fund and *Dist* the distributions from the fund to the GP. Here, the investment period is 2 years and the fund exits the investments after n years.

The advantage of the IRR measure is its simplicity. However, the IRR implicitly assumes that all the cash flows distributed to LPs have been reinvested at the same rate (Gottschalg, Phalippou and Zollo (2003), Jagannathan and Sorensen (2013)). For example, if a fund has a return of 40% and distributed half of the cash very early in the investment life, this number assumes that the amount of money distributed early has been reinvested at a rate of 40% as well, which is very unlikely. This is the reason why it is difficult to compare several investments with the same IRR and a different duration.

The solution brought by Gottschalg and Phalippou is the modified IRR (MIRR) which assumes a fixed rate at which distributions are reinvested, rather than the IRR itself. In their study of 1,184 funds raised between 1980 and 1995, they show that the top-performing fund has an unrealistic IRR of 464% and an M-IRR of 31% using a fixed rate of 8%. Therefore, IRRs can be misleading when comparing the performance of funds, in addition to skewing the performance of "star" funds.

However, there is a second issue with the IRR: as an absolute measure, it does not adjust for the market return, contrary to the CAPM equation, for instance. A new measure, the *public market equivalent* (PME), was introduced by Long and Nickels (1996) and has then been refined by Kaplan and Schoar (2005). The idea is to compare the IRR of the fund with the IRR the investor would have got by investing all the commitments in the S&P500, for instance. According to the definition of terms, if $dist(t)$ and $call(t)$ respectively denote the distribution from the fund to the LPs and the capital calls from the LPs to the fund at time *t*, and $R(t)_M$ is the realized market return (from the S&P500, for example) from the inception of the fund to the time of the distribution or the capital call, then PME is defined as:

$$PME = \frac{\sum_t \frac{dist(t)}{1 + R(t)_M}}{\sum_t \frac{call(t)}{1 + R(t)_M}}$$

As an illustration, a PME of 1.03 means the fund has returned 3% more than public markets over the investment period. You can refer to the numerical example below for a comparison between these three performance measures.

In this example, we suppose that the fund manages to raise $100m from diverse limited partners. It invests these $100m successively during the first 2 years: $60m are invested directly, $20m are invested during year one (for simplicity about discount rates, we suppose that this amount is invested at the end of the year) and finally $20m are invested at the end of year 2. These investments generate distributions (in the form of cash-flows or shares) from year 2 ($5m) to year 10 ($100m) for a total of $295m.

As shown in the table below, the results vary considerably according to the metric used to assess the performance of the fund. The IRR gives an annualized rate of 18.5%. Assuming that all cash-flows are reinvested at a fixed rate of 8%, the MIRR is 14.4%. A fixed rate of 10% gives a 15.1% MIRR and 13.3% when using 5%. Consequently, the value of the MIRR is not extremely sensitive to the fixed rate. Finally, the PME in this example is very high, 3.29.

Figure 4: Performance measurement - A numerical example

Commitments ($m)	100
Distributions ($m)	295
Duration (years)	10

Multiple of invested capital	**2,95**

IRR Calculation

Year	0	1	2	3	4	5	6	7	8	9	10
Commitments	60	20	20	0	0	0	0	0	0	0	0
Distributions	0	0	5	10	20	40	40	40	20	20	100
Total	**-60**	**-20**	**-15**	**10**	**20**	**40**	**40**	**40**	**20**	**20**	**100**

IRR	**18,5%**

MIRR Calculation

Reinvestment rate	**8%**										
Year	0	1	2	3	4	5	6	7	8	9	10
Commitments	60	20	20	0	0	0	0	0	0	0	0
Distributions	0	0	5	10	20	40	40	40	20	20	100
Total	**-60**	**-20**	**-15**	**10**	**20**	**40**	**40**	**40**	**20**	**20**	**100**

Discounted commitments **95,7** ← **= 60+20/(1+8%)+20/(1+8%)**

Compounded distributions **366,6**

= 5*(1+8%)^8+10*(1+8%)^7+…+20*(1+8%)+100

MIRR	**14,4%**

PME Calculation

Year	0	1	2	3	4	5	6	7	8	9	10
S&P 500	-10,1%	-13,0%	-23,4%	-10,1%	26,4%	9,0%	3,0%	13,6%	3,5%	-38,5%	23,5%
Commitments	60	20	20	0	0	0	0	0	0	0	0
Distributions	0	0	5	10	20	40	40	40	20	20	100
Total	**-60**	**-20**	**-15**	**10**	**20**	**40**	**40**	**40**	**20**	**20**	**100**

Discounted commitments 113,0 ← **= 60+20/(1-13.0%)+20/[(1-23.4%)*(1-13.0%)]**

Discounted distributions 372,0 ←

= 5/[(1-23.4%)*(1-13.0%)]+10/[(1-10.1%)*(1-23.4%)*(1-13.0%)+...]

PME	**3,29**

As noted by Jagannathan and Sorensen (2013), the PME is a strong alternative to the standard CAPM measure, according to which the present value should be calculated using the standard discount rate, where r_f is the risk-free rate, β represents the systematic risk of the underlying asset and $E[R_M] - r_f$ is the expected market risk premium:

$$r_{CAPM} = r_f + \beta(E[R_M] - r_f)$$

The PME calculation, which is an ex-post performance measure, seems to be missing the beta that accounts for the risk of the investment, hence why Robinson and Sensoy (2011) concluded that the PME is unlikely to reflect the true risk-adjusted return as it is valid if and only if we assume venture capital has a beta of 1. This will be one of the questions we will answer further in this paper.

Another problem faced by academics is the estimation of the *net asset value*. As previously described (cf. J-curve description), the actual return is known only when the fund is liquidated and once we can observe the cash flows which are given back to investors. Performance can consequently be significantly influenced by the way we estimate non-exited investments, as neither the fund nor its underlying investments are publicly traded. As evidenced by Brown, Gredil and Kaplan (2013), managers tend to boost the NAV during times of fundraising activity. According to them, the NAV can also be manipulated through selective disclosure, the quarterly valuation being performed by external advisors. In general, the quarterly reported accounting value is the unique way of assessing the net asset value. As described by Blaydon and Horvath (2002), accounting practices in private equity vary considerably despite mark-to-market guidelines proposed by the US National Venture Capital Association.

For Kaplan and Schoar (2002), there is a strong correlation coefficient (0.9) between the IRR of the residual asset value and the IRR of the cash flows already distributed to the LPs, hence why the estimation of the IRR of unrealized investments is not an issue. However, Diller and Kaserer (2004) prefer to include liquidated funds for which they have a precise measure, and add unliquidated funds to their sample if and only if they meet the following condition:

$$\frac{Residual\ NAV}{\sum_{t=0}^{N} |CF_t|} \leq q$$

Choosing a q of 0.1, they added non-liquidated funds for which the residual value was not higher than 10% of the absolute value of all previously accrued cash flows, i.e. funds for which the unliquidated part accounted for less than 10% of the whole investment value. Gottschalg, Phalippou and Zollo adopted a different approach to estimate the residual NAV. They studied how empirically residual values for unliquidated funds converted into effective cash flows and showed that historically residual values have underestimated the actual value of future cash flows. They then used a conversion matrix to convert accounting values of residual NAVs into the cash inflow equivalent, implicitly assuming that the historical pattern would hold in the future.

3.2 Understanding the risk-return profile of VC: historical performance, comparison with public markets, alpha and beta

There is no consensus among academics regarding the performance of the venture capital industry, as we can see in the following table. All the PME numbers below, unless otherwise stated, are based on the performance of the S&P500.

Figure 5: Historical performance of VC - Summary of findings

Authors	**Findings**	**Period covered**	**Method**
Bygrave & Timmons (1992)	¤ Average IRR: 13.5%	1974-1989	Portfolio company-level
Woodward & Hall (2003)	¤ Average IRR: 20%	1980-2000	Fund-level analysis
Kaplan & Schoar (2005)	¤ Average IRR: 17% ¤ Average IRR: 0.96	1980-2001	Fund-level analysis
Janeway & McKenzie (2008)	¤ Average PME (S&P): 1.98 ¤ Average PME (Nasqaq): 1.59	1980-2005	Fund-level analysis
Ljungqvist & Richardson (2003)	¤ Average IRR: 19.81%	1981-2001	Fund-level analysis
Robinson & Sensoy (2011)	¤ Average IRR: 9% ¤ Average PME: 1.03	1984-2010	Fund-level analysis
Peng (2001)	¤ Average IRR: 55%	1987-1999	Portfolio company-level
Lerner, Schoar and Wongsunwai (2007)	¤ Average IRR (early): 14% ¤ Average IRR (late): 8%	1991-2001	Fund-level analysis

As we can see, the results change significantly when compared to the performance of public markets. For example, Robinson and Sensoy report a pretty strong IRR of 9% over the 1984-2010 period, but a low PME of 1.03, meaning that funds have outperformed the S&P500 by only 3% over their life.

A second interesting point about public markets is the degree of systematic risk embedded in venture capital transactions. Previous research has extensively focused on this subject, and we have found necessary to describe the different methodologies used to estimate the beta of venture capital first, then to summarize the different estimates of alpha and beta of this asset class.

By definition, the beta measures the systematic risk of an asset compared to a benchmark, generally an index of publicly traded securities such as the S&P500. If $r_{S\&P}$ represents the return of the S&P500 and r_{fund} the return of the observed fund, then the beta for this fund is given by the following formula:

$$\beta = \frac{Cov(r_{fund}, r_{S\&P})}{Var(r_{S\&P})}$$

In order to estimate this beta, the first, straightforward approach has been used by Phalippou and Zollo (2005): for a given fund, they look at the quarterly reported IRR and the performance of the S&P500 during the same quarter. Then, they look at the covariance between the fund's returns and the market return to get the beta and alpha coefficient in an OLS regression[1]. For their results to be valid, they rely on two strong assumptions: that the CAPM hold and that betas are the same within each industry. However, Kaplan and Schoar, using an investment-level approach, estimate the beta differently. For each investment made by the fund, they look at the average unlevered beta[2] of the corresponding industry using traded comparable companies, then re-lever it using the capital structure used in the financing of the transaction. The method is explained in the figure below:

Figure 6: Estimation of the beta of VC - Kaplan and Schoar method

Commitments ($m)	100
Number of investments	3
Tax rate	35%

Investment 1		**Investment 2**		**Investment 3**	
Value ($m)	20	**Value ($m)**	50	**Value ($m)**	30
% total	*20,0%*	***% total***	*50,0%*	***% total***	*30,0%*
Industry	Telecom	**Industry**	Healthcare	**Industry**	Retail
Industry average beta	1,2	**Industry average beta**	1,4	**Industry average beta**	0,9
% debt in the transaction	80%	**D/E for the transaction**	60%	**D/E for the transaction**	90%
Transaction beta	1,8	**Transaction beta**	1,9	**Transaction beta**	1,4
= 1.2*[1+80%*(1-35%)]					

Fund beta
1.8x20% + 1.9x50% + 1.4x30% = 1.8

[1] The principles of OLS regressions will be detailed in the next session of the paper.
[2] The unlevered beta does not take into account the capital structure of a project. If D denotes the amount of debt used in the financing structure of the transaction, E the amount of equity and T_C the tax rate, we have the following link between levered and unlevered betas: $\beta_{Levered} = \beta_{Unlevered} \times (1 + \frac{D}{E}(1 - T_C))$.

Differently, to estimate whether venture capital funds bear some systematic risk exposure, Harris, Jenkinson and Kaplan (2013) tested the sensitivity of the PME measure to different beta levels. By successively assuming that VC investments earns respectively 1.0, 1.5 and 2.0 times the S&P500, they find really close PMEs, indicating a low correlation between the return of VC funds and the return of publicly traded securities. Cochrane (2005) and Gompers, Kovner, Lerner and Scharfstein (2005) find that the VC industry, far from being efficient[1], is highly volatile compared to public markets, due to investors overreacting to perceived investment opportunities.

On the question of the level of systematic risk of venture capital funds, academics, to a certain extent, seem to reach a consensus, with a beta for this asset class slightly above 1, meaning that venture funds would slightly overreact to changes in public markets.

Figure 7: Beta and alpha of VC - Summary of findings

Authors	**Findings**	**Period covered**	**Method**
Cochrane (2003)	¤ Beta: 1.7 ¤ Alpha: 32% per year	1987-2000	Fund-level analysis
Woodward & Hall (2003)	¤ Beta: 0.86	1980-2000	Fund-level analysis
Gottschalg, Phalippou & Zollo (2003)	¤ Beta: 1.2	1980-1995	Fund-level analysis
Phalippou & Zollo (2005)	¤ Beta: 1.6	1980-2003	Fund-level analysis
Kaplan & Schoar (2005)	¤ Beta: 1.7	1980-2001	Portfolio company-level
Ljungqvist & Richardson (2003)	¤ Beta: 1.1 ¤ Alpha: 5-6%	1981-1993	Private data from a unique LP
Jones & Rhodes-Kropf (2003)	¤ Beta: 1.8	n.a.	n.a.
Gompers & Lerner (2004)	¤ Beta: 1.4 ¤ Alpha: 8% per year	n.a.	n.a.
Reyes (1997)	¤ Beta: 1 to 3.8 ¤ Alpha: 8% per year	n.a.	n.a.
Peng (2001)	¤ Beta: 4.7	1987-1999	Portfolio company-level
Driessen, Lin & Phalippou (2009)	¤ Beta: 3.21 ¤ Alpha: -15% per year	1980-2003	Portfolio company-level, using actual cash-flows

A last point of interest brought by previous research regarding the relationship between venture capital and public markets is the amount of capital flowing into the industry, influencing returns. The conclusion of many academics, including Ljungqvist and Richardson (2003), Lerner, Schoar and Wongsunwai (2007) and Robinson and Sensoy (2011) is that

[1] The "efficient market" hypothesis, developed by Eugene Fama, states that the price is always the right price based on the fundamentals of the asset, and that consequently any change in the price should reflect a change in the fundamentals of the asset.

venture capitalists tend to launch new funds in boom times, when public market valuations are high, but this strategy generally results in poor performance, suggesting for practitioners that a contrarian investment strategy would be successful if the historical pattern holds. For Kaplan and Schoar (2005), funds raised in times of high public markets valuations are less likely to raise follow-on funds, suggesting that they performed poorly. These deals, called "money chasing deals" by Gompers and Lerner (1999), are an important factor driving the overall performance of venture capital funds. Studying the link between public markets valuations, venture capital returns and the annual inflow into venture funds, they show that a year with high capital inflow is generally followed by a decrease in the average valuation for portfolio companies of VC funds. In line with the previously described papers of Cochrane (2005) and Gompers, Kovner, Lerner and Scharfstein (2005), they find that the venture capital market is not efficient. If finance theory teaches that the movements of equity prices, for publicly or privately owned companies, should be the consequence of a change either in the expected cash flows or in the firm's cost of capital, they proved that inflows of money into the venture capital industry do influence the valuation of privately held companies and consequently the returns of the associated VC funds.

3.3 Individual performance drivers

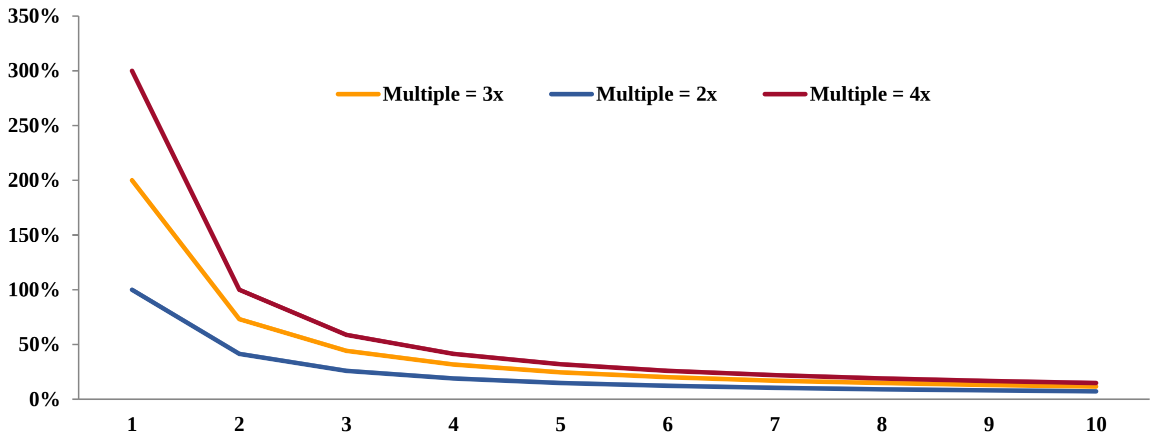
It seems interesting to analyse the performance of funds and see whether we can find some individual characteristics that could help explain why top funds perform better than other funds, characteristics such as size, geography, stage-focus or speed of capital distribution.

There is a large consensus regarding the positive effect of size. Clearly, it appears that a fund size is positively correlated to its IRR or PME. Harris, Jenkinson and Kaplan (2013) show that, ranked by size, funds in the 3rd and 4th quartiles significantly underperform funds in the 2nd and 1st quartiles. The conclusion is the same for Kaplan and Schoar (2005) and Gottschalg, Phalippou and Zollo (2003), regardless of how performance is measured. Additionally, Kaplan and Schoar display a concave relationship between fund size and return, showing that top funds seem to limit their size even if they could raise more funds from outside investors. For Driessen, Lin and Phalippou (2009), larger funds perform better only because they have a higher risk exposure, not because they have higher alphas. This conclusion means that higher betas only drive the performance of big funds, and that these funds are not better managed or do not have any superior screening capability. Lerner, Schoar and Wongsunwai (2007), on the contrary, taking the example of endowments, show how bigger funds perform better because of an early exposure to the venture capital industry and a better understanding of this asset class.

Some papers also point out geographical focus as a main individual driver of performance. The first consistent research by Hege, Palomino and Schwienbacher (2003) shows how contractual aspects differ between the United States, a mature venture capital market, and Europe, a relatively new market for venture financing, and are determinants in the success of a fund. But even more than geography, specialization is a main driver of return. As emphasized by Gompers, Kovner and Lerner (2009), generalist firms tend to underperform relative to specialist firms. This is explained by a better allocation across industries for specialist firms, as well as better investments due to a higher screening capability. However, these results can be mitigated when individuals among the generalist firm are industry specialists themselves.

Speed of capital distribution is often cited as a driver of performance. Indeed, IRR can be written: $IRR\% = \left(\frac{Value\ of\ investment\ at\ exit}{Capital\ commited}\right)^{\frac{1}{duration}} - 1 = (multiple)^{\frac{1}{duration}} - 1.$

Figure 8: IRR as a function of duration



With a constant multiple, the IRR is decreasing in duration, as shown on the above figure. However, Hege, Palomino and Schwienbacher (2003) conclude that this theoretical relationship is only empirically verified in the US, where the longer the project, the lower the return. In Europe, the relation is reversed and venture capital funds benefit from longer investment. Their idea is that European funds, involved in a less mature market than their

American counterparts, learn about the quality of the project over time and thus a greater duration translates into an even higher multiple expansion.

3.4 Is there persistence in performance?

As for the previous section about the performance of VC funds compared to public markets, we would like here to focus first on the different methodologies used by academics, then on their conclusions.

First, we have to admit that little research has been performed on this subject for venture capital. Previous research has focused on other asset classes, for example mutual funds (see Kazemi, Schneeweis and Pancholi (2003) or Bollen and Buse (2005)) and has found no evidence of persistence. Robinson and Sensoy (2011) and Kaplan and Schoar (2005) use a common methodology based on a fund sequence number. The sequence number of a fund tells if the fund is the 1st, 2nd, 3rd etc. raised by the corresponding GP. Then, testing for the size effect and the persistence, they run the following regression, where *e* represents the error coefficient of the regression:

$$PME = \alpha + \beta(FundSize) + \rho(Sequence) + e$$

FundSize represents the logarithm of the capital committed to the fund and *Sequence* the logarithm of the sequence number[1]. In their paper, Janeway and McKenzie (2008) adopt a different approach, detailed and used by Kaplan and Schoar in a previous paper, to assess whether there is persistence in performance. Focusing on a sample of 205 fully liquidated funds over a 25-year long period, they regress the IRR of the latest fund of a GP with the IRR of the two previous funds launched by the same GP. The regression equation, where *i* is the sequence number of a fund, is as follow:

$$IRR_i = \beta_0 + \beta_1 . IRR_{i-1} + \beta_2 . IRR_{i-2} + \varepsilon_t;\ \varepsilon_t \sim N(0, \sigma^2)$$

Both find that GPs whose fund outperformed are likely to raise successful follow-on funds in the future and vice-versa. This is due to the very specificity of the venture capital asset class. The observed persistence, say Janeway and McKenzie, "may well reflect the significant experience and contacts the LPs have accumulated after almost 30 years of investing". Lerner, Schoar and Wongsunwai (2007) largely corroborate this view, saying that "anecdotes in the private equity industry suggest that established LPs often have preferential

[1] The logarithm is used to smooth the results and for its additive properties.

access to funds". These factors are also considered as crucial in the GP selection by LPs for Gomper, Kovner, Lerner and Scharfstein (2006) and Hochberg, Ljungqvist and Lu (2007).

3.5 Selection biases

In the literature, a recurring reservation is made about the potential biases that could exist in the sample selection. Two biases are generally pointed out in the papers: survivorship and selection. The first one, the survivorship bias, means that only existing funds can report the numbers we have access to. Funds which largely underperformed might be dead and might not report anymore. The second one, the selection bias, represents the opportunity for existing but low performing funds to stop reporting. Therefore, the reader should keep in mind that potentially much more failed transactions or negative IRRs exist beyond the ones reported in the database. The methodologies used largely differ, and we will focus only on the most recurring ones.

The first natural idea is, as explained by Ljungqvist and Richardson (2003), to work directly on a dataset sourced from a large LP that includes all the investments made without any bias, i.e. without withdrawing any low performing fund or investment from the sample. The problem is then to know how such an LP has performed compared to other LPs in order to make some general conclusions regarding the venture capital class as a whole.

Second, Kaplan and Schoar (2005) test a potential selective reporting which would result in an upward bias in the observed returns. They use a regression by constructing a dummy variable equal to 1 for the last quarter a fund reported an IRR and 0 otherwise to test whether or not GPs stopped reporting data after successive large negative returns. However, they find no evidence of funds stopping reporting after consecutive negative changes. Another concern they raise is that GPs could stop reporting as soon as they have either a particularly good performing fund (the GP managing the fund would like to "lock" the return) or a very bad performing one. Again, they find no evidence, as GPs of star funds are more likely to keep reporting, but this is more due to the higher probability of raising a follow-on fund afterwards.

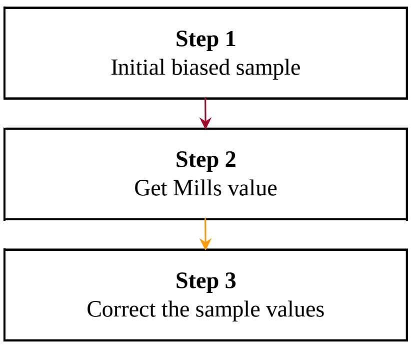
Another convincing method used by Cochrane (2004), at an investment level, is the use of a model of the probability structure of the available data. His analysis relies upon a dataset of funds, between 1987 and 2000. To correct for the selection bias, he uses Heckman's sample selection model. This model was originally built to address the problem of estimating the average wage of women, using a dataset which excluded non-working women, i.e. housewives. The problem with private equity data is similar, as we are trying to estimate the average return using mainly data from successful funds, i.e. using data following a non-i.i.d. (independent and identically distributed) distribution. The problem is as follow: we are trying to find a relationship between IRR and, say, the size of the fund and its duration. However, this information is available only if the return reaches a certain acceptable threshold (say 10%). If $X_i$is the vector (size, duration), we have the following problem:

$$\text{Under the constraint: } IRR_i^* > 10\% \quad (1)$$

$$\text{We observe: } IRR_i^* = X_i\beta + \varepsilon_i \quad (2)$$

Heckman's estimator is able to provide Cochrane with a value (for example, **15**%), called Mills value. This value gives by how much the IRRs in his sample are shifted up due to the selection bias. The interpretation of this value is that the average IRR displayed in his sample is $[\exp(\mathbf{15}\%) - 1] \times 100 = 16.2\%$ higher than a randomly selected IRR.

Figure 9: Peng and Cochrane's methodology



Using such a methodology, Cochrane finds a Mills coefficient of -1.97, and then concludes that the bias-corrected estimation reduces the average log return of venture capital funds from 108% to 15% and the alpha from 462% to 32%.

4 Research questions and hypotheses

In this section, we introduce the research questions that we aim to answer together with our expectations, based on the results synthetized in the literature review. As mentioned at the beginning of this paper, we would like to investigate three main topics regarding the performance of venture capital: the historical performance of VC funds and how it compares to public markets (1), the alpha and beta of this asset class (2) and whether individual characteristics of funds such as size, geography and stage specialization can help explain the performance of a fund (3).

Regarding the historical performance, we would like to understand the reason why investors are focusing more and more on venture capital in their asset allocation. Not only will we look at the absolute performance (IRR, MIRR), but we will also focus on the performance compared to public markets, using the public market equivalent (PME) measure.

Research question 1: What is the historical IRR yielded by venture capital funds over the 1983-2009 period?

Research question 2: Over this period, have VC funds outperformed or underperformed public markets?

Given the success of this asset class, we are expecting a high overall performance and a high PME as well. We expect to reach the conclusion by Robinson and Sensoy (2011) who cover the most recent period (1984-2010), that average IRR is around 9% per annum and the average PME is 1.03. Additionally, previous research has emphasized the dispersion in the performance of buyout funds, with top funds driving the whole performance of the industry (Phalippou and Zollo (2005)). We would like to see if this trend still holds for VC funds by analysing the dispersion of the different results.

The second research question is about the alpha and beta of VC. The beta is interesting as it translates the degree of correlation with the overall market.

Research question 3: What is the beta of venture capital?

Previous research to a certain extent agrees that the beta for VC funds is around 1.5. Our expectations are based on the most updated research paper, by Phalippou and Zollo (2005), covering the 1980-2003 period, who found a beta of 1.6. It is more difficult to anticipate what alpha could be given the dispersion of previous findings.

Finally, we would like to identify to what extent individual characteristics of funds can be seen as drivers of performance. By investigating the relation between the performance and the size, geography, stage focus and duration, we would like to characterize the type of fund that outperforms and underperforms. Our fourth research question follows the findings of Harris, Jenkinson and Kaplan (2013) who show that, ranked by size, funds in the 3rd and 4th quartiles significantly underperform funds in the 2nd and 1st quartiles.

Research question 4: Is size positively correlated with a fund return?

The next interrogation is based on the paper of Hege, Palomino and Schwienbacher (2003), who find higher returns in the mature US market than in Europe.

Research question 5: Does the location of a fund significantly impact its return?

Then, we will study the performance by stage (early stage, later stage etc.). Little research exists on this subject, and our question is based on the findings of Lerner, Schoar and Wongsunwai (2007): early-stage funds significantly outperform later-stage funds.

Research question 6: Does performance vary according to the stage of specialisation?

Finally, we will check the theoretical relationship explained at the beginning of this paper, according to which duration tends to decrease the return of a fund, as shown on figure 8.

5 Dataset, variables and potential sample biases

5.1 Presentation of VentureXpert and potential sample biases

The VentureXpert database (previously called "Thomson Venture Economics" or "TVE") is provided by Thomson Reuters and is considered the reference database, used in many previous research papers[1]. Contrary to some mutual fund databases (see Carhart, Carpenter and Lynch (2002)), VentureXpert does not drop data from the database if it falls below a certain IRR threshold. It is based exclusively on voluntary reporting by general and limited partners, which enables to crosscheck the information and improve the quality of the

[1] Google Scholar, as of March 20, 2014, identifies 332 academic papers using the query "VentureXpert" or "Venture Economics" and "Performance".

database. VentureXpert covers 3,844 funds (both venture and buyout funds) raised since 1969, and the data we have is updated through September 30, 2013 for US funds and June 30, 2013 for EMEA[1] funds. For each fund, VentureXpert gathers individual information regarding its size, location, stage, vintage[2] year, sequence number and whether the fund is liquidated or not. The returns displayed in the database are all net of management fees, carried interest and any potential partnership expense. Different performance measures are available:

- The traditionally used IRR, calculated using quarter-end valuations
- Distribution to paid-in capital (D/PI) measures the cash returned to investors (cash outflows) in proportion to the capital calls (cash inflows).
- Residual value to paid-in capital (RV/PI) measures how much of the cash given by LPs is still waiting to be invested.
- Total value to paid-in capital (TV/PI) is the sum of the two previous indicators and provides a rough estimate of the return to LPs for a non-liquidated fund. It is also called “money multiple” or “multiple” in the private equity industry.
- Paid-in to committed capital (PI/CC) gives the percentage of committed capital which has already been paid out to the GP by LPs.
- Distribution to committed capital (D/CC) is a measure of all the cash received by LPs in proportion to all the capital they committed into the fund.

From VentureXpert, we are able to get data using different filters: the vintage year, the fund stage and its location or size. Interestingly, VentureXpert displays aggregated performance metrics in different ways:

- The average and the median.
- The capital-weighted average and median, which take into account the relative size of each fund.
- Pooled returns: the pooled method treats all funds as a single fund by summing the monthly cash inflows and outflows altogether. It has the advantage to accounts for the scale and timing of cash flows.

However, given the privacy nature of the information and for computational reasons, VentureXpert makes some simplifying assumptions, as emphasized by Gottschalg, Phalippou and Zollo (2003). First, as soon as a cash flow is registered into the database, it is attributed to

[1] Europe, Middle East and Africa.
[2] The vintage year for a fund corresponds to the year of inception.

the last day of the month in which it occurred. Second, distributions are often cash distributions, but they can also take the form of stocks. Stock distributions are recorded using the closing market price as of the distribution day. However, both LPs and GPs often have a lock-up period before being authorized to trade their shares, consequently this treatment of stock distributions is, to a certain extent, inaccurate. Moreover, the residual values, as previously defined, take into account cash, short-term and long-term equity investments, outstanding loans and other assets but exclude capital committed not drawn down.

The nature of the data and these simplifying assumptions result in sample biases. First, the data coming from voluntary reporting, the probability is strong to get a sample made of successful funds only. This is what we called "selection bias" and this is the bias overcome by Heckman's estimator (remember: Heckman wanted to get the average salary of women, but could only gather data from employed women, excluding housewives who are part of the "women" population). This would create an upward bias in our sample. However, on the other side, VentureXpert might undervalue the return of non-liquidated funds given that residual values are valued at their accounting values. We mentioned in the literature review the findings of Gottschalg, Phalippou and Zollo (2003) who used a conversion matrix to account for residual value, after analysing how undervalued IRRs were for non-liquidated funds when using the accounting residual value. Similarly, for Stucke (2011), VentureXpert undervalues the return for non-liquidated funds. He provides evidence by comparing the correct ex-post fund performance (IRR and multiple of invested capital) with the estimate given by VentureXpert before liquidation for 140 funds. The graphs on the following page clearly show that "the vast majority of the data points are below / right of the diagonal line. These are funds for which TVE reports a lower performance than they achieved in reality". The downward bias due to the use of accounting values as an estimate of residual values for non-liquidated funds is therefore evident.

To a certain extent, we can argue that the upward selection bias is partly offset by the downward bias coming from accounting values for non-liquidated funds and that the returns provided by VentureXpert should be good estimates of the "true" return of venture capital.

Figure 10: Strucke (2011) – Comparison of the TVE sample with correct performance data

This figure compares the IRRs (Chart A) and multiples of invested capital (Chart B) of incomplete U.S. funds from the TVE sample with correct performance data from LPs. The abscissa contains the (correct) values of the LP data. The ordinate contains the corresponding values presented by TVE. The scale of the axes is limited to -20% and +40% (Chart A), and to money multiples of up to 3.0 (Chart B).

Chart A: Internal rate of returns (IRR).

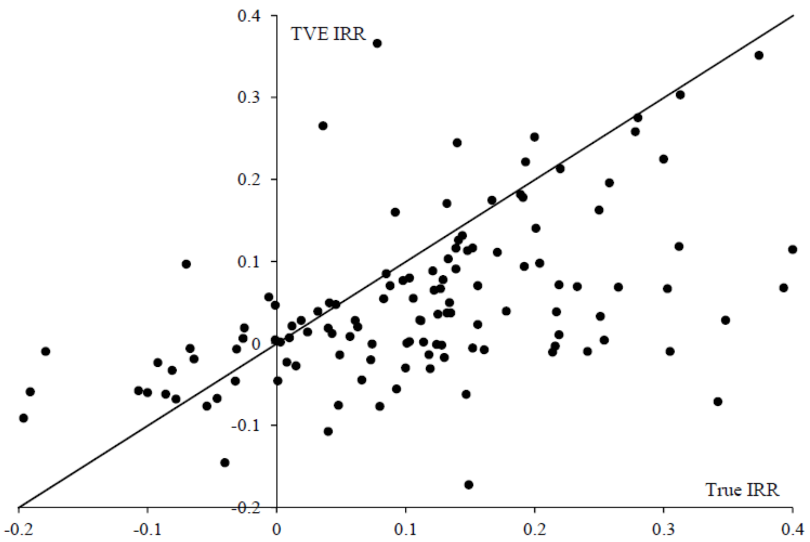
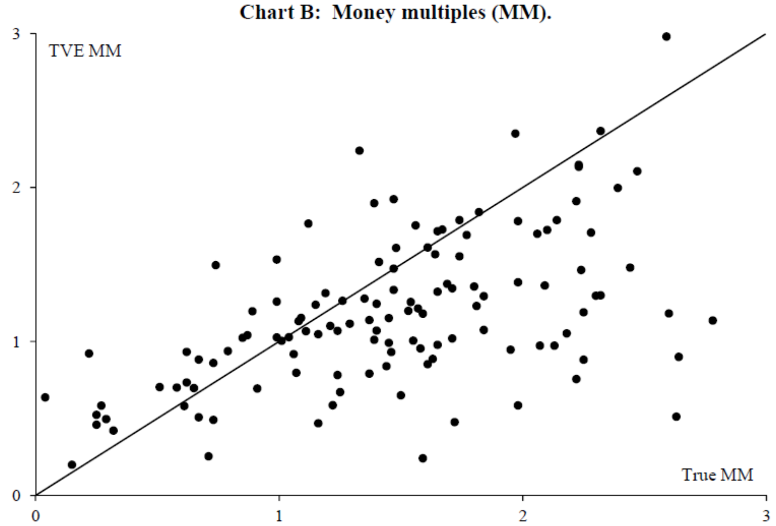


Chart B: Money multiples (MM).



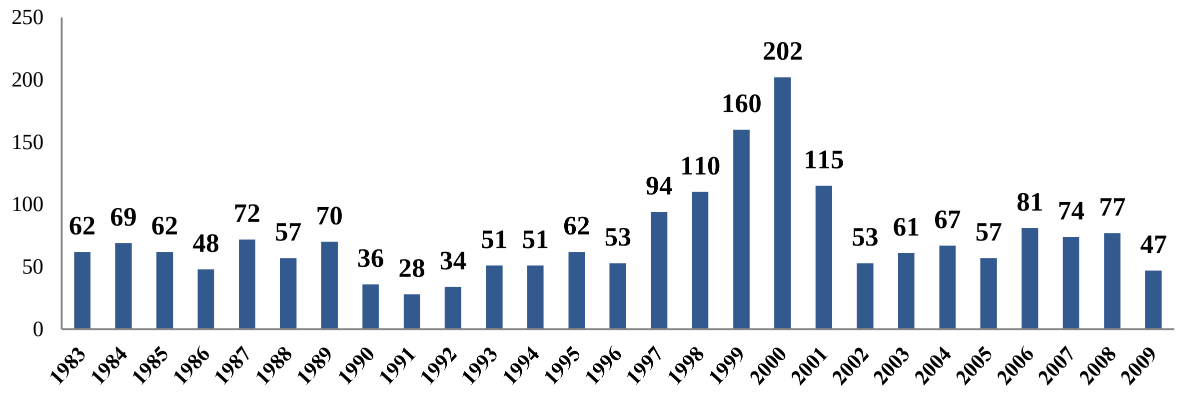
5.2 Dataset and variables

This section first describes the dataset and provides some interesting descriptive statistics about our sample of funds. Then, we describe the way we collect the data and build the variables which will be used to measure the performance in the last part of this paper.

VentureXpert gathers data for 2,166 venture capital funds. We have applied a number of filters to retain only the most relevant ones. First, very little data is available for funds raised before 1983 and consequently it would not have been statistically relevant to include such funds. Our sample is therefore made of funds whose vintage year is 1983 or later. Additionally, we have chosen not retain funds raised after 2009, given that the committed capital might not have been invested yet and the numbers, as shown by Strucke, would have been too biased. This results in a sample with the majority of the committed capital being invested already, limiting the potential biases in our results.

Finally, our dataset consists of 1,953 funds launched over the period of 1983-2009 (27 years), the largest period ever covered by previous research (Robinson and Sensoy covered 26 years). Figure 11 below displays the repartition of funds by vintage year.

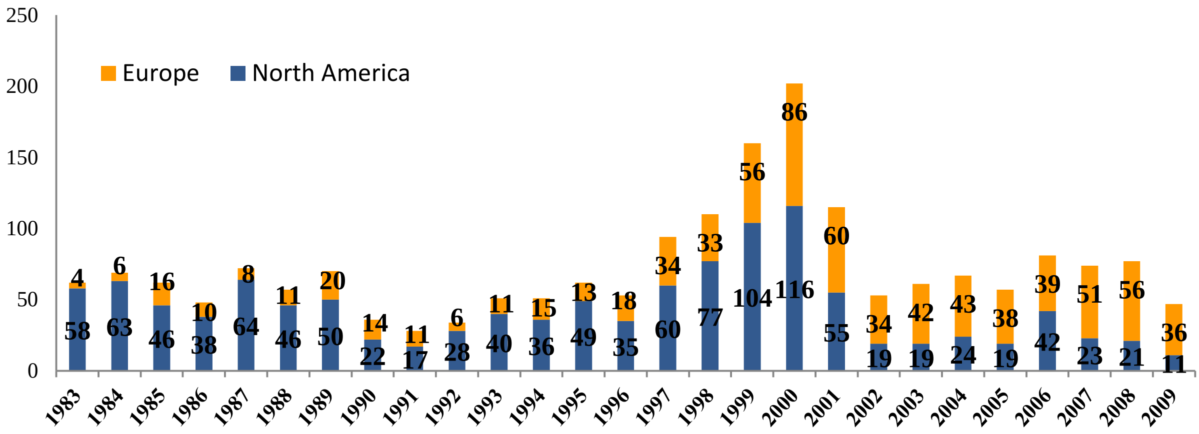
Figure 11: Repartition of funds by vintage year



As the coverage of the VentureXpert database is the best among all the available databases, we can assume that this sample is representative of the whole VC industry. A first observation is that this graph clearly shows the different cycles in the industry, with a first wave of funds raised between 1983 and 1989, a second wave between 1997 and 2001, corresponding the Internet bubble and a last one in the years 2006, 2007 and 2008 when the private equity industry activity reached a peak.

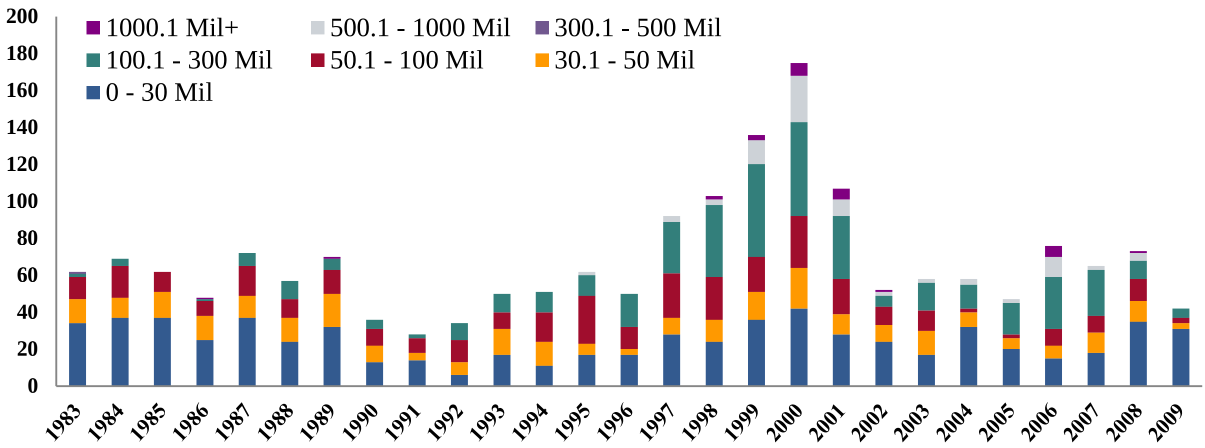
Figure 12 shows the geographical split of our sample. For the analysis by location, we have retained all the 1,953 funds split between “North America” (Canada and the US) and “Europe” (Western Europe, France, Germany and the UK mainly). As emphasized by Hege, Palomino and Schwienbacher (2003), this graph reveals that the American VC market is much mature, as the 1983 level (58 funds raised this year) in the US has been reached in 1999 in Europe (56 funds raised). If the European VC industry has emerged later than in the US, they both follow the same previously described cycles.

Figure 12: Repartition of funds by location



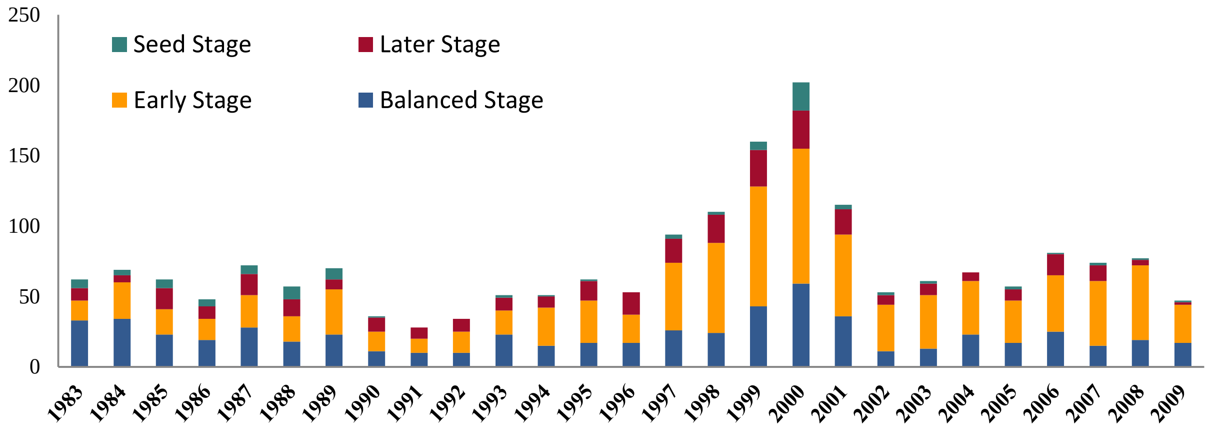
Below is the repartition of funds by vintage year and by size. The different size ranges provided by VentureXpert are the following: [$0m;$30m], [$30m;$50m], [$50m;$100m], [$100m;$300m], [$300m;$500m], [$500m;$1000m] and [$1000m;$1000m+]. For our analysis, we have retained all the intervals, even if some of them contain little data. We can notice that size repartition does not seem to have changed during the time period we have selected, except for big funds above $300m, which seem to represent a higher percentage of total funds during peak periods and vice-versa.

Figure 13: Repartition of funds by size bracket



VC funds are in majority small-size funds below 100m but size increases when higher returns are perceived, i.e. during bubbles (1983-1990, 1997-2001 and 2006-2008). A first hypothesis could be that institutional investors allocate a higher part of their portfolio to venture capital when the overall sentiment is positive.

Figure 14: Repartition of funds by stage focus



The different stages have previously been described in this paper. "*Balanced*" represents non-specialized funds that can invest in either seed, early or later-stage companies. From this graph, we see that VC funds are primarily focused on early-stage companies or not focused on any type, i.e., balanced. The split between early-stage, later-stage and balanced funds seems to hold during all the period. The pattern only changes between 1997 and 2001, the dotcom bubble, when funds were mainly early-stage funds investing massively in Internet start-ups.

We will now describe the different measures used in our analysis and the way we build them. As described above, our sample is made of funds raised between 1983 and 2009.

1st part: Historical performance of VC funds and comparision with public markets

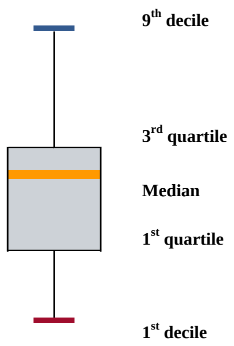
The first part of our analysis is dedicated to the historical performance of VC funds by vintage year. We focus on 4 previously introduced measures: the IRR, the modified IRR (MIRR), the public market equivalent (PME) and the TV/PI ("Total value / Paid-in capital") multiple. We collected these measures in two different ways:

- A first file gives, for each fund, its vintage year, stage, location, size range, IRR and TV/PI multiple. For funds still active, VentureXpert estimates the residual value of cash-flows and we then have data for funds raised between 1983 and 2009.
- A second file provides aggregated cash-flow data by vintage year. For every quarter from January 1983 to September 2013, we know how much money funds raised in 1983, 1984,…, 2009 distributed and took down from investors. From this, we then

calculate two MIRRs, using reinvestment rates of 8% (the "hurdle rate") and 10% and two IRRs, one using the S&P500 as benchmark and the other one using the Nasdaq Composite Index. However, this cash-flow based methodology only enables us to use data for funds raised between 1983 and 2003. Funds raised after 2004 are still active and therefore we lack a significant part of the distributions, which would average our results downward.

It is interesting for us to use these two methods, one using data aggregated by VentureXpert for each vintage year and the other one using the actual cash-flows. We will be able to cross-check our results.

From the first file, we build box plots for each vintage year using the IRR to understand how performance varied in time. The box plot follows the following scheme:



the 1^{st} and 9^{th} deciles show the outliers, i.e. the top 10% and the worst 10% funds ranked by IRR. The 1^{st} quartile (3^{rd}) splits off the lowest 25% of data (75%). The distance between the 1^{st} and the 3^{rd} quartile, called the interquartile range, represents the dispersion of the performance of the funds raised during this given vintage year. Finally, the median is the number where half funds have a higher performance and the other half have lower IRRs.

From the second file, we build MIRRs and PMEs to compare the performance with public markets. For each vintage year, we use the previously described methodology to calculate MIRRs and PMEs: for the MIRR calculation, we discount all the drawdowns using 8% and compound all the distributions using the same rate. However, as we are using aggregated data for funds raised during the same vintage year, it often happens that a few funds are still not liquidated after 15 years or more and continue to distribute cash-flows back to investors. In order not to skew our results, we consider that the last cash-flow occurs when 98% of all the distributions from funds raised in a same vintage year have been given back to investors. We then reiterate this operation using a 10% reinvestment rate for the second M-IRR calculation. The goal is to understand how sensitive our results are to the chosen rate and check that the return patterns we find are not dependent on the rate used in the MIRR calculation.

The PME calculation is based on the same cash-flow schedule displayed by the database for each vintage year. It is calculated following the previous example, i.e. discounting all the cash inflows and outflows with the market return. Again, to crosscheck our results, we have found interesting to calculate the PME based on the S&P500 quarterly returns and the NASDAQ returns as well. By definition, the S&P500 is a market-value weighted index, i.e. each stock weights its relative market capitalization, based on 500 leading companies in diversified industries. It is considered to be a good benchmark for the overall US stock market and, more generally, the world market. The comparison with the NASDAQ seems interesting to us as the NASDAQ is a market-capitalization weighted index made of more than 3,000 stocks listed on the Nasdaq stock exchange. The companies covered by this index are mainly Internet-related companies, which is interesting in the context of venture capital. In order to check the consistence of our results, we will also use traditional statistical t-tests.

2nd part: the alpha and beta of venture capital

The second part of our research is dedicated to the alpha and beta of venture capital. We will use Phalippou and Zollo (2005) method and look at the covariance between VC funds' returns and the market return to get the beta and alpha coefficient in an OLS regression[1]. This method assumes that the two following conditions hold:

- CAPM holds
- Betas are the same in each industry

We cannot use the two previously described files, as the results are given for each vintage year, and we need here to construct a venture capital index. We will use the "PE Index" from VentureXpert. The Private Equity Index reflects the aggregated returns of private equity funds and is calculated based on the quarterly percent change of the net appreciation of net asset values, as previously defined, taking into account cash-flows during the period, starting with a base 100 in January 1983. We will run the regression using quarterly available data, the most granular data available. We believe this is more relevant than annual data, as a lot of information is present when using returns over short intervals. Moreover, given the

[1] By definition, according to the CAPM, the return of any asset follows this equation: $r_{CAPM} = r_f + \beta(E[R_M] - r_f)$. We will get such a relationship between the return of VC funds and public markets for every quarter. The OLS regression will provide us with alpha and beta coefficient estimates such as: $r_{VC} = \alpha_{VC} + \beta_{VC} \times r_{Market}$.

uncertainty of the returns of venture capital, we will check our results using two other famous publicly available venture capital indexes, from Sand Hill Econometrics and Cambridge Associates.

We will not follow the naïve CAPM regression. As emphasized by Woodward S. (2009), this method leads to misleading conclusions. Running a regression of venture capital returns from Cambridge Associates minus the US three-month bill rate on the Wilshire 500 minus the three-month bill rate, she shows how impressive the findings look: alpha equals 2.39% per quarter. However, residuals are strongly correlated, revealing that we "miss something" in the regression. "The problem is that individual quarterly returns to venture capital are, by construction, related to not only contemporaneous market returns but also lagging market returns. The method for constructing returns introduces serial correlation into return"[1]. Consequently, using such a methodology, she reports a beta of 2.2 and a quarterly alpha of 0.51%.

Therefore, we will estimate the beta of venture capital using both current and lagging market returns. We will test the following equation:

$$r_{VC,t} - r_{f,t} = \alpha_{VC} + \beta_{-5} \times \left(r_{M,t-5} - r_{f,t-5}\right) + \beta_{-4} \times \left(r_{M,t-4} - r_{f,t-4}\right) + \beta_{-3} \times \left(r_{M,t-3} - r_{f,t-3}\right) + \beta_{-2} \times \left(r_{M,t-2} - r_{f,t-2}\right) + \beta_{-1} \times \left(r_{M,t-1} - r_{f,t-1}\right) + \beta_0 \times (r_{M,t} - r_{f,t})$$

where:

- $r_{VC,t}$ is the return of venture capital in time *t*
- $r_{f,t}$ is the risk-free rate at time *t*
- $r_{M,t}$ is the return of the benchmark at time *t*

We will then define the total beta of venture capital as the following:

$$\beta_{VC} = \beta_{-5} + \beta_{-4} + \beta_{-3} + \beta_{-2} + \beta_{-1} + \beta_0$$

The rationale for using 5 quarter lagging returns is Woodward's paper, where she explains how VC reacts to public markets. Market returns will be quarterly returns of the S&P500 firstly, of the NASDAQ secondly. We will therefore be able to test the sensitivity of beta to the selected benchmark.

[1] Woodward S. (2009), "Measuring risk for venture capital and private equity portfolios".

3rd part: Individual characteristics of funds, drivers of returns?

The last part will deal with individual characteristics of venture capital funds as performance drivers, characteristics such as size, location and stage focus. We will use the first sample with detailed characteristics. For each fund, we have:

- Its size bracket. The different size brackets are described above in figure 13.
- Its location (either North America or Europe)
- Its stage-focus

For each of these characteristics, we will look at the average, median, min, max and standard deviation and compare groups to one another. In order to strengthen our conclusions, we will conduct statistical tests when necessary.

Finally, we want to confirm the theoretical relationship between a fund return and its duration. In order to estimate the duration for each fund, (the time between the first investment and the exit) we will use the method developed by Michiel Celis[1] (2010) following the approximation below:

$$IRR \approx money\ multiple^{1/duration} - 1$$

$$\leftrightarrow IRR \approx (TV/PI)^{1/duration} - 1$$

$$\leftrightarrow Duration \approx \frac{\ln(\frac{TV}{PI})}{\ln(IRR + 1)}$$

This relationship is true if there is only one distribution at the exit of the investment. Therefore, this is only a rough approximation. Another bias could come from funds which report a slightly negative IRR. The denominator will then tend to zero and consequently we will get extremely high values for the duration. We will therefore exclude some of the funds before we run a regression between durations and IRRs and TV/PI multiples to see how performance varies with duration.

[1] "The performance of real estate private equity funds: fund characteristics, diversification and persistence in times of declining alpha performance (1994-2004)", 2010.

6 Empirical analysis: results and findings

In this section, we present our findings regarding the three questions we are willing to answer. The first part deals with the historical performance of VC funds and the comparison with publicly traded securities. We then regress the returns of VC provided by VentureXpert and two other indices with the returns of public markets to estimate the beta and alpha of VC funds. Finally, we try to explain whether size, location and stage-focus can help explain the performance of such funds.

6.1 Historical performance and comparison with public markets

We will focus first on the file containing data at a fund level. It provides the most detailed approach, as we have data from 1,953 funds. The second approach, using aggregated cash-flows, will be used in a second time to confirm the patterns found with the first method and compare the performance with publicly traded securities.

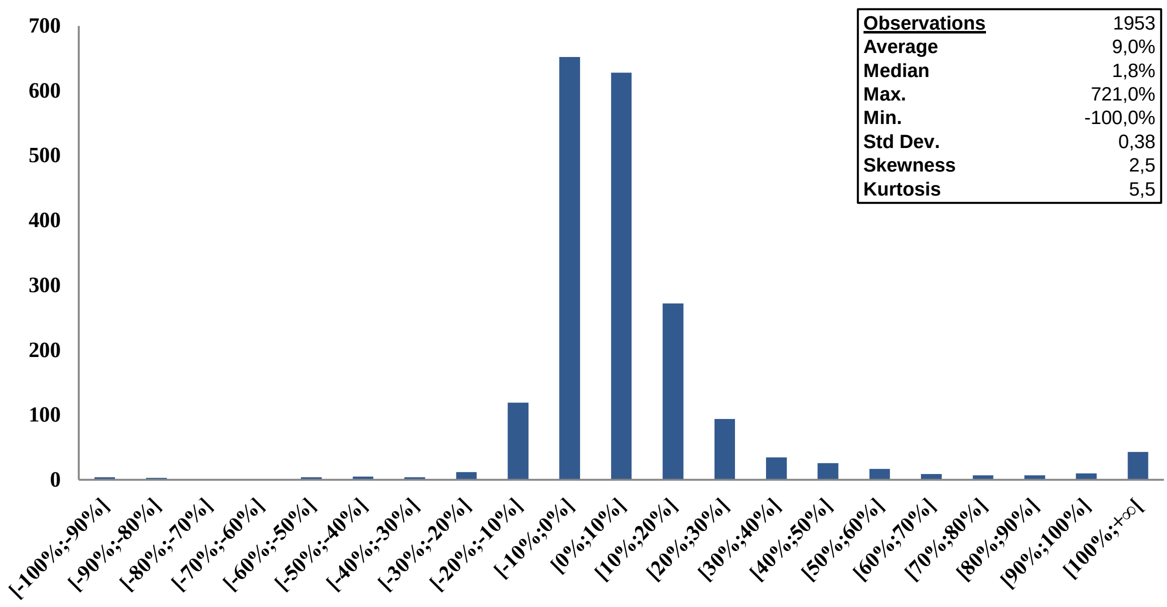
Fund-level approach

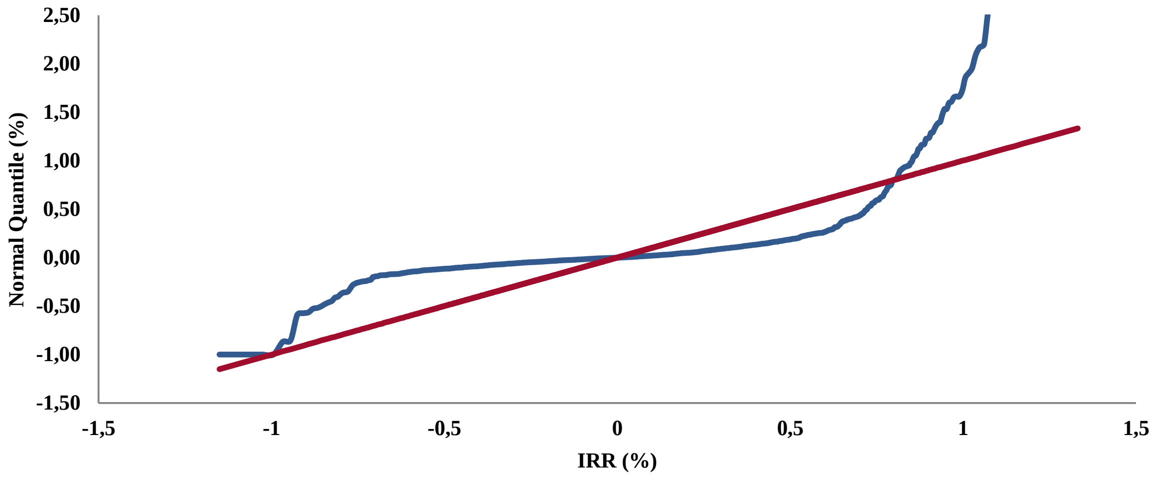
As emphasized in the previous part, the fund-level approach provides us with the IRR of every fund raised between 1983 and 2009. We have decided to keep all the 1,953 funds in our initial sample, including the extreme outliers. After all, this is an intrinsic characteristic of private equity funds. Based on this data from VentureXpert, we report an average IRR of 9.0%, exactly as documented by Robinson and Sensoy (2011). However, the median IRR of 1.8% proves the extreme dispersion of the IRRs and reveals an extreme skewness to the right: half of the funds generate an IRR below 1.8% but the average is 5 times this number. Figure 15 shows the histogram of IRRs by range. We notice that IRRs between -10% and 10% are overrepresented in the sample, hence a low median IRR of 1.8%. The distribution is skewed to the right, as emphasized by the high skewness (2.5) but this is not surprising: losses are limited to 100% by definition, whereas gains are not capped and can even reach more than 700% for the best-performing funds in our sample.

In order to understand this exceptional skewness, we have compared in the second graph the actual repartition of IRRs (blue line) to a normal distribution (red line). A first observation is that extreme IRRs are overrepresented compared to a normal distribution. This is not surprising given the extremely high value of the kurtosis (5.5), which means that our sample follows a leptokurtic distribution, i.e. the values are concentrated around the mean and the tails are thicker, which translates into higher probabilities for extreme values.

Figure 15: Historical return of VC funds (IRR)

The first graph is a histogram describing the repartition of IRR among different ranges. It also provides informative descriptive statistics of IRR fund performance. The second graph is a Q-Q plot. It is a simple method to compare two sets of sample quantiles, here the IRR quantiles from the actual data and the quantiles from a theoretical normal distribution.



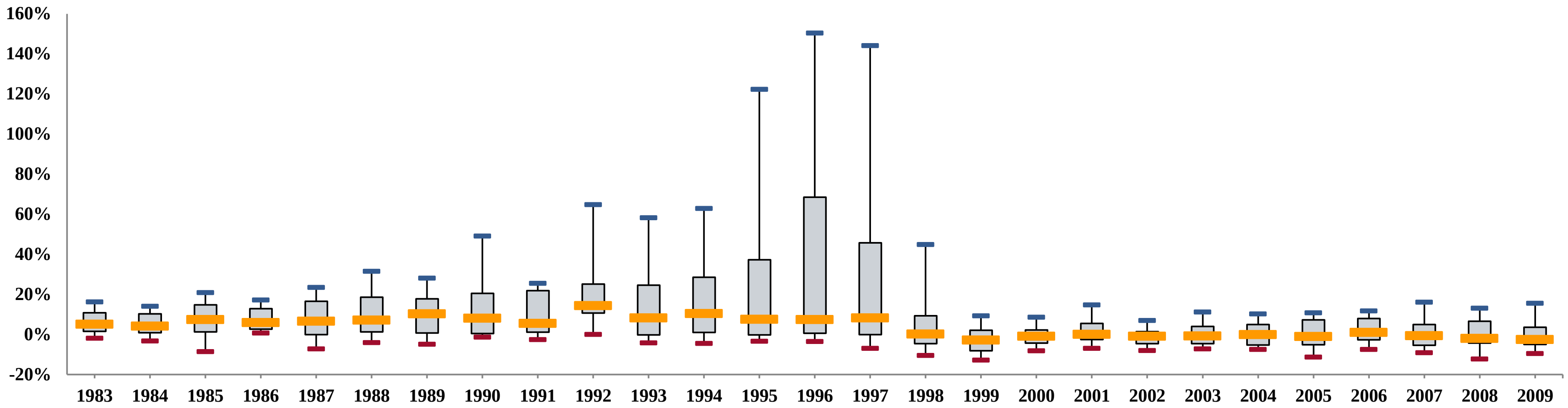


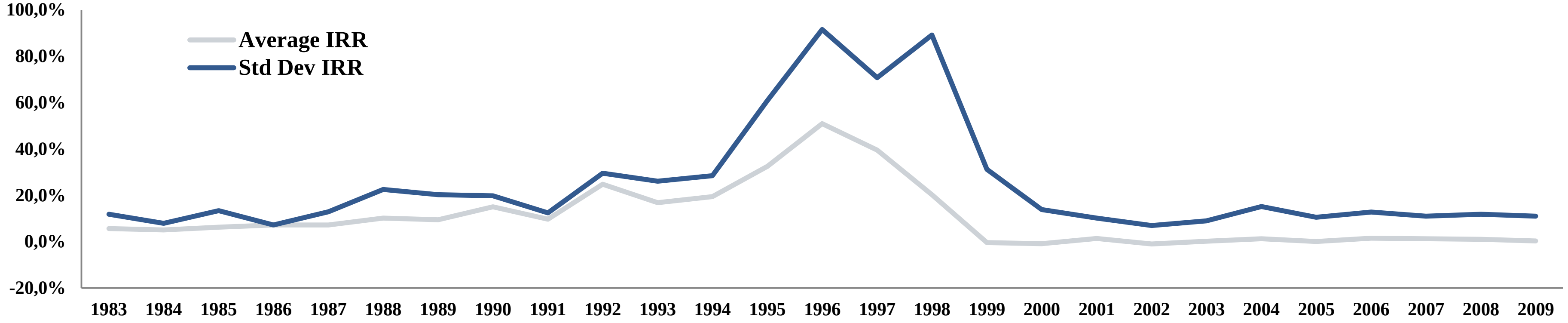
We now focus on the historical evolution of the performance of VC funds. Figure 16 below gives a boxplot for each vintage year. Firstly, it clearly appears that the median is extremely stable, around 2% as well as the 1st decile. We can conclude that the performance pattern for the lower half of funds is stable across years. We notice however a strong disparity for top-performing funds. The interquartile range (they grey box) is larger in boom times: 1987-1990, 1993-1997 and 2006-2008. Consequently, the volatility tends to increase with returns. This pattern is confirmed by the second graph on the following page. The standard deviation of returns overreacts when the average IRR increases, for example in 1996. As a conclusion, we can write that the uncertainty in the returns provided by venture capital funds increases when these returns increase. Another interesting point from the next figure is the apparent convergence in the returns after 1999. One hypothesis could be that the European market is maturing, and therefore returns are being more and more concentrated around the median. Another hypothesis could also well be that our sample is biased: funds raised after 2000 are probably still active, and therefore returns are underestimated if we stick to Stuck's findings, as VentureXpert use the accounting value to estimate the residual value. Returns are being more and more concentrated around 0% and yet the asset class keeps growing, as emphasized by figure 1.

We want to understand this apparent contradiction. The first reason behind it could probably be that despite their poor IRRs, VC funds still outperform publicly traded securities and therefore investors are still attracted to such funds. We will test this hypothesis in the next section of this part. Before jumping to the comparison with public markets and in order to answer whether the historical performance of venture capital funds justifies the impressive growth of the venture capital industry, we have performed some statistical tests on the average IRR by vintage year. After all, the pretty high average of 9.0% hides a low median of 1.8% and a strong standard deviation, therefore it is legitimate to test statistically whether the returns of venture capital are significantly different from zero.

Figure 16: Performance by vintage year

The graph below shows a series of boxplots for each vintage year, as per the previous description (p.31). For each year, the 9th decile, the 1st quartile, the median, the 3rd quartile and the 1st decile are represented. The coloured part represents the interquartile range. The second graph shows the average IRR by vintage year with its standard deviation.





The next figure displays the statistical t-tests we did in order to make sure that the performance is significantly different from zero.

Figure 17: Statistical tests on IRRs

These tables describe the IRRs by vintage year. For each vintage year, the p-value represents the conclusion of a t-test with the hypothesis: returns are significantly equal to zero. A low p-value leads to the rejection of this hypothesis.

	1983	**1984**	**1985**	**1986**	**1987**	**1988**	**1989**	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**
Average IRR	**5,7%**	**5,1%**	**6,3%**	**7,2%**	**7,3%**	**10,3%**	**9,5%**	**15,0%**	**9,7%**	**24,8%**	**16,9%**	**19,5%**	**32,5%**	**50,9%**
Std Dev IRR	**0,12**	**0,08**	**0,13**	**0,07**	**0,13**	**0,23**	**0,20**	**0,20**	**0,12**	**0,30**	**0,26**	**0,28**	**0,61**	**0,92**
t-stat	3,76	5,31	3,71	6,93	4,76	3,42	3,93	4,54	4,12	4,89	4,62	4,89	4,17	4,05
p-value	0,02%	0,00%	0,02%	0,00%	0,00%	0,06%	0,01%	0,00%	0,02%	0,00%	0,00%	0,00%	0,01%	0,01%
# observations	62	69	62	48	72	57	70	36	28	34	51	51	62	53

	1997	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**Total sample**
Average IRR	**39,5%**	**20,3%**	**-0,3%**	**-0,8%**	**1,5%**	**-0,9%**	**0,2%**	**1,3%**	**0,1%**	**1,5%**	**1,3%**	**1,0%**	**0,3%**	**9,0%**
Std Dev IRR	**0,71**	**0,89**	**0,31**	**0,14**	**0,10**	**0,07**	**0,09**	**0,15**	**0,11**	**0,13**	**0,11**	**0,12**	**0,11**	**0,38**
t-stat	5,42	2,36	-0,12	-0,79	1,54	-0,98	0,21	0,69	0,05	1,08	1,04	0,77	0,21	**10,65**
p-value	0,00%	1,00%	45,18%	21,48%	6,32%	16,60%	41,81%	24,51%	48,09%	14,24%	15,12%	22,13%	41,63%	**0,00%**
# observations	94	110	160	202	115	53	61	67	57	81	74	77	47	**1953**

Note: The hypothesis in the t-tests above is that the average IRR equals zero.
* Confidence at a 5% level.

It appears clearly that from 1983 to 1998, the returns of venture capital are significantly different from zero. However, after 1998 and until 2005 during peak times, we reject this hypothesis. This further strengthens our previous conclusion that star funds have unlimited returns during peak times, but the overall performance converges to zero. The potential explanation is that during peak times, investors allocate more money to venture capital in order to share the anticipated strong profits but this excess money is invested in projects which are, in average, less profitable, leading to lower profits.

Cash-flow based approach

In this second section, we will use the other results we have from the aggregated cash-flows. We would like to confirm the previous patterns and focus on the performance compared to public markets. We were not able with the previous results to calculate the PME or the MIRR as we had no information regarding the timing of cash-flows. This is the reason why we now focus on this second sample. You can find more details about the results in the appendix 1 at the end of this paper.

From the cash flows by vintage year, we have measured the performance with different measures. The TV/PI multiple represents the "money multiple", i.e. the ratio of the amount of money distributed by the fund to investors and the amount of money given by investors to the fund. Then, we have calculated the modified IRR (MIRR) using two different reinvestment rates: 8% and 10%. We have used 8% because it corresponds to the hurdle rate, the minimum rate of return required by investors and the rate above which the general partner starts collecting fees. We have then used 10% to check whether the performance pattern changes with a higher rate. Eventually, we focus on the public market equivalent (PME) to check whether venture capital funds have outperformed public markets. Below is a table which summarizes the correlations between these different measures.

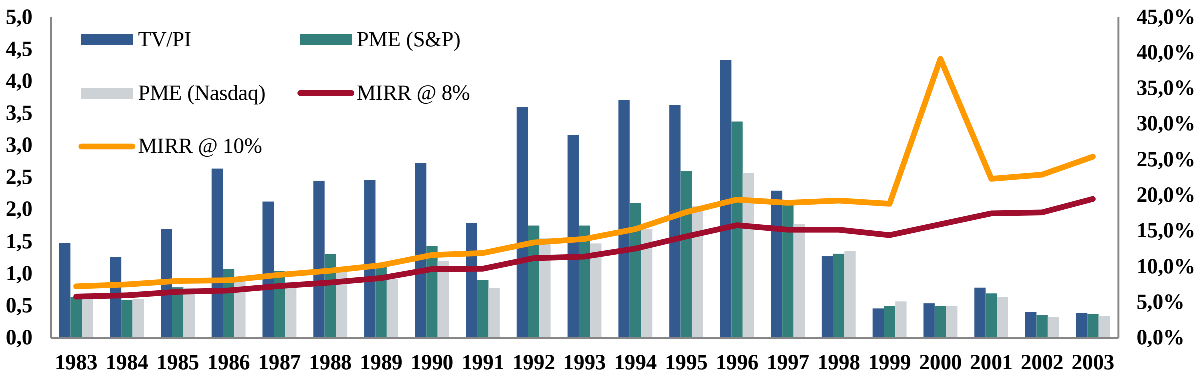
Figure 18: Correlation matrix between performance measures

	TV/PI	MIRR $_{8\%}$	MIRR $_{10\%}$	PME $_{S\&P500}$	PME $_{Nasdaq}$
TV/PI	1				
MIRR 8%	0,30	1			
MIRR 10%	0,24	1,00	1		
PME S&P500	0,86	0,67	0,63	1	
PME Nasdaq	0,82	0,72	0,68	0,99	1

First, PMEs and MIRRs are highly correlated, suggesting that these two measures accurately translate the actual performance of venture capital funds. The low correlation between TV/PI multiple and MIRRs (8% and 10%) is surprising and suggests that venture capital funds are subject to business cycles: as TV/PI is the actual money multiple and PMEs account for the market variation, these two measures both account for business risk. However, the MIRR does not, as it assumes a fixed rate over the fund life, hence why one conclusion is that market cycles do influence the return of venture capital.

Below is a graph with the evolution of each measure across time. As underlined in section 5, we are not able to display any of this measure after 2003, because a majority of funds are still active and therefore the cash-flow based analysis does not enable to get accurate data. The three measures TV/PI, PME $_{S\&P500}$ and S&P $_{Nasdaq}$ both follow the same pattern: they increase dramatically for funds raised between 1983 and 1996 because of the Internet bubble probably, and then collapse for funds raised in 1997 onwards. The explanation is that these funds might have invested during the dotcom bubble but started the distribution phase when valuations of dotcom companies started decreasing. One exception is the year 1991, and the IRR measure using the previous dataset follows the same trend. As emphasized previously, we notice that the MIRR is much less sensitive to cycles. The upward trend stops after 1996 but the decrease

Figure 19: Historical performance of VC according to different measures



(1983-2003)	TV/PI	MIRR @ 8%	MIRR @ 10%	PME (S&P)	PME (Nasdaq)
Average	**2,06**	**11,8%**	**15,7%**	**1,26**	**1,08**
Std. Dev.	**1,20**	**0,04**	**0,08**	**0,79**	**0,59**
t-stat	5,62	2,83	2,63	2,34	1,68
p-value	0,00%	0,61%	0,90%	1,64%	5,66%
# observations	21	21	21	21	21

Note 1: For the TV/PI t-test above, the hypothesis is that the average TV/PI is equal to zero.
Note 2: For the MIRRs t-tests above, the hypotheses are that the average MIRR is equal to 8%, the hurdle rate, and 10%.
Note 3: For the PMEs t-test, the hypotheses are that the average PME is equal to one.
* Confidence at a 5% level.

is much less marked than with other measures and MIRRs even increase in 1998 when other measures collapse. One of our initial questions was whether or not the VC asset class had higher returns than publicly traded securities.

The graph and the table below it show strong evidence of outperformance versus public markets. Our average PME $_{S\&P500}$ of 1.26 (1.08 with the Nasdaq) is in the middle-range of previous findings. However, Janeway and McKenzie (2008) find even higher PMEs for roughly the same time period, 1.98 and 1.59 versus the S&P500 and the Nasdaq respectively. The statistical tests performed on each performance measure comfort our conclusions that venture capital has overall a very strong absolute performance but also a clearly higher risk-adjusted performance than publicly traded securities: given the low p-values, we largely accept that:

- Venture capital brings a TV/PI multiple above one
- MIRR is significantly above the 8% minimum hurdle rate

- Venture capital brings superior performance compared to public equities

6.2 The alpha and beta of venture capital

We try to estimate the alpha and beta of venture capital by using the previously described equation. We will regress the quarterly returns of the S&P500 and the Nasdaq on:

- The returns from VentureXpert. The PE Index is a value-weighted index taking into account monthly returns and net asset values from venture capital investments
- The Sand Hill Econometrics index, which is a value-weighted and continuously invested index. It is said to be "free of survivor bias".
- The Cambridge Associates (CA) Index, a quarterly updated value-weighted index using pooled returns.

We use the US three-month bill rate as the risk-free rate. We present below the results of our OLS regressions. The quality of our regressions is high, and you can find further details about the quality (correlations among independent variables and test statistic) in appendix.

Figure 20: Regression provided by the VentureXpert PE Index

S&P500	Coefficient	Std. Error	t-stat	P-value
Alpha	0,01	0,01	1,19	23,7%
Beta (0)	-0,03	0,07	-0,35	72,5%
Beta (-1)	0,34	0,07	4,61	0,0%
Beta (-2)	0,14	0,07	1,86	6,5%
Beta (-3)	0,16	0,07	2,18	3,1%
Beta (-4)	0,16	0,07	2,22	2,9%
Beta (-5)	0,17	0,07	2,33	2,2%
R-squared	29,5%	S.E of regression		6,6%
Adjusted R-squared	25,7%	Observations		118

Nasdaq	Coefficient	Std. Error	t-stat	P-value
Alpha	0,00	0,01	0,54	59,2%
Beta (0)	0,25	0,05	5,16	0,0%
Beta (-1)	0,22	0,05	4,75	0,0%
Beta (-2)	0,14	0,05	2,91	0,4%
Beta (-3)	0,12	0,05	2,61	1,0%
Beta (-4)	0,15	0,05	3,24	0,2%
Beta (-5)	0,08	0,05	1,77	8,0%
R-squared	48,6%	S.E of regression		5,7%
Adjusted R-squared	45,8%	Observations		118

* Confidence at a 5% level.

The PE Index from VentureXpert provides a beta of 0.95 with the S&P500 and 0.96 with the Nasdaq. However, the quarterly alphas differ significantly, from 0.29% (Nasdaq) to 0.80% (S&P500). Therefore, we want to check how these results vary with the two other venture capital indices.

Figure 21: Regressions provided by the Cambridge Associates index

S&P500	Coefficient	Std. Error	t-stat	P-value
Alpha	0,02	0,01	2,12	3,6%
Beta (0)	0,01	0,11	0,12	90,4%
Beta (-1)	0,41	0,11	3,86	0,0%
Beta (-2)	0,11	0,10	1,09	27,8%
Beta (-3)	0,21	0,10	2,03	4,5%
Beta (-4)	0,21	0,11	1,99	4,9%
Beta (-5)	0,22	0,11	2,05	4,2%
R-squared	23,2%	S.E of regression		9,5%
Adjusted R-squared	19,0%	Observations		118

Nasdaq	Coefficient	Std. Error	t-stat	P-value
Alpha	0,01	0,01	1,86	6,6%
Beta (0)	0,32	0,07	4,50	0,0%
Beta (-1)	0,24	0,07	3,49	0,1%
Beta (-2)	0,14	0,07	2,06	4,1%
Beta (-3)	0,16	0,07	2,29	2,4%
Beta (-4)	0,21	0,07	3,01	0,3%
Beta (-5)	0,16	0,07	2,25	2,6%
R-squared	40,1%	S.E of regression		8,4%
Adjusted R-squared	36,9%	Observations		118

* Confidence at a 5% level.

Interestingly, the Cambridge Associates index provides similar betas, although slightly higher: 1.17 using the S&P500 and 1.23 using the Nasdaq. The alpha is here exceptionally strong compared to the previous regression, 2.05% and 1.48% respectively. These results follow the conclusion of Woodward, who writes that "consistently venture betas calculated using CA data are higher than those from Thomson data"[1]. For these last regressions using the Sand Hill Econometrics Index, quarterly data is available only between Q1 1992 and Q2 2010.

[1] Woodward S. (2009), "Measuring risk for venture capital and private equity portfolios".

Figure 22: Regressions provided by the Sand Hill Index

S&P500	Coefficient	Std. Error	t-stat	P-value
Alpha	0,05	0,01	4,17	0,0%
Beta (0)	-0,06	0,14	-0,42	67,3%
Beta (-1)	1,91	0,14	13,93	0,0%
Beta (-2)	-0,31	0,14	-2,19	3,2%
Beta (-3)	0,05	0,14	0,37	71,0%
Beta (-4)	0,07	0,14	0,48	63,2%
Beta (-5)	0,14	0,14	0,99	32,5%
R-squared	76,5%		S.E of regression	9,3%
Adjusted R-squared	74,2%		Observations	68

Nasdaq	Coefficient	Std. Error	t-stat	P-value
Alpha	3,16%	1,54%	2,04	4,5%
Beta (0)	1,02	13,03%	7,80	0,0%
Beta (-1)	0,40	12,77%	3,17	0,2%
Beta (-2)	0,11	12,80%	0,83	41,1%
Beta (-3)	-0,13	12,73%	-1,05	29,6%
Beta (-4)	0,11	12,79%	0,87	38,8%
Beta (-5)	0,02	13,20%	0,15	87,8%
R-squared	57,2%		S.E of regression	12,5%
Adjusted R-squared	53,0%		Observations	68

* Confidence at a 5% level.

This index gives a S&P500 beta of 1.81 and a Nasdaq beta of 1.52, slightly above our previous findings. As for the beta, the alpha is above the results provided by the other indices: 5.22% and 3.16% respectively.

The findings given by the Cambridge Associates and the Sand Hill indices are closer, whereas the results provided by VentureXpert are lower. We can attribute it to non-liquidated funds being recognised at their accounting value. Given the high values provided by Sand Hill with the S&P500 compared to other regressions, we base our conclusions on the CA and Sand Hill (Nasdaq) indices:

- Beta for venture capital lies between 1.0 and 1.8
- Alpha (by quarter) stands around 0.3%-5.1%

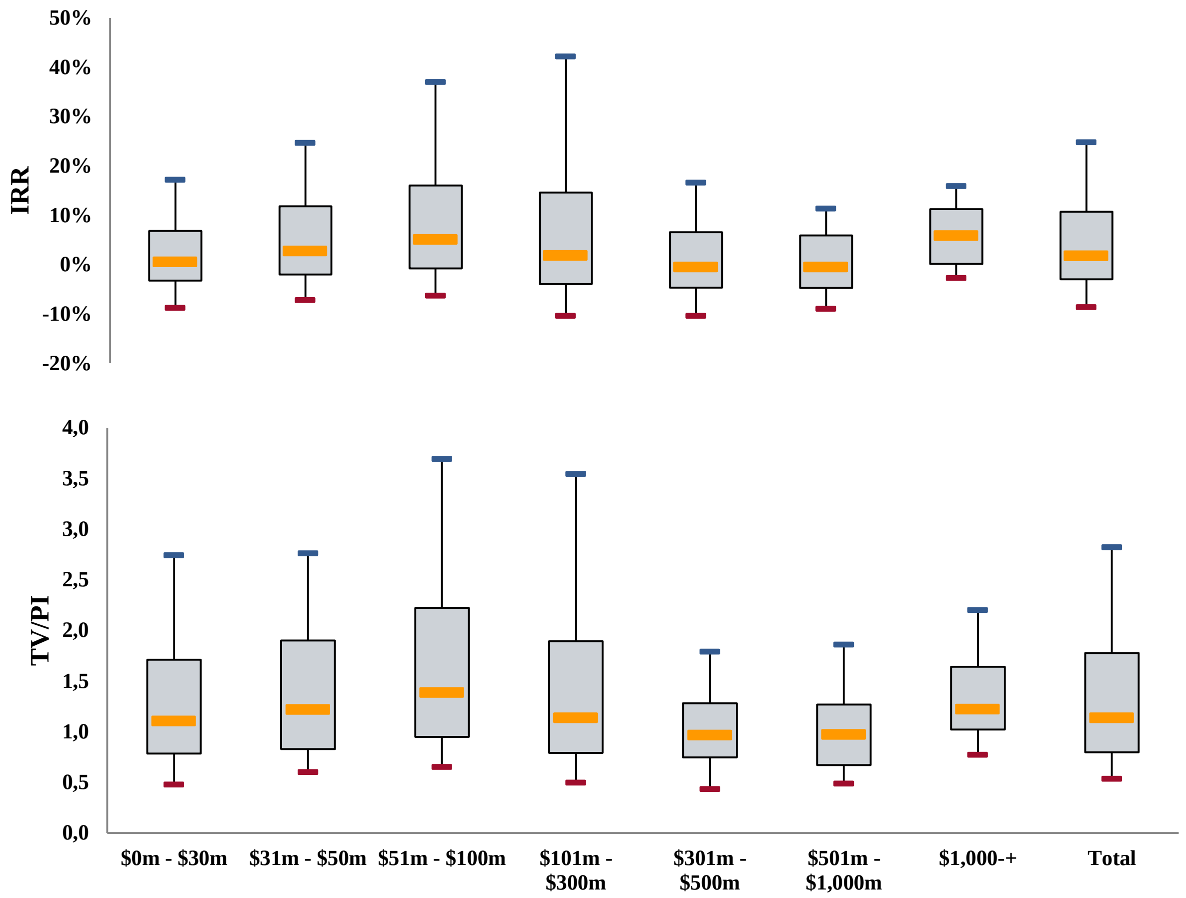
6.3 Individual performance drivers

In this section, we focus on individual characteristics of funds such as size, geography, stage focus and duration. We would like to understand how they drive the overall returns.

Does size influence returns?

We have split the performance of funds into seven different brackets. You can find in appendix 3 some details about the average, median, standard deviation, minimum and maximum by bracket. In figure 20 below, we have represented the differences between size brackets through a boxplot.

Figure 24: Performance by size brackets



It seems that size does not positively or negatively influence returns, as the highest average and quartile IRRs are coming from three of the smallest size brackets: $31m-$50m, $51m-$100m and $101-$300m. The overall median is driven upward by these three brackets as well. This pattern still holds when looking at the TV/PI performance measure. Interestingly, we notice that returns are more concentrated for big-size funds above $300m. Moreover, the maximum IRRs or TV/PI multiples are located in the third and fourth size brackets. As a conclusion, we find no evidence of size increasing returns.

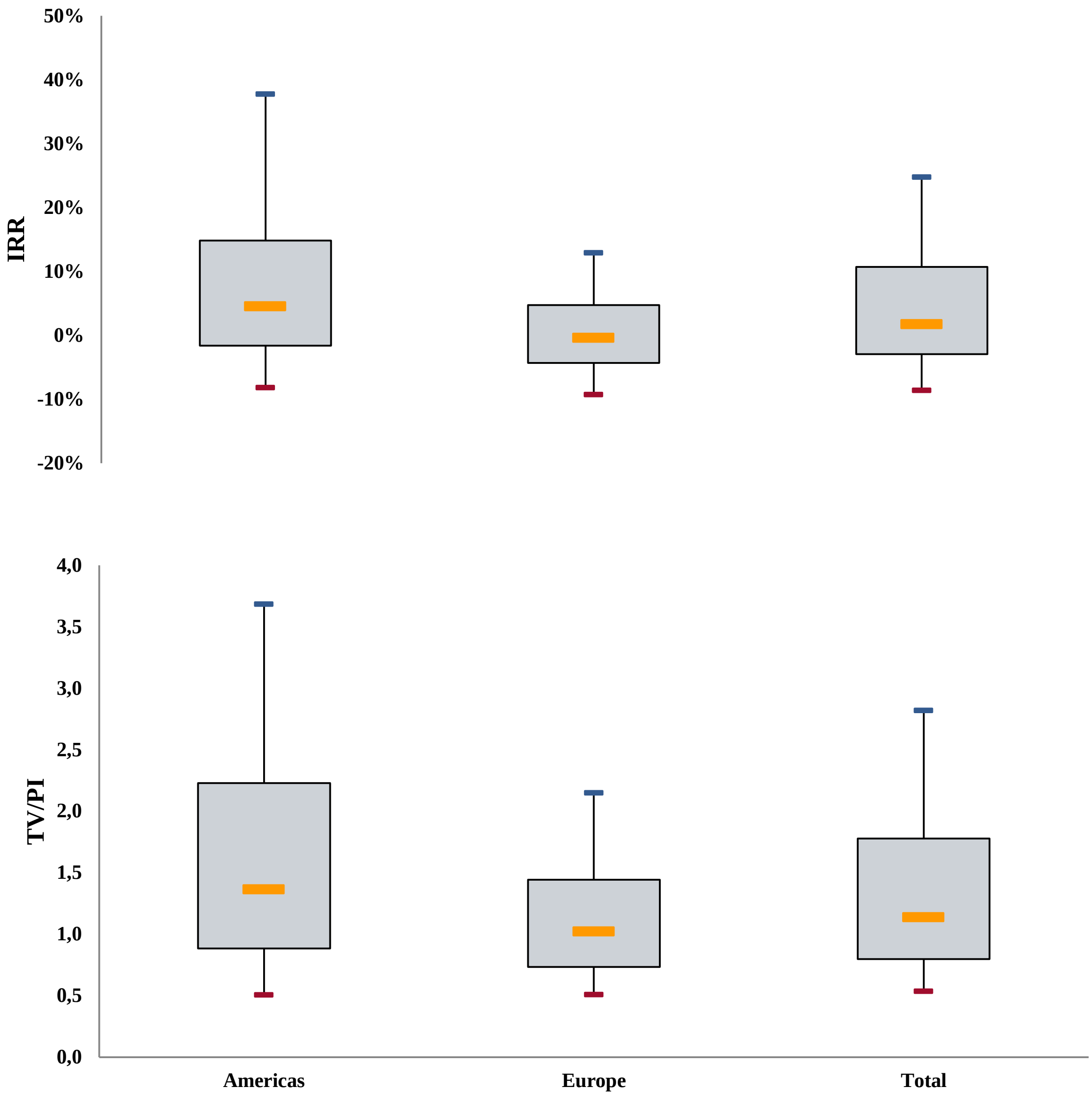
Influence of location on returns

In this section, we try to understand if there are differences in the return between US funds ("North America") and European ones. Appendix 4 reports the detailed findings. Both measures, IRR and TV/PI, show strong evidence of outperformance of funds located in "North America" versus European funds. The gap in performance is striking, as the 1^{st} quartile for European funds is just above the 1^{st} decile of US funds. The performance in Europe is also less volatile, as emphasized by the much larger interquartile range for US funds.

The reader should bear in mind that, however, European funds might invest in the US and vice-versa. We don't have the detail of the investments, consequently our findings should be considered with caution. In order to validate these conclusions, we run a statistical t-test for difference in mean. We find strong evidence for differences in means (H_O: difference is equal to zero, p-value = 0.0% at a 5% level of significance). Consequently, we conclude that American VC funds significantly outperform European VC funds. This suggests for practitioners that everything else being equal, it would be wise to focus more on American VC funds.

We would like to underline these results by Hege, Palomino and Schwienbacher's findings that "US venture capital firms show a significantly higher performance on average than their European counterparts". This performance gap would be attributable to differences in the contractual relationship between funds and entrepreneurs, with US funds using more often control rights (use of convertibles and replacement of entrepreneurs) and having a better screening capacity.

Figure 25: Performance by location

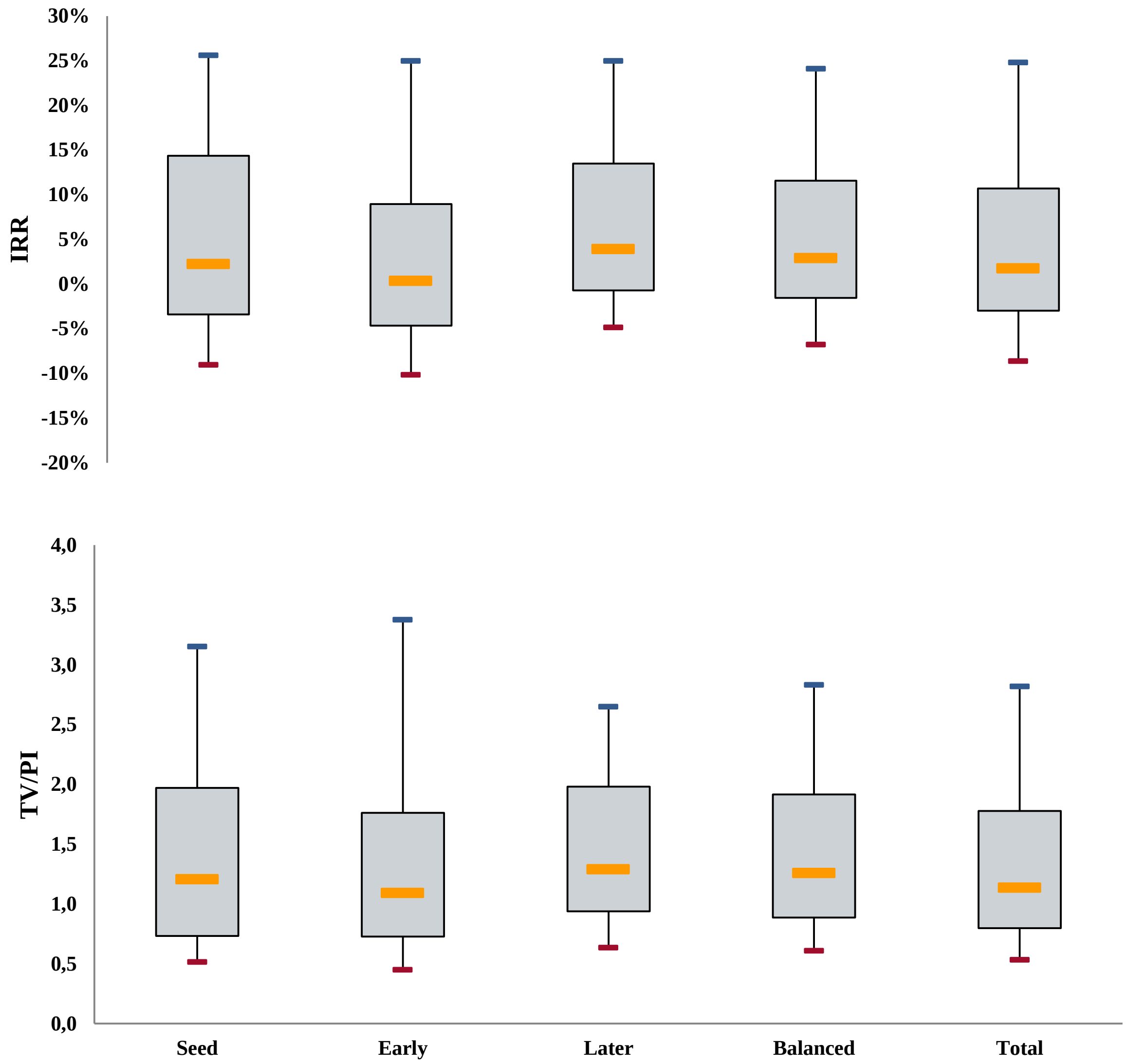


	IRR					
	# observations	Average	Median	Std. Dev	Max	Min
Americas	1182	13,5%	4,6%	0,44	721,0%	-100,0%
Europe	771	2,2%	-0,4%	0,24	311,1%	-100,0%
Total	**1953**	**9,0%**	**1,8%**	**0,38**	**721,0%**	**-100,0%**

Stage focus and returns

Figure 22 below shows how close the returns are among different stages. There is only one exception regarding balanced funds, i.e. non-specialized funds. Not only the average but also the maximum is below other brackets. This pattern holds with both IRRs and TV/PI multiple (you can find more details in appendix). This finding is close from the conclusion reached by Gompers, Kovner and Lerner (2009). Generalist firms would have a lower performance than specialist ones, as they better allocate resources across industries and orientate investments towards better projects.

Figure 26: Performance by stage focus



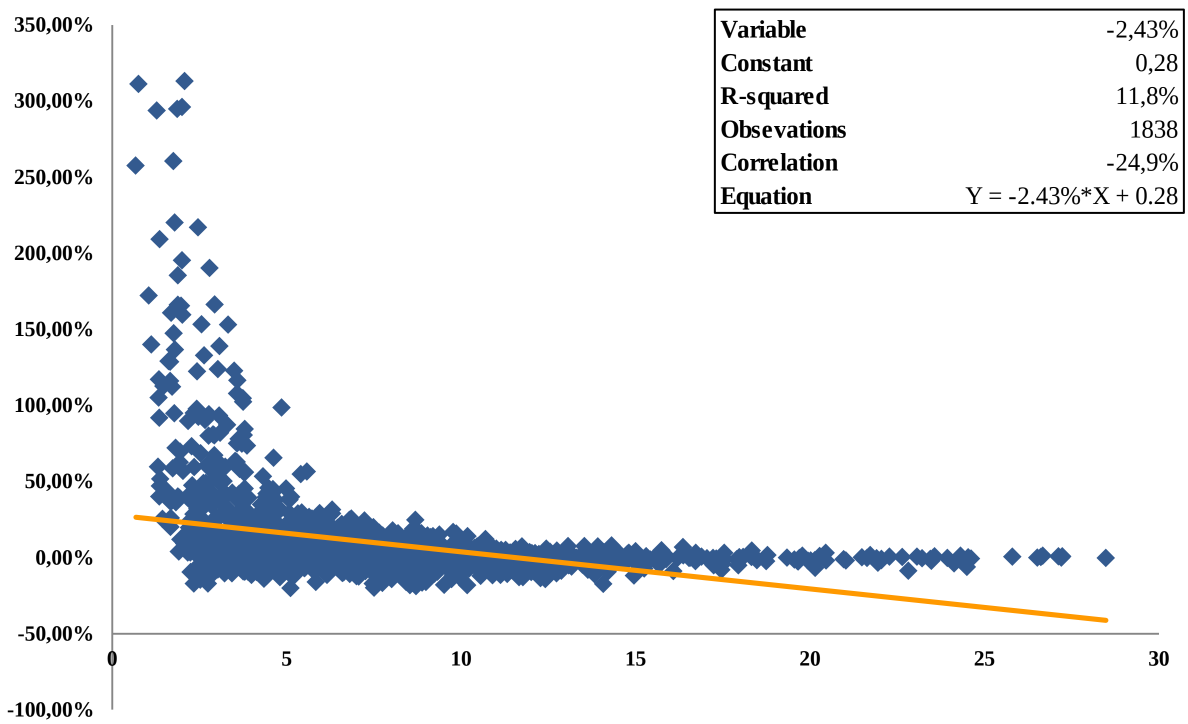
	IRR					
	# observations	Average	Median	Std. Dev	Max	Min
Seed	94	9,9%	2,3%	0,32	257,6%	-23,5%
Early	935	9,3%	0,4%	0,47	721,0%	-100,0%
Later	315	9,3%	3,9%	0,28	311,1%	-100,0%
Balanced	609	8,3%	2,9%	0,26	260,3%	-86,8%
Total	**1953**	**9,0%**	**1,8%**	**0,38**	**721,0%**	**-100,0%**

Relationship between duration and return

Finally, in this last section, we want to confirm the theoretical relationship between duration and IRR. We are using the previously described formula to estimate the duration of each fund. We will run a regression to understand this relationship. One of the caveats of our formula[1] is that duration may be infinite for funds whose IRR is close to zero. This is why we adjust our initial sample for extreme outliers, and finally keep 1,838 funds (94% of our initial sample).

The reason why we are testing such a relationship is the following: even if, at first sight, the link between IRR and duration seems endogenous, there can be exceptions. Indeed, figure 8 showed an inverse relationship, but this relationship is true **everything else being equal**. Previous literature showed that, in certain cases, exiting an investment longer lead to a better understanding of portfolio companies and then to a multiple expansion. The question is therefor to understand to what extent a higher duration leads to an even higher multiple expansion.

Figure 27: Relationship between fund duration and IRR



[1] $Duration \approx \frac{\ln(\frac{TV}{PI})}{\ln(IRR+1)}$.

Although the R-squared is disappointing, there is a clear negative relationship between a fund IRR and its duration: the longer it takes a fund to pay back investors and distribute money from exited investments, the lower the IRR. However, we mitigate this finding when comparing the situation in the US and in Europe. As shown in the previous graph, the blended correlation coefficient is -24.9%. This coefficient is equal to -28.7% in the US and -13.5% in Europe. This finding should be compared with Hege, Palomino and Schwienbacher's conclusion that the negative relationship between duration and IRR is less strong in Europe where funds learn about the quality of the project over time, leading to higher multiples.

7 Conclusion

Our initial goal was to better understand the returns and risk profile of venture capital. Previous literature had largely covered this subject, however to our knowledge this paper is the first to cover such a broad spectrum and to provide a “big picture” of the returns of venture capital.

Historically, venture capital funds have yielded an average IRR of 9% per annum. However, a deeper analysis reveals a strong disparity between fund returns, with a median IRR of 1.8%. This disparity is what makes venture capital unique: if returns are lower-bounded (a fund cannot lose more than 100%), start funds sometimes report IRRs higher than 500%. Undoubtedly, the 90s have been a golden era for venture capital funds, whose returns reached an average of 51% in 1996. Nevertheless, since 2000, this performance has been converging to lower levels, probably under the effect of maturing markets in Europe and the US. Additionally, we find significant outperformance of venture capital funds over public markets, with a strong PME of 1.26 and 1.08 using the S&P500 and the Nasdaq respectively. However, as for absolute returns, this outperformance starts shrinking slightly at the end of our sample. One remaining question and a potential focus for further research would be a comparison of current PMEs between Europe and the US.

Whether venture capital overreacts to movements in public markets and whether it brings positive risk-adjusted returns has considerably been debated. Previous research focused on one private equity index, generally the Cambridge Associates index or the Sand Hill index, considered as the most relevant VC indices, to estimate the beta and alpha of this asset class. We use a unique combination of these two indices and the PE Index from VentureXpert as well as a CAPM formula accounting for lagging market returns to estimate these parameters. We report a statistically strong evidence of beta between 1.0 and 1.8, which is in the middle range of previous findings. Despite this pretty high beta, we document a quarterly alpha of about 0.3%-5.1%, revealing a strong risk-adjusted performance for venture capital funds.

Finally, we tried to understand whether any individual characteristic of funds, such as size, location and stage focus could enhance returns. Unlike a majority of previous papers, we find no direct relationship between size and IRR. Stage focus is not per se a driver of performance. However, we find that balanced, non-specialised funds slightly underperform funds focused on any stage. We confirmed the striking difference in returns between US

(“North America”) funds and their European counterparts. We eventually find a strong, negative relationship between a fund duration and its performance. We believe that it would be interesting for both GPs and LPs to further understand how their individual actions impact returns. Further research could therefore investigate other potential drivers such as industry focus, geographic focus (do funds invest nationally, regionally or globally?) or operational drivers, for example the relationship between the GP and the managers.

Beyond its academic goal, we hope this paper, providing a general overview of the risk profile and returns of venture capital, will help practitioners understand better the challenges and issues surrounding this industry. Our findings also highlight the need for future research to investigate to what extent operational aspects can drive future returns.

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Appendix

Appendix 1: Results from the quarterly cash-flows by vintage year

This table summarises the results collected from the quarterly cash-flows by vintage year. We are able to report a TV/PI multiple, two MIRRs (8% and 10%) and two PMEs (versus the S&P500 and the Nasdaq). We stop reporting results after 2003 as we lack cash-flow data for funds raised in 2004 onwards. Therefore, the results would not be representative.

	TV/PI	MIRR @ 8%	MIRR @ 10%	PME (S&P)	PME (Nasdaq)
1983	1,48	5,78%	7,24%	0,64	0,69
1984	1,26	5,97%	7,49%	0,59	0,60
1985	1,70	6,44%	7,98%	0,79	0,78
1986	2,64	6,66%	8,10%	1,08	0,94
1987	2,12	7,27%	8,87%	1,04	0,87
1988	2,45	7,78%	9,41%	1,31	1,06
1989	2,46	8,42%	10,18%	1,16	0,93
1990	2,73	9,67%	11,64%	1,43	1,20
1991	1,79	9,72%	11,89%	0,90	0,77
1992	3,60	11,18%	13,39%	1,75	1,55
1993	3,16	11,40%	13,87%	1,75	1,47
1994	3,71	12,51%	15,26%	2,10	1,70
1995	3,62	14,24%	17,63%	2,61	2,05
1996	4,34	15,79%	19,41%	3,37	2,57
1997	2,29	15,16%	18,96%	2,12	1,77
1998	1,27	15,20%	19,28%	1,31	1,35
1999	0,46	14,44%	18,81%	0,49	0,57
2000	0,54	15,92%	39,17%	0,50	0,50
2001	0,78	17,46%	22,31%	0,69	0,63
2002	0,40	17,62%	22,88%	0,36	0,33
2003	0,39	19,50%	25,43%	0,37	0,35

Appendix 2: Quality of regressions – Correlations and test statistics (1/3)

VentureXpert – S&P500

Correlation coefficients	Return-rf	RP(0)	RP(-1)	RP(-2)	RP(-3)	RP(-4)	RP(-5)
Return-rf	**1,00**						
RP (0)	**0,04** (0.32)	**1,00**					
RP (-1)	**0,4** (0.20)	**0,07** (0.43)	**1,00**				
RP (-2)	**0,2** (0.19)	**0,02** (0.38)	**0,08** (0.44)	**1,00**			
RP (-3)	**0,22** (0.16)	**0,01** (0.34)	**0,02** (0.41)	**0,09** (0.46)	**1,00**		
RP (-4)	**0,21** (0.12)	**0,07** (0.28)	**0,01** (035)	**0,02** (0.40)	**0,09** (0.43)	**1,00**	
RP (-5)	**0,23** (0.12)	**0,11** (0.28)	**0,07** (0.35)	**0,00** (0.41)	**0,33** (0.45)	**0,08** (0.49)	**1,00**

Note: p-value is in parenthesis. We calculate the t-stat for each of the pair-wise correlations above, testing for the equality of means.
* 5% confidence level.

VentureXpert – Nasdaq

Correlation coefficients	Return-rf	RP(0)	RP(-1)	RP(-2)	RP(-3)	RP(-4)	RP(-5)
Return-rf	**1,00**						
RP (0)	**0,41** (0.01)	**1,00**					
RP (-1)	**0,42** (0.21)	**0,06** (0.45)	**1,00**				
RP (-2)	**0,26** (0.37)	**0,00** (0.40)	**0,07** (0.45)	**1,00**			
RP (-3)	**0,29** (0.30)	**0,20** (0.33)	**0,01** (0.40)	**0,00** (0.44)	**1,00**		
RP (-4)	**0,82** (0.26)	**0,03** (0.33)	**0,20** (0.36)	**0,01** (0.42)	**0,08** (0.47)	**1,00**	
RP (-5)	**0,13** (0.31)	**0,15** (0.36)	**0,02** (0.39)	**0,19** (0.43)	**0,01** (0.49)	**0,07** (0.48)	**1,00**

Note: p-value is in parenthesis. We calculate the t-stat for each of the pair-wise correlations above, testing for the equality of means.
* 5% confidence level.

Appendix 2: Quality of regressions – Correlations and test statistics (2/3)

Cambridge Associates – S&P500

Correlation coefficients	Return-rf	RP(0)	RP(-1)	RP(-2)	RP(-3)	RP(-4)	RP(-5)
Return-rf	**1,00**						
RP (0)	**0,07** (0.13)	**1,00**					
RP (-1)	**0,35** (0.07)	**0,07** (0.43)	**1,00**				
RP (-2)	**0,14** (0.07)	**0,02** (0.38)	**0,39** (0.44)	**1,00**			
RP (-3)	**0,20** (0.06)	**0,01** (0.34)	**0,02** (0.41)	**0,09** (0.46)	**1,00**		
RP (-4)	**0,20** (0.04)	**0,07** (0.28)	**0,01** (0.35)	**0,02** (0.40)	**0,09** (0.43)	**1,00**	
RP (-5)	**0,21** (0.04)	**0,11** (0.28)	**0,06** (0.35)	**0,00** (0.41)	**0,02** (0.45)	**0,08** (0.49)	**1,00**

Note: p-value is in parenthesis. We calculate the t-stat for each of the pair-wise correlations above, testing for the equality of means.
* 5% confidence level.

Cambridge Associates – Nasdaq

Correlation coefficients	Return-rf	RP(0)	RP(-1)	RP(-2)	RP(-3)	RP(-4)	RP(-5)
Return-rf	**1,00**						
RP (0)	**0,37** (0.23)	**1,00**					
RP (-1)	**0,35** (0.19)	**0,06** (0.55)	**1,00**				
RP (-2)	**0,22** (0.17)	**0,00** (0.40)	**0,07** (0.45)	**1,00**			
RP (-3)	**0,27** (0.12)	**0,20** (0.33)	**0,01** (0.40)	**0,08** (0.44)	**1,00**		
RP (-4)	**0,32** (0.10)	**0,03** (0.33)	**0,20** (0.36)	**0,01** (0.42)	**0,01** (0.47)	**1,00**	
RP (-5)	**0,17** (0.14)	**0,15** (0.36)	**0,02** (0.39)	**0,19** (0.43)	**0,01** (0.49)	**0,07** (0.48)	**1,00**

Note: p-value is in parenthesis. We calculate the t-stat for each of the pair-wise correlations above, testing for the equality of means.
* 5% confidence level.

Appendix 2: Quality of regressions – Correlations and test statistics (3/3)

Sand Hill – S&P500

Correlation coefficients	Return-rf	RP(0)	RP(-1)	RP(-2)	RP(-3)	RP(-4)	RP(-5)
Return-rf	**1,00**						
RP (0)	**0,02** (0.07)	**1,00**					
RP (-1)	**0,86** (0.01)	**0,08** (0.44)	**1,00**				
RP (-2)	**0,04** (0.08)	**0,11** (0.50)	**0,10** (0,45)	**1,00**			
RP (-3)	**0,10** (0.06)	**0,02** (0.48)	**0,09** (0.46)	**0,12** (0.48)	**1,00**		
RP (-4)	**0,01** (0.07)	**0,04** (0.46)	**0,03** (0.49)	**0,11** (0.46)	**0,11** (0.47)	**1,00**	
RP (-5)	**0,06** (0.05)	**0,14** (0.39)	**0,01** (0.44)	**0,00** (0.39)	**0,09** (0.40)	**0,09** (0.42)	**1,00**

Note: p-value is in parenthesis. We calculate the t-stat for each of the pair-wise correlations above, testing for the equality of means.
* 5% confidence level.

Sand Hill – Nasdaq

Correlation coefficients	Return-rf	RP(0)	RP(-1)	RP(-2)	RP(-3)	RP(-4)	RP(-5)
Return-rf	**1,00**						
RP (0)	**0,68** (0.05)	**1,00**					
RP (-1)	**0,34** (0.11)	**0,07** (0.50)	**1,00**				
RP (-2)	**0,11** (0.14)	**0,03** (0.49)	**0,07** (0.49)	**1,00**			
RP (-3)	**0,07** (0.14)	**0,2** (0.48)	**0,03** (0.48)	**0,07** (0.49)	**1,00**		
RP (-4)	**0,08** (0.13)	**0,07** (0.47)	**0,2** (0.46)	**0,02** (0.47)	**0,07** (0.48)	**1,00**	
RP (-5)	**0,14** (0.13)	**0,23** (0.41)	**0,06** (0.40)	**0,17** (0.39)	**0,01** (0.41)	**0,06** (0.43)	**1,00**

Note: p-value is in parenthesis. We calculate the t-stat for each of the pair-wise correlations above, testing for the equality of means.
* 5% confidence level.

Appendix 3: Performance statistics by size bracket

This table summarises the results collected from the fund-level data by size bracket. The first table shows the statistics regarding the IRR measure. The second table focuses on the TV/PI multiple.

	IRR					
	# observations	**Average**	**Median**	**Std. Dev**	**Max**	**Min**
$0m - $30m	671	5,3%	0,6%	0,33	454,9%	-100,0%
$31m - $50m	287	7,9%	2,8%	0,26	257,6%	-100,0%
$51m - $100m	350	13,5%	5,1%	0,32	294,6%	-28,4%
$101m - $300m	417	15,1%	1,8%	0,57	721,0%	-100,0%
$301m - $500m	119	3,6%	-0,5%	0,33	313,0%	-86,8%
$501m - $1,000m	81	2,9%	-0,5%	0,17	104,9%	-18,1%
$1,000m - +	28	6,0%	5,9%	0,09	23,3%	-12,2%
Total	**1953**	**9,0%**	**1,8%**	**0,38**	**721,0%**	**-100,0%**

	TV/PI					
	# observations	**Average**	**Median**	**Std. Dev**	**Max**	**Min**
$0m - $30m	671	1,49	1,11	1,50	16,51	0,00
$31m - $50m	287	1,62	1,22	1,63	14,62	0,02
$51m - $100m	350	2,03	1,39	2,51	28,04	0,13
$101m - $300m	417	1,86	1,14	2,42	19,61	0,00
$301m - $500m	119	1,22	0,97	1,77	19,07	0,00
$501m - $1,000m	81	1,14	0,97	0,90	7,56	0,15
$1,000m - +	28	1,43	1,22	0,78	4,37	-0,06
Total	**1953**	**1,61**	**1,14**	**1,91**	**28,04**	**0,00**

Appendix 4: Performance statistics by location

This table summarises the results collected from the fund-level data by location. The first table shows the statistics regarding the IRR measure. The second table focuses on the TV/PI multiple.

	IRR					
	# observations	**Average**	**Median**	**Std. Dev**	**Max**	**Min**
Americas	1182	13,5%	4,6%	0,44	721,0%	-100,0%
Europe	771	2,2%	-0,4%	0,24	311,1%	-100,0%
Total	**1953**	**9,0%**	**1,8%**	**0,38**	**721,0%**	**-100,0%**

	TV/PI					
	# observations	**Average**	**Median**	**Std. Dev**	**Max**	**Min**
Americas	671	1,99	1,36	2,42	28,04	0,00
Europe	287	1,26	1,02	1,08	12,16	0,00
Total	**1953**	**1,61**	**1,14**	**1,91**	**28,04**	**0,00**

Appendix 5: Performance statistics by stage specialization

This table summarises the results collected from the fund-level data by stage focus. The first table shows the statistics regarding the IRR measure. The second table focuses on the TV/PI multiple.

	IRR					
	# observations	**Average**	**Median**	**Std. Dev**	**Max**	**Min**
Seed	94	9,9%	2,3%	0,32	257,6%	-23,5%
Early	935	9,3%	0,4%	0,47	721,0%	-100,0%
Later	315	9,3%	3,9%	0,28	311,1%	-100,0%
Balanced	609	8,3%	2,9%	0,26	260,3%	-86,8%
Total	**1953**	**9,0%**	**1,8%**	**0,38**	**721,0%**	**-100,0%**

	TV/PI					
	# observations	**Average**	**Median**	**Std. Dev**	**Max**	**Min**
Seed	94	1,58	1,21	1,19	6,35	0,07
Early	935	1,66	1,09	2,43	28,04	0,02
Later	315	1,59	1,29	1,24	14,62	0,00
Balanced	609	1,57	1,26	1,27	10,82	0,00
Total	**1953**	**1,61**	**1,14**	**1,91**	**28,04**	**0,00**