Bergen, Spring 2011
Advisor: Prof. Jarle Møen

Norges Handelshøyskole

Venture Capital

An introduction to the industry and

its effects on firm investments in R&D

NHH

Finn Filip Sigurjonsson Finborud

Venture capital: An introduction to the industry and its effects on firm investments in R&D

Master thesis,
Bergen, spring 2011

School: Norwegian School of Economics (NHH)
Major: Finance
Advisor: Professor Jarle Møen

I Abstract

The first part of this master thesis provides a comprehensive account of venture capital in the financial literature. Venture capital is explained in depth, the history of venture capital, the patterns of venture capital investments, the intricate workings of the highly specialized venture capital industry, the impact of venture capital on economic performance and innovation, and the government's role in venture capital are all explained thoroughly.

One thing that is evident from the Norwegian statistics on venture capital is that the ICT sector is, by far, the most important sector of venture capital in Norway, comprising almost a third of total venture capital investments in 2008 and 2009.

The thesis goes on to present the results of an empirical study on the additionality of venture capital in relation to R&D, using data from the Statistics Norway (SSB). The hypothesis for the empirical analysis was that firms receiving venture capital and spending it on R&D have a tendency also to receive other types of external capital for R&D, i.e. there is an additionality effect greater than one related to venture capital. The results showed the opposite, that the additionality effect is less than one. Hence, venture capital appears to be crowding out other forms of financing for R&D. One interpretation of this is that as a firm receives venture capital and spends it on R&D it simultaneously removes some of the other forms of R&D financing. Another interpretation is simply that a weak construct validity and potential measurement errors bias the coefficients towards zero. The additionality effect was also found to be greater for smaller firms than bigger firms, which indicates that venture capital may be more important for smaller firms as a way to finance R&D and that smaller firms are therefore more capital constraint than bigger firms. More research is necessary to understand the exact mechanism of this additionality effect.

II Preface

This is paper is a master thesis written in relation to the Finance major at the Norwegian School of Economics (NHH), and accounts for 30 ECTS, or one semester, of the Master Program at NHH.

I would first and foremost like to thank my advisor, Professor Jarle Møen, for his timely and comprehensive guidance and constructive feedbacks, which greatly improved the quality of my thesis. I would also like to extend my appreciation to Statistics Norway (SSB) for providing the data from their annual R&D survey, without which it would not have been possible to perform an additionality study. I would also like to show my appreciation to the National Venture capital Association in the USA for providing free and easy access to all of their research reports on their web page. At last, I would also like to show my gratitude to the Norwegian Venture capital & Private Equity Association for being very helpful in sending me their 2009 Activity Survey free of charge, and for providing additional research reports on their web page free of charge.

Most of the statistics and analyses in the first part of the thesis are based on statistics from the USA. The USA was where the venture capital industry first arose, and the USA still comprise a disproportionately large share of global venture capital, which may make it fairly representative for all of the continents of the world. I was forced to work within this limitation as it proved very expensive to attain venture capital statistics from other regions around the world as their venture capital associations demanded a very high price for their reports, and were unwilling to give them away free of charge to a student writing a master thesis on the subject.

Table of Contents

III Introduction

Venture capital is a very interesting topic of study, as it can have a profound impact on the economy; providing capital constrained entrepreneurs with much needed capital and management expertise, thereby affecting the growth and structure of the entire economy. Venture capital is the link between clever entrepreneurs and their innovative products and commercial success. Many game changing firms started out as small entrepreneurial firms receiving venture capital, with Microsoft and Google being, perhaps, the most famous examples. Would they still have succeeded without the capital and management expertise provided by venture capital funds, or would they have disappeared and be forgotten like so many unsuccessful firms do every year?

The venture capital industry has been studied quite thoroughly, and most researchers seem to agree that venture capital has a tendency to increase the growth and commercial success of firms, but a major unsolved issue still being debated in the financial literature is whether venture capital makes firms more innovative or simply that innovative firms are selected as recipients of venture capital. To answer this question in full is beyond the scope of this master thesis, but as it studies the additionality effect of venture capital on total R&D it does touch upon the subject.

Having first provided a comprehensive account of venture capital in the financial literature, I will present the results of an empirical study on the relationship between venture capital and other types of external capital in relation to R&D financing. The hypothesis for the empirical study is that there is a tendency for firms who receive and use venture capital for R&D also to receive other types of external capital for R&D. The empirical study is, therefore, an attempt to identify the additionality effect of venture capital on total R&D spending. A Fixed Effects (FE) regression framework was used in an effort to control for most relevant influences on the outcome of the dependent variable, thereby trying to identify the counterfactual in order to identify the causal relationship between venture capital and total R&D.

The paper is structured in three parts. The first part provides a brief description of venture capital and explains how venture capital is the free market solution to a market failure, presents the history of venture capital, and the patterns of venture capital investments, and there is also one chapter on the venture capital industry in Norway. The second part dives into the details of venture capital and presents many empirical findings from previous studies, thereby providing a greater understanding of the specialized nature of venture capital and the intricate workings of the venture capital industry. The third part is an empirical study on the additionality of venture capital on the financing of R&D using a panel dataset from the R&D survey performed by Statistics Norway (SSB).

Part 1: Introduction to Venture Capital

1.0.0 The Private Equity Universe

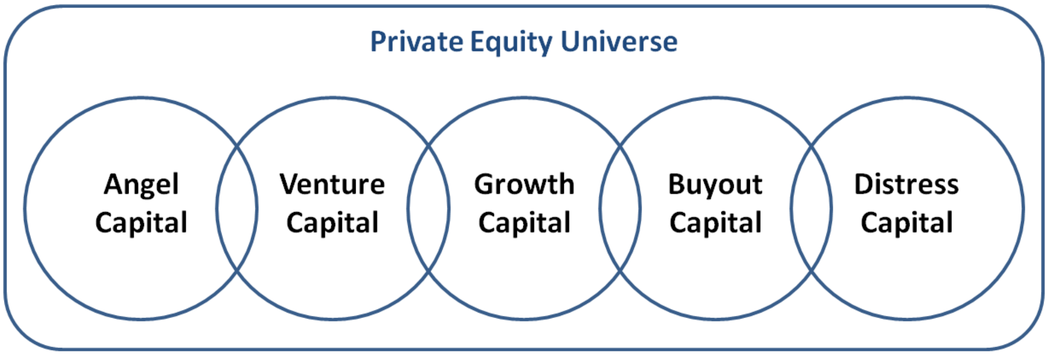

Figure 1 – Source: a modified version of Metrick's 2007 figure

Private equity is, broadly speaking, risk capital invested in firms that are *not* publicly traded on a stock exchange. The private equity universe can be broken down into the five categories seen in figure 1: (1) Angel Capital, (2) Venture capital, (3) Growth Capital, (4) Buyout Capital, and (5) Distress Capital; although other researchers have broken down private equity in other ways. In the following, I will explain the differences between the five types of capital in the private equity universe.

(1) Angel Capital is equity provided by angel investors, or groups of angel investors, who are wealthy individuals investing their own capital. They usually provide capital to inventors and entrepreneurs, with nothing but an idea, who are looking to start up a firm (seed-stage) and to very young, start-up firms (start-up stage); stages that require only small amounts of capital. Consequently, Angel investors tend to make smaller, but a larger number of investments than for example venture capital funds. Since they invest their own capital, they can keep all the returns to their labor, and therefore have a correspondingly lower cost of capital compared to a financial intermediary, and can invest in deals that would not work for other types of private equity funds (Metrick 2007). According to Metrick (2007), total angel capital under management is estimated to be about the same size as total venture capital under management. Furthermore, Kerr, Lerner & Schoar (2010) find that start-ups receiving angel capital are 27% more likely to survive for at least 4 years compared to start-ups not receiving angel capital. They also find that these firms are 44% more likely to receive subsequent venture investment. These findings indicate the importance and potential of angel capital to the overall economy. An interesting follow-on question would be if governments could, with the same efficacy, provide angel capital to entrepreneurs and start-up firms, thereby increasing economic growth.

(2) venture capital is a form of equity provided through venture capital funds, which, unlike angel capital organizations, are financial intermediaries. Venture capital funds usually invest in young firms, whose products or services are either in development or are commercially available, but have yet to establish a commercial organization and start selling. They also invest in firms with established organizations and products that need more capital to expand the business. This latter point about venture capital investments shows the overlap with growth capital investments. (Metrick 2007)

(3) Growth Capital[1] is most often provided through financial intermediaries, such as late-stage investments by venture capital funds, specialized growth capital investment firms, and to some extent more traditional buyout investment firms. Firms seeking growth capital are usually able to generate revenue and profit, but don't have sufficient cash generation to fund major expansions, acquisitions, or other investments (e.g. entering new markets). (Metrick 2007)

(4) Buyout Capital is equity investments, which is most often pooled with acquisition debt and used to make acquisitions with the aim of taking majority control over a mature company, or part of a company, already generating operating cash flows. The buyout capitalists hope to increase the profitability of the acquired firm and either relist the firm on a stock exchange or sell it to other investors after a few years, making a profit. The equity usually makes up between 10% and 40% of the total capital, with traditional bank debt and mezzanine debt making up the rest. The most famous buyout of all time is the $25billion purchase of RJR Nabisco by Kohlberg, Kravis and Roberts (KKR) in 1989, but most buyouts are of "middle-market" companies receiving little attention by public markets, because they are engaged in mature industries with stable cash flows and limited potential for internal growth (Metrick 2007). According to Metrick (2007), total Buyout Capital under management is about three times larger than venture capital under management, which makes it the largest category of private equity. (Metrick 2007)

(5) Distress Capital is similar to Buyout Capital, but specializes on making investments in distressed companies with subsequent long-term turnaround operations. (Metrick 2007)

[1] http://en.wikipedia.org/wiki/Growth_capital

2.0.0 Venture Capital in Brief

As described above, venture capital focuses mostly on early-stage firms that have already completed the seed-stage and start-up stage and are at or near commercialization of its products. Venture capital providers are professional, institutional managers who provide venture capital through venture capital funds, i.e. financial intermediaries. Investors of venture capital commit an agreed amount to the venture capital fund, but they do not transfer the money to the fund until it is needed for investments into portfolio firms. Each venture capital fund is a separate Limited Partnership where the investors are called Limited Partners (LPs) and the managers of the fund are called General Partners (GPs). The venture capital organization, or the GPs, can simultaneously run several venture capital funds. LPs have limited liability to the venture capital fund, and are required not to be engaged in the day-to-day operations of the fund to keep the limited liability. Limited Partnerships are based on comprehensive contracts with many covenants to prevent the GPs from doing as they like with the LPs' money. Each fund has a limited life span, usually between 7 to 12 years, and can also have a defined investment strategy (e.g. only invest in biotech or IT, or only invest in early-stage or late-stage firms). Since each fund has a limited life span, each investment must be viable to succeed in a few years, and all investments made by the fund must be exited before the end of the fund's life. Each portfolio firm receives staged funding, meaning that after an initial funding of a firm the venture capital fund typically reserves 3 to 4 times the first investment for follow-on investments in subsequent funding rounds. (Gompers & Lerner 1999)

The investments are made into essentially illiquid stocks, which, more or less, make them worthless unless the firms succeed in commercializing its products so that the firms can be sold through an IPO or a sale to other investors several years down the road. Clearly, venture capital investments are long-term, high-risk investments, and "the payoff comes after the company is acquired or goes public. Although the investor has high hopes for any company getting funded, only one in six ever goes public and one in three is acquired."(NVCA 2010 Yearbook). This explains why venture capital organizations are so focused on thorough due diligence before selecting which firms to invest in, and why they spend so much resources on monitoring and actively engaging in the portfolio firm after making the first investment; venture capitalists usually take at least one position on the board of directors of their portfolio firms, and they use their reputation and network among industry professionals to attract and hire high-quality management to their portfolio firms. "For every 100 business plans that come to a venture capital firm for funding, usually only 10 or so get a serious look, and only one ends up being funded."…"These days, a business concept needs to address world markets, have superb scalability, be made successful in a reasonable timeframe, and be truly innovative. A concept that promises a 10 or 20 percent improvement on something that already exists is not likely to get a close look" (NVCA 2010 Yearbook). A concept that promises an incremental improvement on something that already exists is more likely to be developed in large corporations attempting to improve their current technology. On the other hand, these same corporations are unlikely to be willing to invest in new technologies that will make their current technologies and operations completely obsolete. "Many talented teams have come to the venture capital process when their projects were turned down by their companies" (NVCA 2010 Yearbook).

Another characteristic of venture capital funds is that they increasingly make the decision to invest conditional on another venture capital fund agreeing on becoming a syndication partner in the investment, another venture capital fund that agrees that the investment is attractive and is willing to co-invest (Gompers & Lerner 1999). There are several reasons for this, which I will come back to later.

I will now use Metrick's (2007) five main characteristics of venture capital to sum up what I have presented about venture capital so far. (1) venture capital is provided through venture capital funds, which are financial intermediaries. (2) venture capital investments are made only into private firms. (3) venture capital organizations take an active role in monitoring and helping the companies in its portfolio. (4) The primary goal of venture capitalists is to maximize the return on its investments into portfolio firms by way of an IPO or a sale to other investors. (5) venture capital investments are made to fund the internal growth of companies, as opposed to growth through acquisitions.

Below (table 1) are some famous examples of successful venture capital investments during the venture capital industry's 60 years of existence:

Venture Capital Backed Companies Known for Innovative Business Models Employment at IPO and Now

Company	As of IPO	Current	# Change
The Home Depot	650	331,000	330,350
Starbucks Corporation	2,521	176,000	173,479
Staples	1,693	75,588	73,895
Whole Foods Market, Inc.	2,350	52,900	50,550
eBay	138	15,500	15,362

Venture Capital Backed Companies Known for Innovative Technology and Products Employment at IPO and Now

Company	As of IPO	Current	# Change
Microsoft	1,153	91,000	89,847
Intel Corporation	460	86,300	85,840
Medtronic, Inc.	1,287	40,000	38,713
Apple Inc.	1,015	35,100	34,085
Google	3,021	16,805	13,784
JetBlue	4,011	11,632	7,621

Source: IHS Global Insight. Current data is FY 2007 Year End Data

Table 1 – Source: NVCA 2010 Yearbook

3.0.0 Venture Capital – The Free Market Solution to a Market Failure

The following chapter describes three factors, *Information asymmetry*, *adverse selection* and *moral hazard*, which are the cause of a certain type of market failure, and explains that the consequence of this market failure is that certain high-risk projects are unable to raise external financing. The chapter then explains how venture capital is able to mitigate some of these problems and provide financing for some of these high-risk projects. The sources of the knowledge presented in this chapter are Hall & Lerner (2009), Peneder (2009) and lecture notes from the corporate finance course at NHH.

Information asymmetry refers to a situation where the insiders, for example the entrepreneurs, are better informed about the firm's operations and risks than its investors and creditors; the information is asymmetrically distributed among stakeholders. The problem of *adverse selection* and *moral hazard* on the part of the entrepreneur arises from the separation of ownership and management, where the entrepreneur has an incentive to engage in behavior that is not value-maximizing to the financiers. Ownership, in this context, can also extend to debt financing as that entails ownership of part of the firm's future cash flow. Adverse selection and moral hazard are so called agency costs and can only occur when there are information asymmetries.

To explain these terms I will use an example of an entrepreneur looking to borrow traditional bank debt. When there are severe information asymmetries, the bank cannot accurately monitor the risk taking of the entrepreneur, and would not be able to see if the entrepreneur increased the risk of the firm's operations after receiving the debt financing. After the entrepreneur has received the debt financing the incentives for risk shifting arise. It is this incentive for risk shifting that is called moral hazard and can be explained as follows. The equity can be seen as a call option on the firm, and the debt can be seen as a risk free asset minus a put option on the firm (see figure 2).

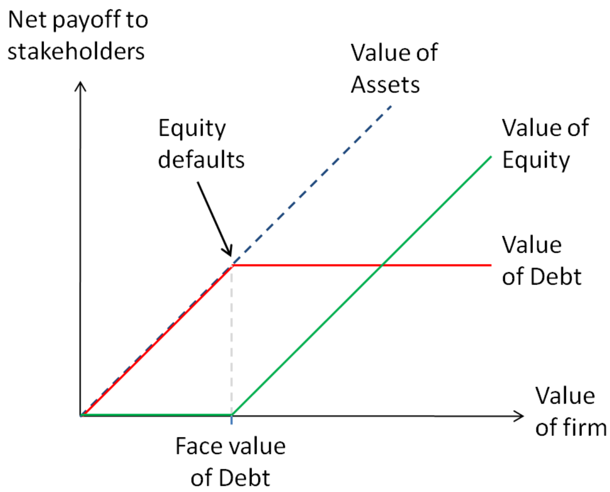

Figure 2 – Source: Lecture notes in Corporate Finance at NHH (Fall 2009)

One of the drivers of the value of options is the variance, or the risk, of the underlying asset, which in this case is the firm. Increased variance makes an option more valuable, because the probability of getting a large payout increases; this applies to both call and put options. This means that the entrepreneur, who is the equity owner, or the owner of the call option, has an incentive to increase the risk of the firm thereby increasing the probability of a large payout. On the other hand, the increased risk reduces the value of the debt, because the value of the debt is equal to a risk free investment *minus* a put option. As long as the bank cannot accurately observe the actions of the entrepreneur and adjust the interest rates on the debt according to the increased risk of the firm, the entrepreneur has an incentive to increase risk, thereby increasing the value of the equity at the expense of the bank.

To compensate for risk shifting, the bank would ideally want to raise the interest rates on the debt. But since it cannot accurately monitor the firm, it can also not discriminate between those firms that act in the best interest of the bank and those undertaking risk shifting at the expense of the bank. It would have to raise the interest rates on all firms were severe information asymmetries exist. The higher interest rates would discourage all but the most risky borrowers, so that only the risky borrowers would end up borrowing money from the bank, and the quality of the bank's loan pool would decline markedly. This effect is the adverse selection problem. Instead of raising interest rates, the bank uses covenants to restrict the amount of lending and demands collateral in the form of tangible assets to reduce the problem of moral hazard. The bank will also preclude lending to firms where the problem of asymmetric information is particularly severe.

The problem of information asymmetry is not limited to debt financing. In the case of an entrepreneur receiving external equity from outside investors, the entrepreneur can take advantage of the information asymmetry by engaging in wasteful spending, (e.g. a lavish office, corporate parties, expensive company cars etc.) from which the entrepreneur benefits disproportionately but does not bear their entire cost. The entrepreneur might also pass up a favorable investment opportunity because there is a certain probability that the company goes bankrupt and the entrepreneur loses his/her job. Since most investors are wary of this problem they will demand a higher rate of return than would be the case if the funds were internally generated. Even if the manager is motivated to maximize shareholder value, informational asymmetries may make raising external capital more expensive or even preclude it entirely.

To sum up, those firms that are particularly prone to information asymmetries and do not have sufficient tangible assets for collateral will most likely not receive traditional financing from banks or external investors. Thus, when these firms cannot generate sufficient internal cash or the entrepreneurs do not possess sufficient capital on their own, they will not be able to finance their projects.

Michael Peneder explains it differently in his 2009 article "The impact of Venture capital on Innovation Behavior and Firm Growth". He writes: "In the ideal case of perfect markets without information problems, the amount of financially feasible projects for risk-neutral capital investors is exclusively determined through the expected profits and therefore independent of the extent of uncertainty Var(π)." He goes on to write: "In imperfect markets with asymmetric information, additional costs m are generated through the need for more elaborate selection and monitoring processes in order to mitigate problems of adverse selection and moral hazard." He concludes by writing that: "In this situation a financing gap arises, as certain projects are no longer considered financially feasible due to increased monitoring, advising, and control costs (even if the expected profits are positive in the case of perfect information)." Here, Peneder touches upon an important consequence of risk and return in situations of asymmetric information; the amount of financially feasible projects for risk-neutral capital investors is not independent of risk, but rather determined by the interaction of risk and return. This is because the greater the uncertainty, the greater is the cost to overcome the information asymmetry, and the higher is the required return by investors. If we also conclude that investors are not, in fact, risk neutral, but rather risk averse, then the impact of information asymmetry is further amplified. I have illustrated this point in figure 3.

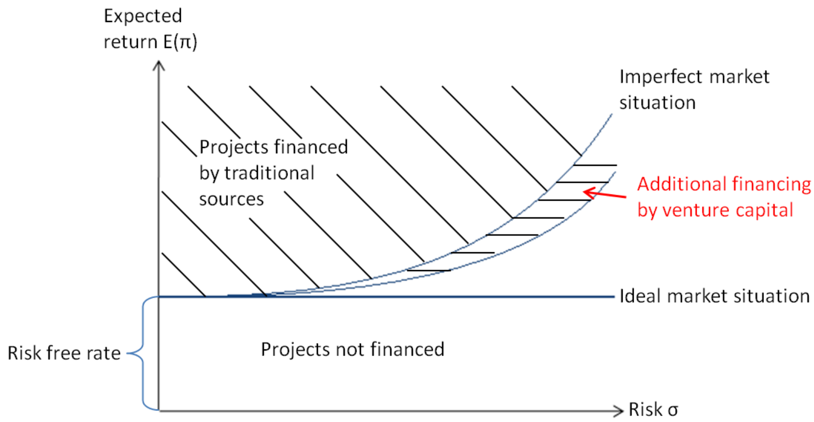

Figure 3 – Source: Simplified and modified version of Peneder's 2009 figure

> The ideal market situation referred to in the figure assumes perfect capital markets with no taxes, no transaction costs, no information asymmetries and risk-neutral investors. The imperfect market situation referred to in the figure only adds information asymmetries and risk-averse investors but keeps the assumptions of no taxes and no transaction costs.

Given the assumptions of the ideal market situation, investors will be willing to finance any projects with an expected return above the risk free rate. Given the assumptions of the imperfect market situation, investors will still be willing to finance projects with an expected return close to the risk free rate when the uncertainty is very low (i.e. when the cost associated with information asymmetry are negligible). As the uncertainty increases and the costs to mitigate information asymmetries increases, investors will demand increasingly higher expected returns to compensate for the increased risk and increased costs to overcome information asymmetries. As figure 3 hints at, information asymmetries can be at least partly overcome by intensively scrutinizing firms before providing capital and then monitoring them afterwards. This alleviates some of the information gaps and reduces capital constraints to those firms that are particularly prone to the problems of information asymmetries.

Banks, Insurance companies, pension funds, mutual funds, and public stock exchanges, which can be considered traditional sources of finance, only go so far as to alleviate information gaps and provide funding to marginal projects. They will only pay for selection and monitoring as long as their marginal cost of engaging in additional selection and monitoring is lower than their marginal benefit. The top boundary in figure 3 represents marginal projects financed by these traditional sources of capital. The middle boundary in figure 3 represents marginal projects financed by venture capital organizations, which is lower than the boundary for traditional sources of capital. This resets on an important assumption about venture capital organizations, namely that their specialization with high-risk projects provides them with competitive advantages in selecting and monitoring high-risk investments; their marginal cost of overcoming problems of information asymmetry and agency costs is lower than that of traditional capital providers. The implication of this insight is that venture capital organizations will seek to invest only in those firms that are particularly prone to problems of information asymmetry and agency costs, in which venture capital organizations have the most to gain on their competitive advantage in selection and monitoring.

By their very nature, young R&D firms within the high-tech IT and biotechnology industries are the ones most prone to problems of information asymmetry and agency costs. Young firms have little history to show for, which increases the uncertainty about their future performance. Firms engaged in Research and Development (R&D) also have highly uncertain futures, because there is no guarantee that their research efforts will pay off, and they usually have very little tangible assets to put up as collateral; investing in R&D firms is tantamount to buying a call option on a particular R&D effort. Furthermore, since high-tech IT and biotechnology is so complex and advanced, it requires expertise to have genuine insights into their workings and potential. Consequently, firms with all of these traits will be most prone to problems of information asymmetry and agency costs. Following this argument and the last argument in the previous paragraph, venture capital funds will invest mostly in these types of firms, where they will have the greatest benefit from their expertise in selecting and monitoring.

There is one last tool, besides intense selection and monitoring, venture capitalists use to reduce the incentive for destructive behavior on the part of the entrepreneur due to moral hazard, which has given the venture capital industry a reputation as a sort of thief of companies. This tool was studied by Kaplan and Strömberg (2003) who documented how venture capitalists allocate control and ownership rights contingent on financial and non-financial performance. If a portfolio company performs poorly, venture capitalists obtain full control. As performance improves, the entrepreneur obtains more control. If the firm does well, the venture capitalists relinquish most of their control rights but retain their equity stake. So, in order to remain in control of their company the entrepreneur has to work hard to ensure good progress and performance.

4.0.0 The History of Venture Capital

Banks have long functioned in the same fundamental way; they provide loans to businesses in exchange for an interest rate and secure those loans by demanding collateral in the businesses' assets. If entrepreneurs did not generate sufficient cash on their own, did not have wealthy friends (Angel investors), and could not provide valuable collateral, then they were unable to fund their projects; until one man came up with the innovation called Venture capital. That man was George Doriot, who established the world's first venture capital organization called American Research and Development Corporation (ARD) in 1946. "Unlike modern funds, it was organized as a corporation and was publicly traded. In its 25-year existence as a public company, ARD earned annualized returns for its investors of 15.8 percent" (Metrick 2007). The venture capital industry grew slowly in the first decade, but recognizing the potential of venture capital, the US government established so called Small Business Investment Companies (SBICs) after the Small Business Act of 1958 was enacted, which, first and foremost, served to train a pool of venture capitalists for later decades. The structure of limited partnerships described in the previous section was developed in the 1960s. It had become the dominant investment structure in venture capital funds by 1978, and is by far the most common form of organization in the venture capital industry today (Hall & Lerner 2009). Despite the creation of SBICs and the limited partnership structure, total venture capital fundraising was still less than $1billion a year throughout the 1970s (Metrick 2007).

In the following decade, the growth of the venture capital industry increased substantially, and the following quote explains both the early slow growth and why it was boosted: "Activity in the venture industry increased dramatically in early 1980s. Much of the growth stemmed from the US Department of Labor's clarification of Employee Retirement Income Security Act's 'prudent man' rule in 1979, which had prohibited pension funds from investing substantial amounts of money into venture capital or high-risk asset classes. The rule clarification explicitly allowed pension managers to invest in high-risk assets, including venture capital" (Hall & Lerner 2009). "To this day, pension funds continue to supply nearly half of all the money for venture capital in the United States. The participation by pension funds hastened the participation for other institutional investors, and the modern era of venture capital began" (Metrick 2007).

As capital commitments to venture capital funds grew, so did the cyclicality of the venture capital industry, creating serious instability in venture capital investments, which can be seen in figure 7 showing year over year changes in capital commitments[2], capital under management[3], and investments, as well as changes to GDP. Metrick (2007) has divided the history of the venture capital industry from 1980 until today into three periods: The pre-boom period (1980-1994), the boom period (1995-2000), and the post-boom period (2000-today), and the division is quite clear when looking at the venture capital investment statistics (see figures 4, 5, and 6). Venture capital commitments exploded from 1996 to 2000 when returns related to the internet bubble started climbing, which as we all know, burst in 2000 and sent the world economy into a recession, with a sharp decline in new venture capital commitments as a natural consequence. "…the industry as whole may lose more dollars from its investments in 1999 and 2000 than it made in all prior years combined" (Metrick 2007). Venture capital commitments relative to GDP has also been highly volatile and capital commitments to the venture capital industry as a share of GDP was almost at the same level in 2009 as they were in the pre-boom period. Consequently, venture capital under management both in absolute values and relative to GDP is likely to continue its decline for another few years before it stabilizes; the fact that funds have a life of about 7-10 years creates a delay from changes in capital commitments until capital under management is affected. As old venture capital funds are discontinued, some capital will not be funneled back into new venture capital funds. Venture capital investment largely follows new venture capital commitments, but is slightly less volatile. This is as one would expect, since it takes some time from the funds are established until they have found the right projects to invest in.

A question raised by Metrick is how large a share of GDP should optimally be invested in venture capital backed firms? He emphasized that most innovation happens in large corporations like Microsoft, IBM, Intel, Pfizer etc, and that only innovation in small firms with a potential to penetrate large markets is backed by venture capital funds. So how much innovation should occur in small firms? He does not propose an exact figure, but he refers to the theory of the firm introduced by Ronald Coase (1937), which says that "a universal reduction in transactions costs should reduce the optimal scale of firms and allow for greater levels of innovation by small companies" (Metrick 2007). Everyone would agree that transaction costs have gone down in the past few decades, and that the higher levels of venture capital investments in the post-boom period compared to the pre-boom period could possibly be explained by this theory.

[2] Capital commitments refer to the process were investors to venture capital funds promise to provide capital as they are needed by the venture capital funds.

[3] Capital under management refers to the cumulated capital commitments that have been promised by investors, i.e. total capital available for investments by venture capital funds (incl. investments already made).

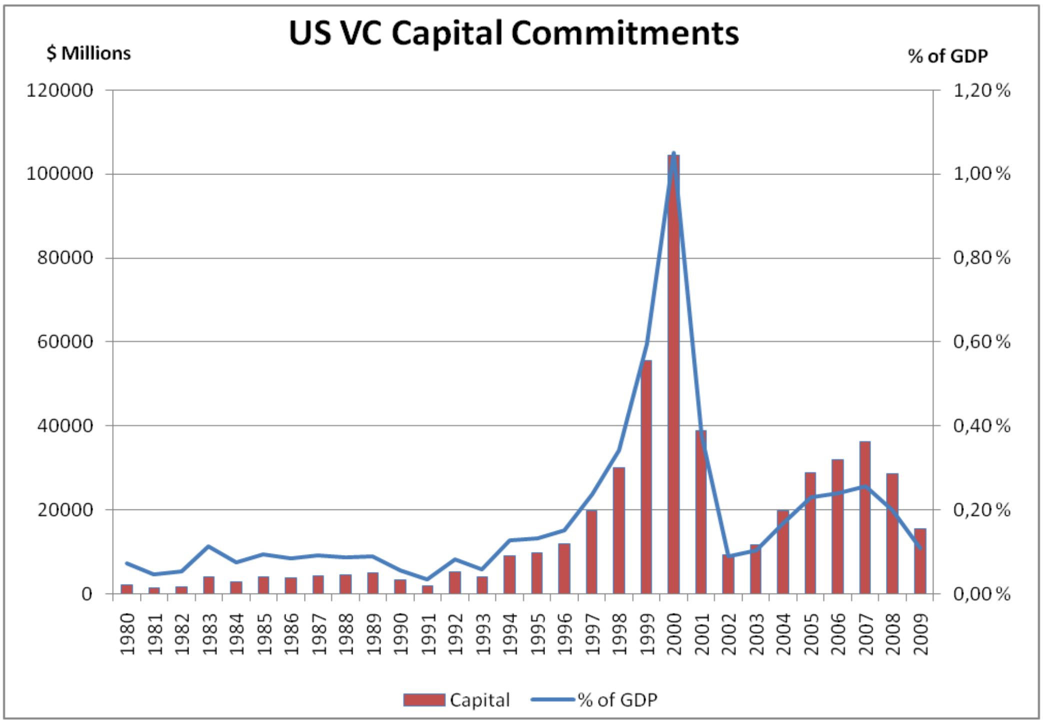

Figure 4 – Source: NVCA 2010 Yearbook

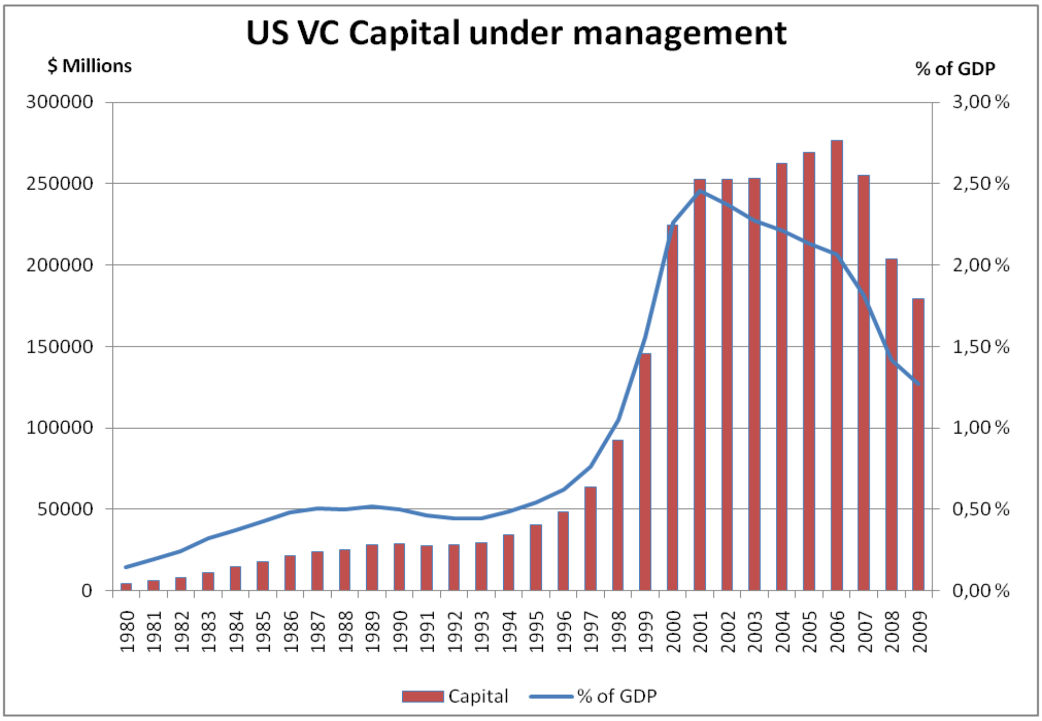

Figure 5 – Source: NVCA 2010 Yearbook

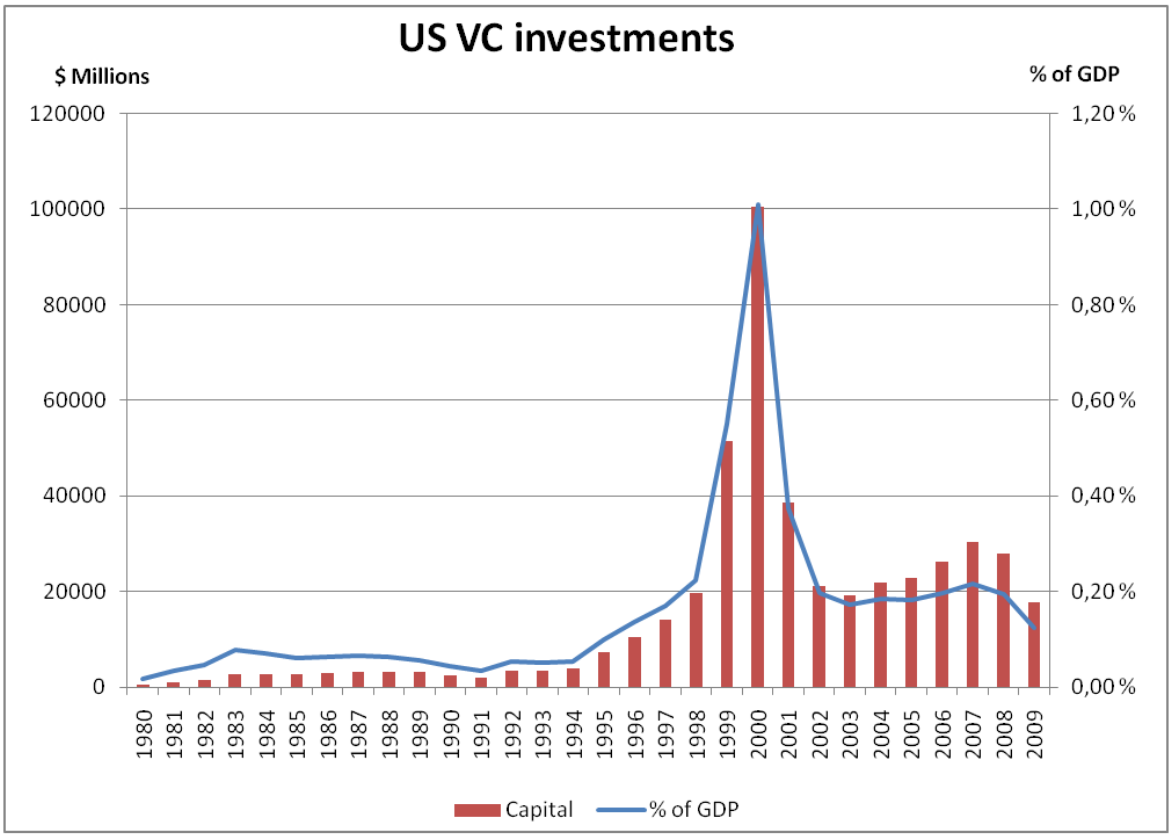

Figure 6 – Source: NVCA 2010 Yearbook

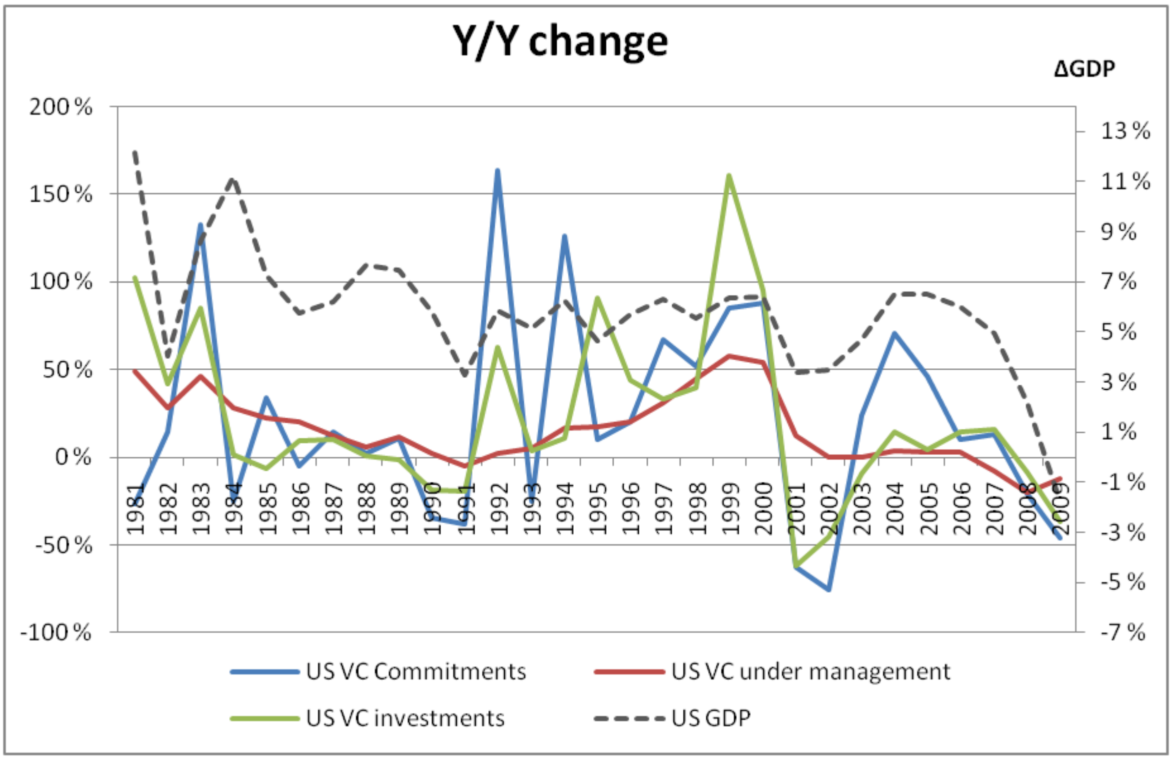

Figure 7– Source: NVCA 2010 Yearbook

5.0.0 Patterns of Venture Capital Investments

Firstly, figure 8 shows which investors supply the capital to the venture capital industry: 42% comes from pension funds, 25% comes from finance and insurance corporations, 21% comes from endowments and foundations, 10% comes from individuals and families, and 2% comes from corporations operating funds (NVCA Venture capital 101).

Secondly, figure 9 shows how venture capital investments made from 1991 to 2000 were exited: 14% of venture capital backed firms went public, 33% were acquired, 18% are known to have failed, and 35% either remain privately owned or have an unknown outcome (NVCA Venture capital 101).

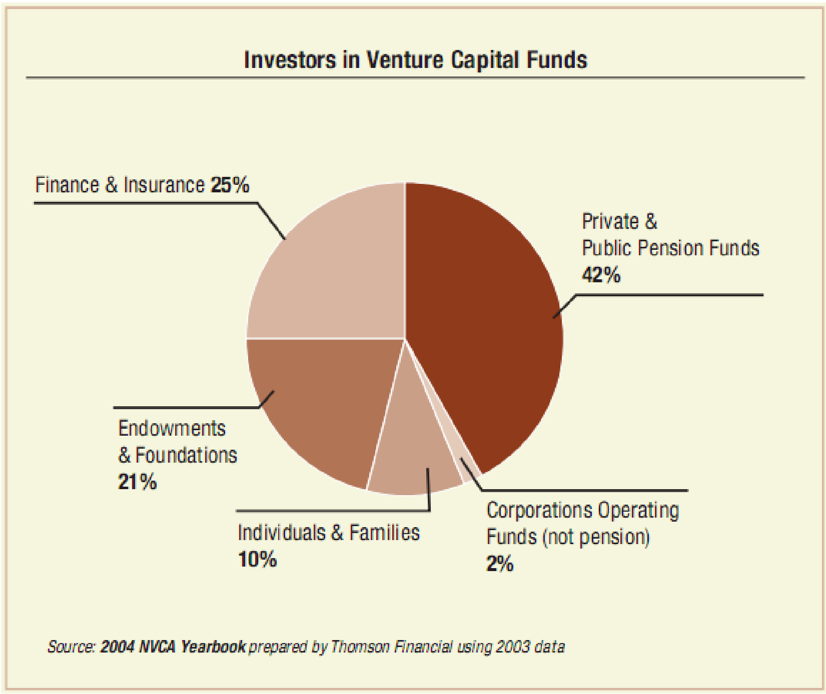

Figure 8 – Source: NVCA "Venture capital 101"

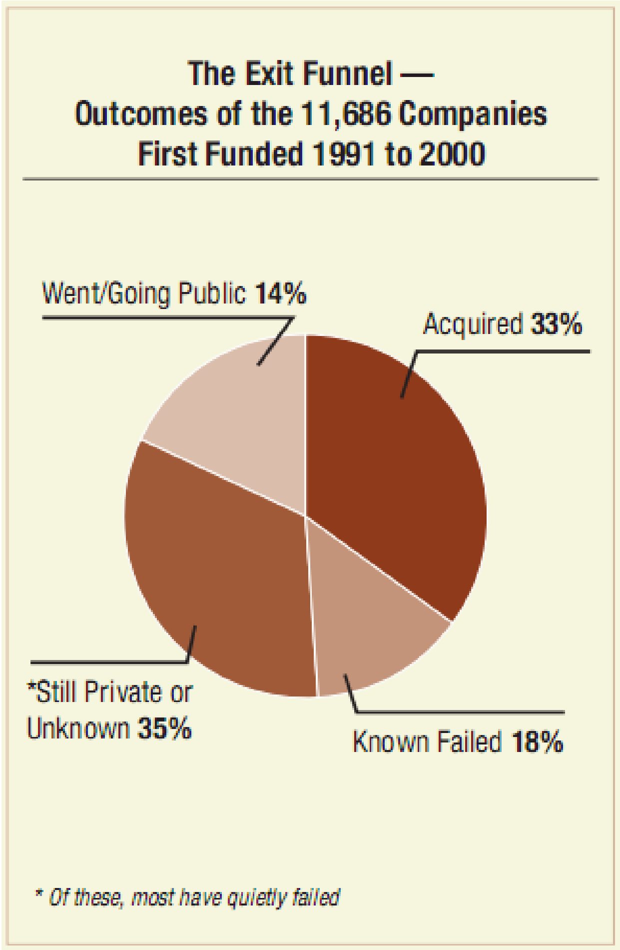

Figure 9 – Source: NVCA "Venture capital 101"

5.1.0 Investments by Industry

Venture capital investments have, at least since 1980, been concentrated in two broad sectors; IT and Healthcare. IT includes IT services, software, semiconductors, and hardware, as well as Telecom and telecom equipment. We could also include the Media and entertainment category, since much of the media and entertainment investments are internet related. Healthcare includes Biotechnology and Healthcare devices and equipment. The two broad sectors made up about 50% of US venture capital investments in 1980 and almost 80% of US venture capital investments in 2009 (see figure 10), and their dominant position among venture capital funds is not coincidental. Since venture capital investments need to have the potential to grow quickly and penetrate large markets they generally need a technological advantage, hence venture capital funds focus on the high-tech industries of healthcare and IT.

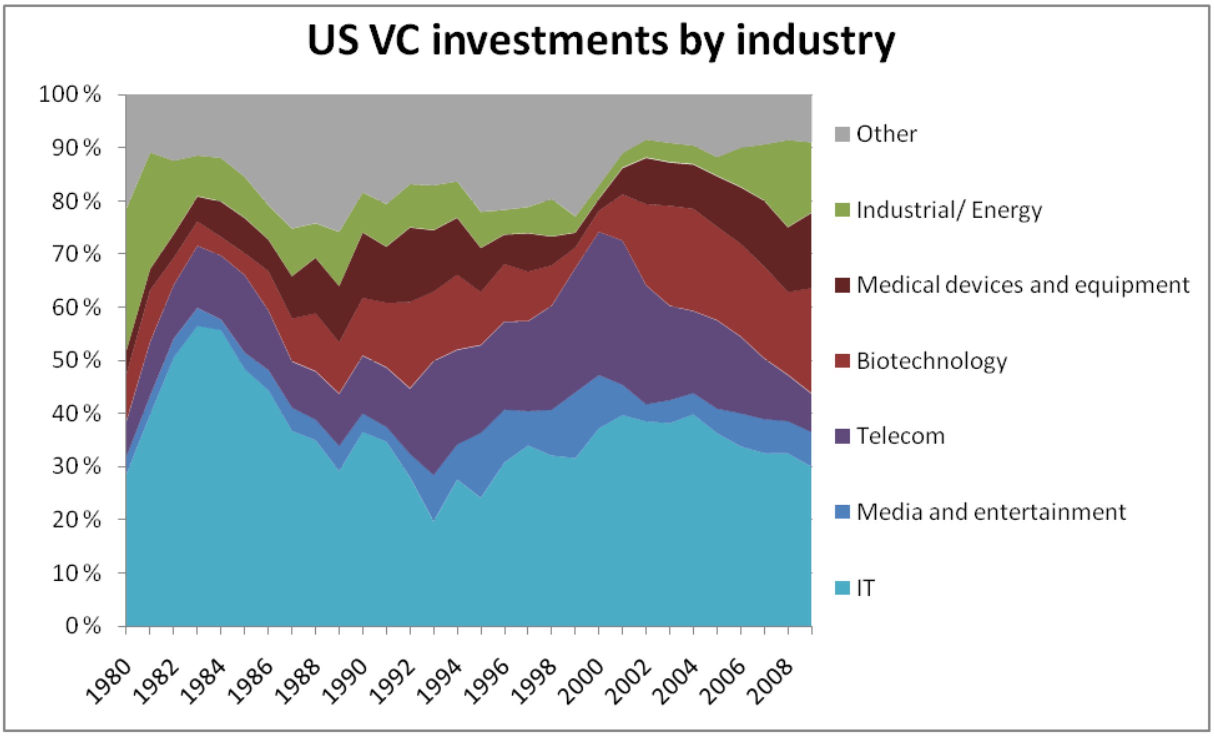

Figure 10 – Source: NVCA 2010 Yearbook

5.2.0 Investments by Stage

Venture capital investments can also be broken down into stages of firm development; startup stage (or seed stage), early stage, expansion stage, and late stage. When the venture capital industry began its upward trend in 1980, the fraction of venture capital going to late stage firms was relatively small, and the fraction of venture capital going to firms in the other three stages was of roughly equal size (see figure 11). What is clear from the figure is that up until the year 2000 the relative share of expansion stage investments rose and the relative share of startup stage investments declined. By 2000, the relative share of expansion stage investments made up about half of all venture capital investments. Metrick (2007) attributes this development to three factors: Angel Capital largely replaced venture capital in startup stage investments, some new venture capital firms were created to focus on later stages, and some old venture capital firms grew so large from their success that they needed to find larger investments to invest all their capital. The large influx of new venture capital commitments during the dotcom bubble must have exacerbated the need for larger investments to put all the capital to work, which is probably why new venture capital firms were created to focus on later stages.

After 2000, the relative share of late stage investments grew substantially, and the relative share of expansion stage investments declined. This might be explained by two factors: a natural development as many of the expansion stage investments matured into late stage investments, and losses related to venture capital investments during 1999 and 2000 were so great, and new venture capital commitments dropped so much, that the need to find larger investments to invest all the capital in was reversed. Also, after 2000, the relative share of startup stage investments has gradually started increasing, so that in total, the development from 1980 until 2000 seems to be reversing. (The source of all venture capital investment numbers is the NVCA 2010 Yearbook).

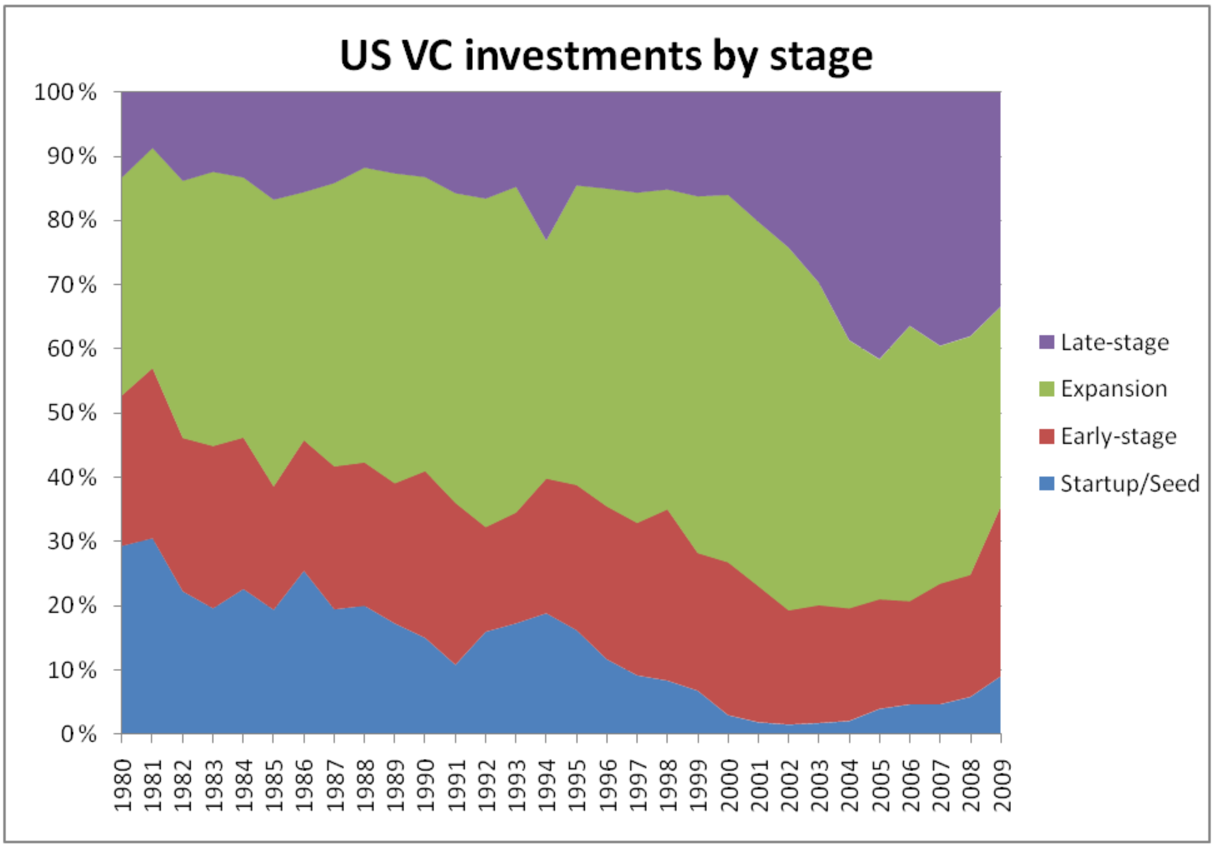

Figure 11 – Source: NVCA 2010 Yearbook

6.0.0 Venture Capital in Norway

Norway is a small country and the Norwegian Venture capital & Private Equity Association is fairly young and only has a few years of records on the venture capital industry. Also, the association does not distinguish explicitly between venture capital and the broader Private Equity category in many of its statistics, so many of the numbers and graphs presented in this chapter are from the Private Equity industry as a whole. Keep this in mind when reading the comparisons between the statistics of venture capital in the USA presented in chapters 4 and 5 and the statistics presented in this chapter. Nevertheless, as this paper includes an empirical study on venture capital in Norway, it is useful to spend a little time on the statistics of the Norwegian Venture capital & Private Equity Association presented in their 2009 activity survey.

New capital commitments to venture capital funds in Norway is very volatile and reached a record 2 billion NOK in 2008 and a low of 106 million NOK in 2009; capital under management nearly doubled from about 4 billion NOK in 2006 to above 7 billion NOK in 2009; due to the establishment of Investinor and the capital expansion at Argentum, the Norwegian government accounted for 44% of new funds in 2008 and 2009; total new investments increased by more than threefold between 2003 and 2007, and subsequently fell sharply back to 2005 levels in 2009; The ICT, renewable energy and environmental technology, life science and biotechnology, and petroleum sectors made up about three quarters of all new investments in 2009 as well as all accumulated investments at the end of 2009 both in terms of the number of investments and the investment amount; and, lastly, by far the largest form of divestments in 2008 and 2009 were sales to industrial buyers, while only one divestment was in the form of an IPO.

6.1.0 New Capital Commitments

After seeing a doubling in capital under management compared to five years earlier, new capital commitments fell to just 106 million Euro in 2009, down from a record 2095 million Euro in 2008 (see figure 12). There were raised 7 new funds and 3 funds had second closings. The new capital commitments as a percentage of GDP in Norway can be compared against the new capital commitments in the USA seen in Figure 4; Norway's new capital commitments were lower in the last years of the boom-period and somewhat higher in the post-boom period after 2000, particularly in the last few years (keep in mind that the Norwegian numbers include capital commitments to buyout funds, which the US numbers do not).

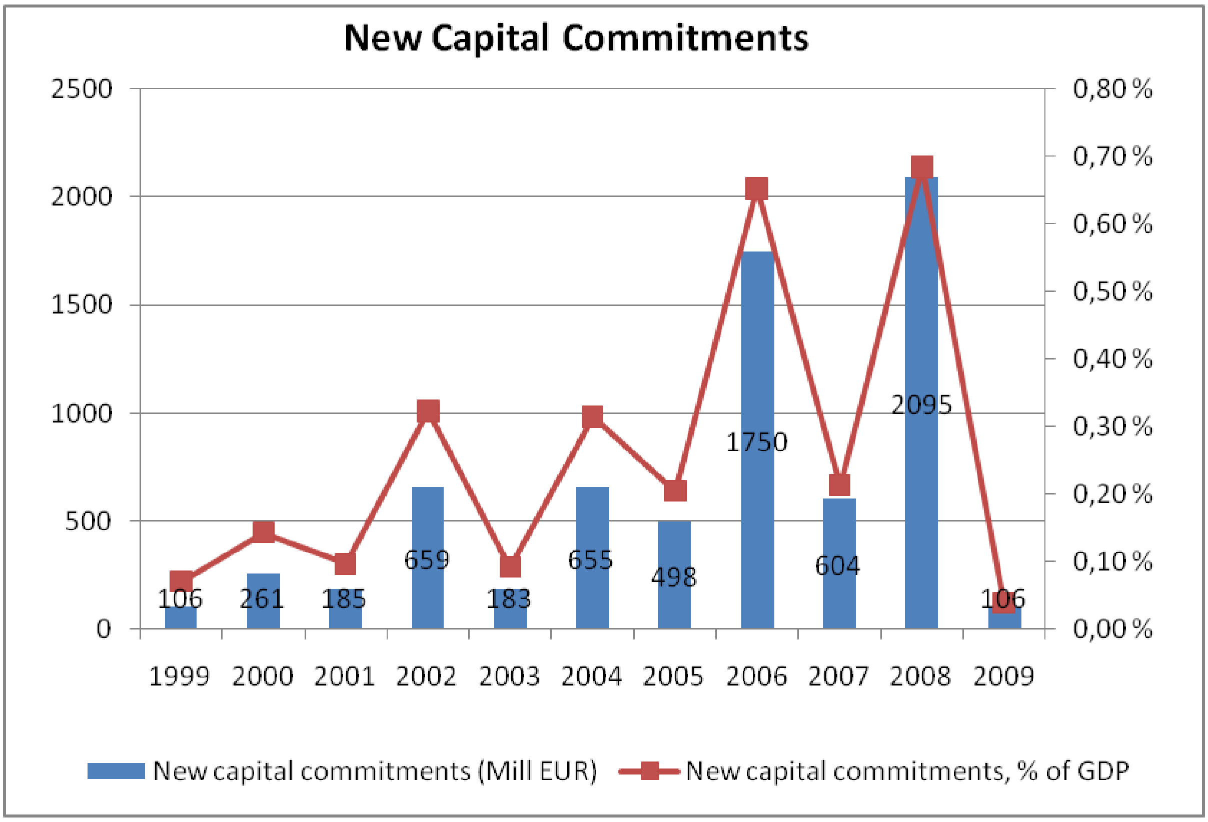

Figure 12 – Source: Norwegian Venture capital and Private Equity Association "Activity survey 2009"

6.2.0 Capital under Management

Capital under management stabilized after a few big funds were closed at the end of their lifetime, thereby outweighing the new capital commitments (see figure 13). Capital under management seems to have increased quite sharply, from about 4 billion Euros in 2006 to 7155 million Euros in 2009, equivalent to 2.6% of GDP, which is substantially higher than capital under management in the US seen in Figure 5.

A breakdown of capital under management relative to the stages of firm development shows that Buyout funds and Start-up funds were by far the two biggest categories in 2009 with 3302 and 2847 million Euros under management respectively, while Expansion funds had 607 million Euros under management and Seed funds 399 million Euros under management (see figure 14). The figure also shows that capital under management in Buyout funds and Start-up funds increased a lot between 2004 and 2009, while capital under management in Seed funds and Expansion funds only increased slightly.

Capital under management and accumulated investments (EUR mill)

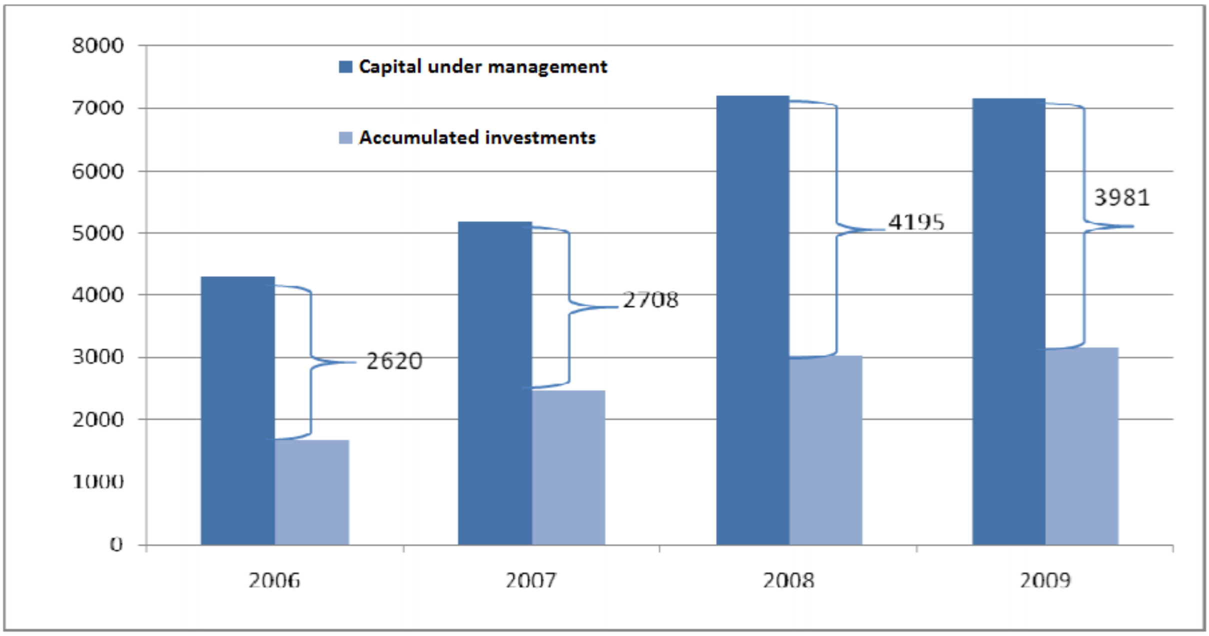

Figure 13 – Source: Norwegian Venture capital and Private Equity Association "Activity survey 2009"

Capital under management (EUR mill)

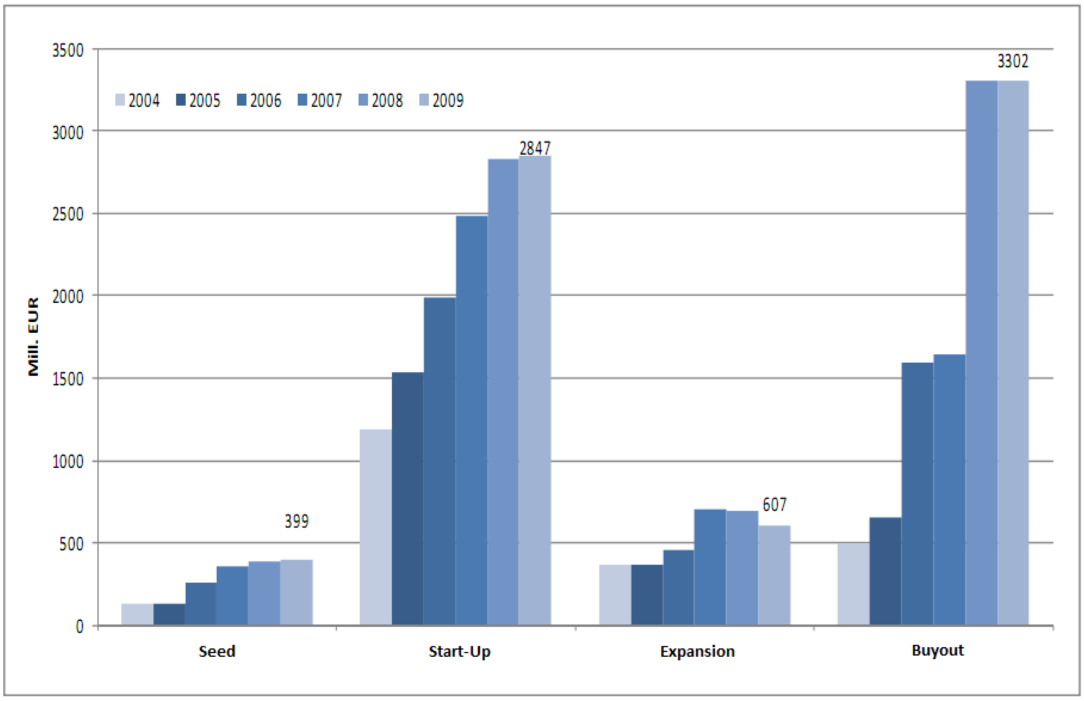

Figure 14 – Source: Norwegian Venture capital and Private Equity Association "Activity survey 2009"

6.3.0 Investor Types

A breakdown of investor type in new Private Equity funds established in 2008 and 2009 in Norway can be seen in figure 15; fund of funds made up 42% of which Argentum made up 21%; the public early-stage investment entity Investinor made up 23%; corporate investors 8%; family corporations 8%; private pension funds 7%; public pension funds 5%; and other investor types (insurance corporations, banks, endowments, private investors, and others) made up the remaining 7%. The venture capital association wrote that pension funds and insurance corporations made up about 40% of investors in comparable European funds established in 2008 and 2009, while such institutional investors only made up 12% in Norway, so it is clear that the investor breakdown in Norway is somewhat unusual. The venture capital association also wrote that about 50% of the new capital came from foreign investors.

The Norwegian government made up a sizeable portion of the new funds established in 2008 and 2009 with a share of total new funds of 44%, in which Argentum made up 21% and Investinor 23%. Argentum is an asset manager specializing in Nordic Private Equity funds, i.e. Argentum is a fund of funds investor. Argentum was formally established in 2001 by the Norwegian Government with a share capital of 2.45 billion NOK. It is wholly owned by the Norwegian Ministry of Trade and Industry, and the government decided to expand Argentum's total share capital by 2 billion NOK between 2008 and 2009. Investinor is a fully owned subsidiary of Innovation Norway, which itself is owned by the Norwegian Ministry of Trade and Industry. Investinor was established through parliamentary proposition number 8 of 2007-2008 and is mandated to manage 2.2 billion NOK on behalf of the Norwegian government. Investinor operates much like any other venture capital fund in that it invests risk capital into internationally oriented and competitive Norwegian firms in early and expansion stages, takes an active leadership role in its portfolio firms, and has a goal of exiting its investments within 3-7 years.

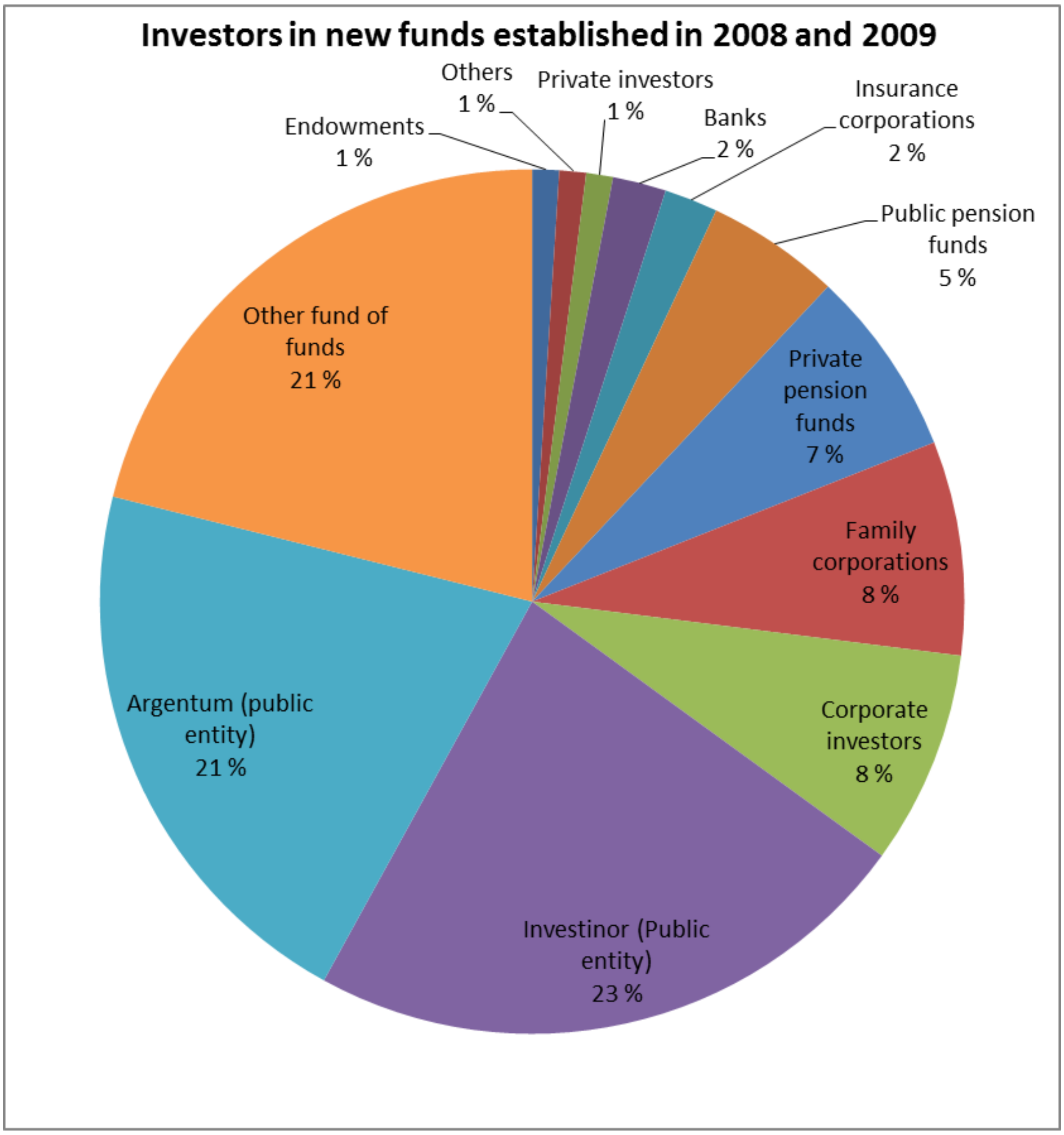

Figure 15 – Source: Norwegian Venture capital and Private Equity Association "Activity survey 2009" and Argentum's annual report 2009

6.4.0 New Investments

Although capital under management has stopped growing, investments by Private Equity funds have continued, so that the difference between capital under management and accumulated investments has decreased somewhat (see figures 13 and 16). Total new investments, as seen in figure 13, increased sharply until it peaked in 2007 at almost 800 million Euros. Total investments later fell to 596 million Euros in 2008 and 319 million Euros in 2009. As a percentage of GDP, total investments were about the same in Norway as in the USA during the post-boom period (see figure 6 and 16). As explained in the previous paragraph, Argentum was formally established by the Norwegian Government in 2001, and made its first investment in 2002. With a total share capital of 2.45 billion NOK at its formation, it is not unthinkable that the establishment of Argentum greatly contributed to bring total new venture capital investments in Norway up to the American level, relative to GDP, during the post-boom period.

The venture capital association wrote that the financial crisis had a strong negative impact on new investments by Private Equity funds, but that new investments started growing again by the second quarter of 2009, and more than two thirds of new investments in 2009 were made in the second half of 2009. We can therefore expect venture capital investments to continue to grow in the coming years.

Figure 17 shows a breakdown of new investments into firm stages; the fraction of venture capital going to firms in the seed stage has remained low and relatively stable since 2003; the fraction going to firms in the start-up stage has clearly trended upwards, and stood at about 50% in 2009; the fraction going to firms in the expansion stage, on the other hand, has clearly trended downwards from 65% in 2003 to only about 10% in 2009; and lastly, the fraction going to buyouts peaked at about 50% in 2007, but has since been falling to about 40% in 2009.

Figure 18 shows a breakdown by industry of new and follow-on investments in 2009 and it is clearly the ICT segment that has received most attention both in number of new and follow-on investments and in million Euros, comprising almost a third of the total. There are four segments that stand out as most important to the Private Equity industry, as seen by figure 18; ICT, Renewable energy & environmental technologies, Life science & biotechnology, and Petroleum. They made up about three quarters of total investments, both in number of investments and in invested amounts. Compared to investments in the USA, as seen in figure 10, the Norwegian composition has a higher tilt towards petroleum and clean-tech, but that might be quite natural when you consider that Norway has a large oil and gas production and also has a strong tradition for renewable energy production in the form of hydropower.

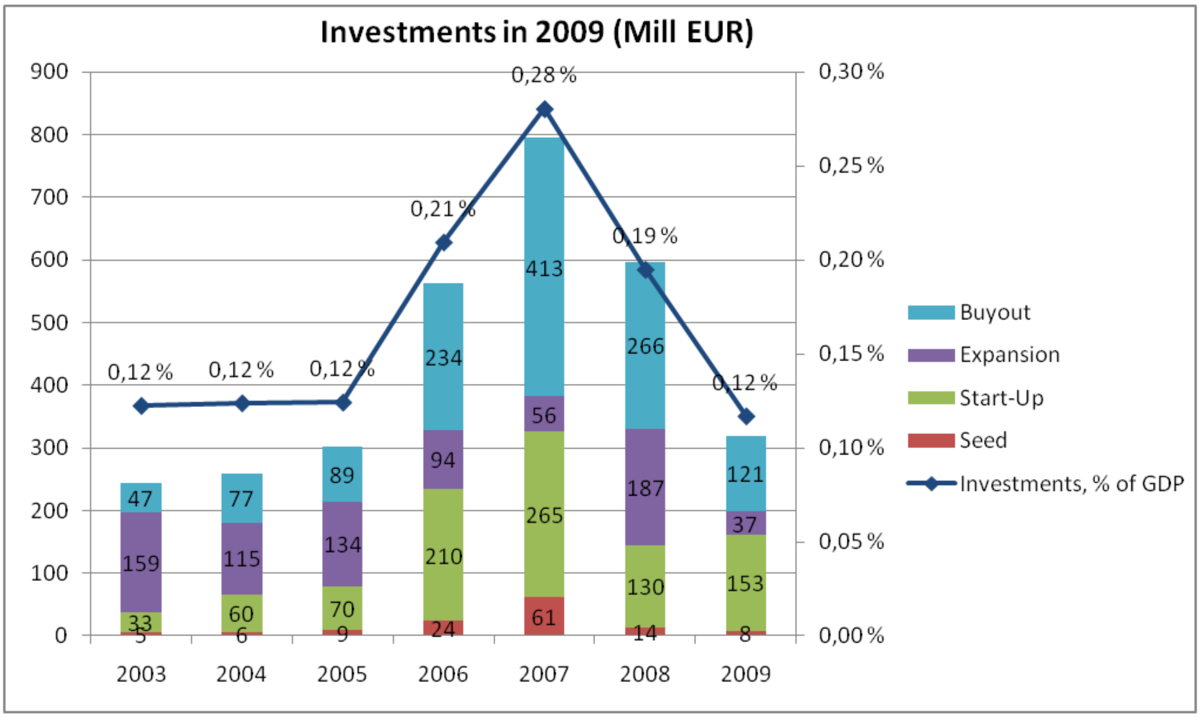

Figure 16– Source: Norwegian Venture capital and Private Equity Association "Activity survey 2009"

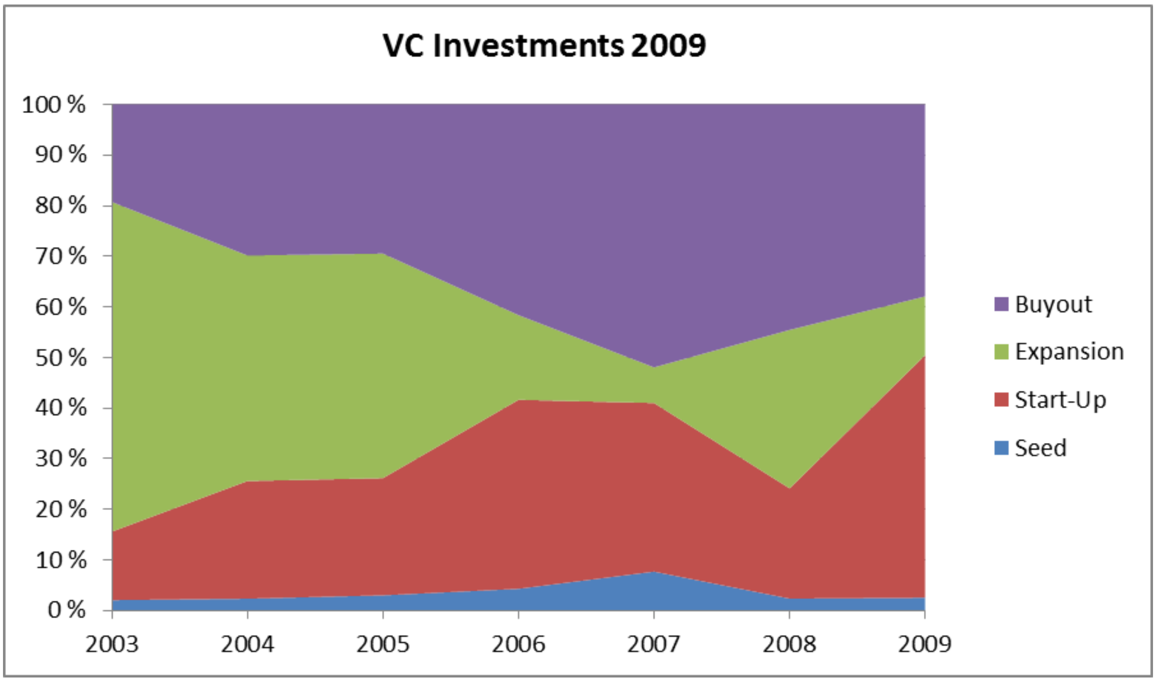

Figure 17 – Source: Norwegian Venture capital and Private Equity Association "Activity survey 2009"

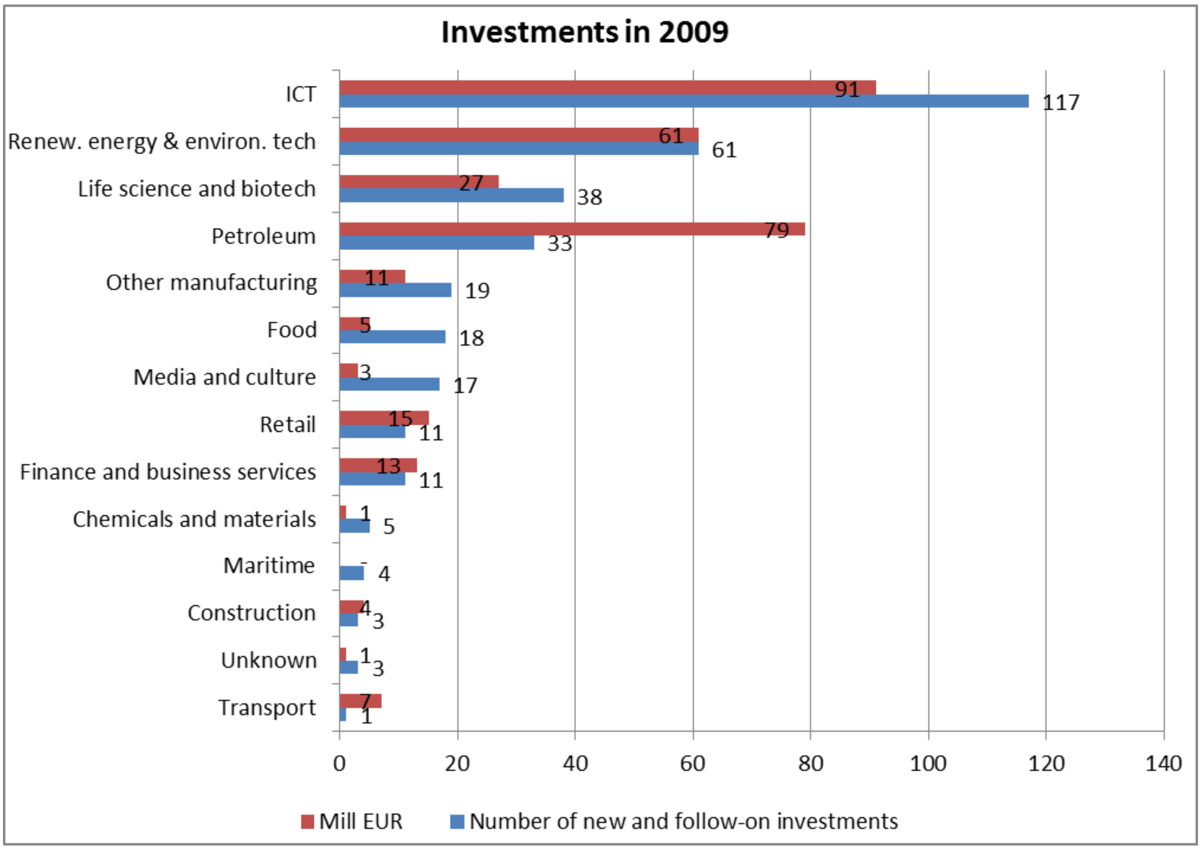

Figure 18 – Source: Norwegian Venture capital and Private Equity Association "Activity survey 2009"

6.5.0 Total Investment Positions

The four major segments mentioned in the previous paragraph are, not surprisingly, also the four largest segments when considering all investments held by Private Equity funds at the end of 2009 (see figure 19). Private Equity funds were invested in 216 portfolio firms within the ICT segment, 102 portfolio firms within the Life science & biotechnology segment, 85 portfolio firms within the Petroleum segment, and 71 portfolio firms within the Renewable energy & environmental technology segment. Once again, it is clear that the ICT segment is dominant with about a third of the total, and the four largest segments made up about three quarters of the total, about the same fraction as new investments.

Accumulated investments held at the end of 2009 came to 3172[4] million Euros, compared to total capital under management of 7155 million Euros (see figure 20); after having received capital commitments from investors it takes time for venture capital funds to find appropriate investments, and when they do find a candidate, they reserve 3 to 4 times the first capital investment for additional capital injections through staged investments, which explains why total capital under

[4] Discrepancies between the numbers in figures 13, 14 and 20 are due to rounding errors.

management is about twice the size as accumulated investments. Figure 20 shows a breakdown of accumulated investments by firm-stage; the largest segment was the Start-up segment with 1415 million Euros in 319 portfolio firms; followed by the Buyout segment with 1086 million Euros in 96 portfolio firms; the Expansion segment with 459 million Euros in 141 portfolio firms; and the Seed segment with 213 million Euros in 135 portfolio firms. As one might expect, accumulated investments per portfolio firm in the Buyout segment is much higher than in the other segments. Portfolio firms in the Buyout segment are usually larger and more mature than portfolio firms in the other segments, and the goal of the Buyout funds is to take full control in each firm or at least become the majority shareholder. Funds in the other segments, on the other hand, are usually minority shareholders in their portfolio firms.

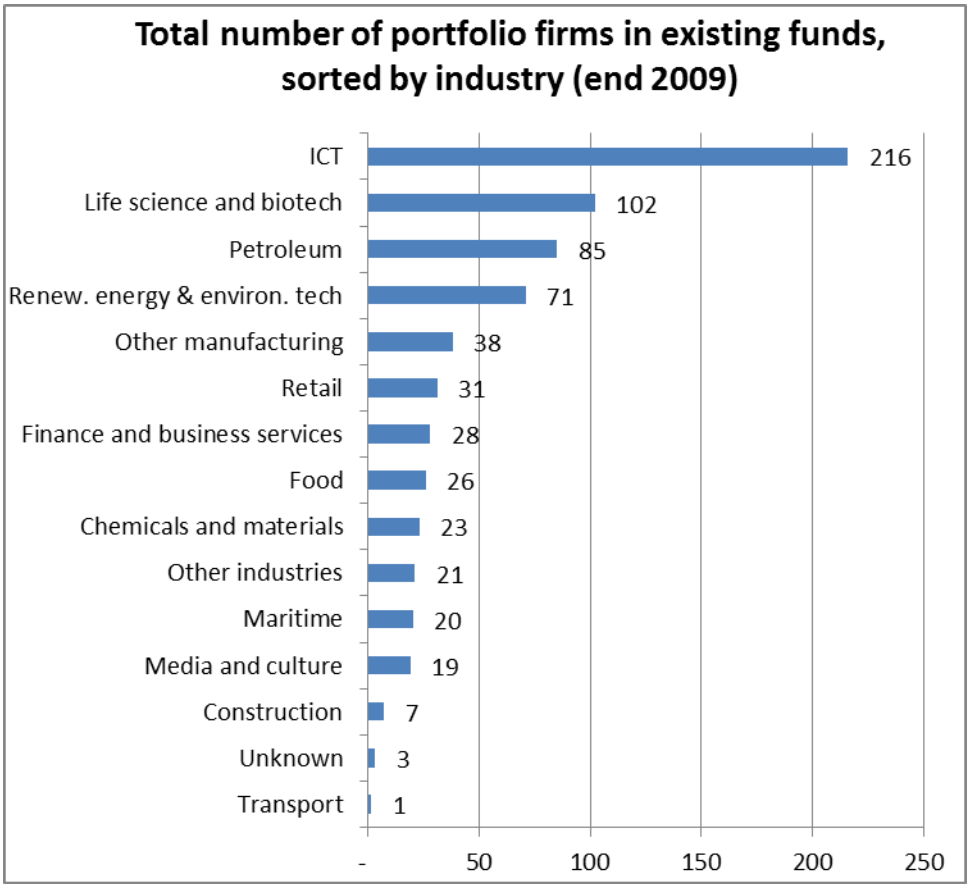

Figure 19 – Source: Norwegian Venture capital and Private Equity Association “Activity survey 2009”

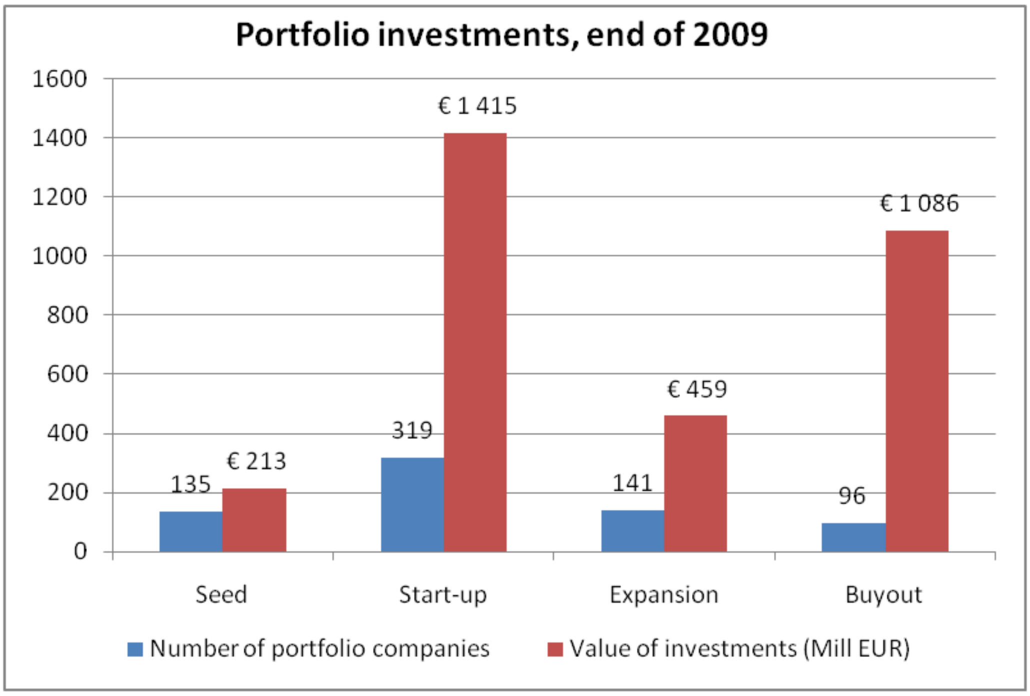

Figure 20 – Source: Norwegian Venture capital and Private Equity Association "Activity survey 2009"

6.6.0 Divestments

Figure 21 shows how venture capital funds in Norway divested their investments in 2008 and 2009 measured in number of portfolio firms. Divestments through IPOs have historically been, by far, the most profitable divestment form for venture capital funds, but as the figure shows, only 1 divestment was made through IPOs in 2008 and 2009. The very low number of IPOs is likely affected by the financial crisis, and can be expected to increase as the economy moves out of crisis mode and back into growth. Divestments by sale to other corporate buyers and other funds are on average the divestments with the second highest return, but these returns are much lower than the returns from IPOs (see chapter 7.3.0 for more details on the estimated historical average returns from venture capital divestments); there were 28 divestment to industrial buyers, the most prominent form of divestments, and 5 divestments to other funds in 2008 and 2009.

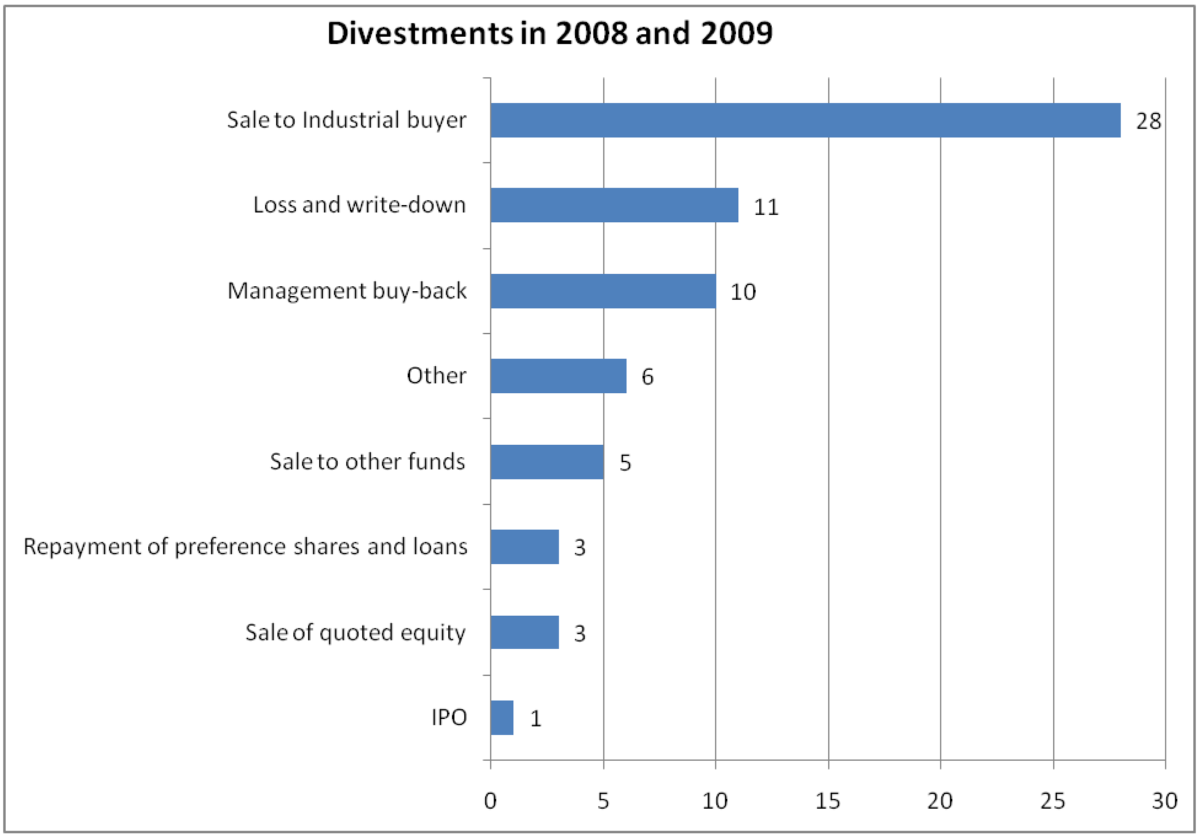

Figure 21 – Source: Norwegian Venture capital and Private Equity Association "Activity survey 2008" and "Activity survey 2009"

Part 2: Venture Capital in More Detail and Some Empirical Findings

7.0.0 The Venture Capital Cycle

Gompers and Lerner (1999) wrote a comprehensive book on what they call the venture capital cycle, and the following chapter uses their book as the only reference for knowledge, facts, and figures about the venture capital cycle, and the chapter can be considered a summary of their findings.

Gompers and Lerner (1999) present three key traits about the venture capital industry: (1) tremendous incentive and information problems, not only in the firms that receive venture capital financing but also between the investors or Limited Partners (LPs) and the venture capitalists or General Partners (GPs); (2) the strong interrelatedness of the three steps in the venture capital cycle, fundraising, investing, and exiting; and (3) the slow adjustment of the venture capital industry to changes in the supply of capital or demand for venture capital financing (investment opportunities).

I have already written about incentive and information problems between the venture capital funds and the firms receiving venture capital financing, so I will not focus more attention on that. In the following I will explain the three steps of the venture capital cycle, fundraising, investing and exiting, and highlight the problems between LPs and GPs.

As mentioned earlier, venture capital organizations are financial intermediaries specializing in providing equity capital to young, high-risk, firms. They do this by raising periodic venture capital funds, which are most often in the form of limited partnerships, with a 7 to 12 year life. Due to their limited life, venture capital investments must eventually be liquidated and the funds returned to the LPs, and the venture capital organizations must raise new funds to stay in business, usually once every 2 to 5 years. The most successful portfolio firms are liquidated through IPOs and make up the bulk of the venture capital returns. Other somewhat less successful portfolio firms are sold to other private investors. Unsuccessful firms have their assets liquidated, go bankrupt, or remain operational at moderate levels of activity.

7.1.0 Fundraising

In this part of the chapter, I will explain the nature of the fundraising process and present various empirical results related to the fundraising process.

The partnership agreement between GPs and LPs in the fundraising process is important because it is the crucial mechanism for limiting the behavior of GPs and aligning their incentives with the LPs. Many of the oversight mechanisms found in corporations – powerful boards of directors and the market for corporate control – are not available here. If LPs become involved in the day-to-day management of a venture capital fund, they risk losing their limited liability. No liquid market for partnership interests exists, and LPs are frequently restricted from selling their partnership interests. Consequently, the primary remedy for LPs is legal action triggered by a violation of the covenants in the agreement.

7.1.1 Covenants

So what do the covenants typically cover? There are three groups of covenants; (i) the first group regulates the overall management of the fund, (ii) the second group regulates the activities of the GPs, and (iii) the third group regulates the types of investments. (i) In the first group are covenants that: (1) limit the amount invested in any one firm; (2) limit the use of debt; (3) restrict co-investments with the venture organizations earlier and later funds (remember that each fund is a separate limited partnership); (4) regulate reinvestment of profits. (ii) In the second group are covenants that: (5) limit GPs investment of personal funds in firms the venture capital fund is invested in; (6) limit GPs from selling their share of the venture capital fund's profits; (7) limit GPs fundraising activities; (8) limit GPs outside activities; (9) limit the addition of new GPs. (iii) In the third group are covenants that: (10) limit the fraction of the fund invested in a given investment class; (11) limit the sum of the fractions invested in two or more investment classes.

Each of these covenants is designed to address problems of incentive and information between LPs and GPs, and, without going into each and every one of them, here are some examples: (1) is designed to prevent GPs from attempting to salvage an investment in a poorly performing firm by investing significant resources in follow-on funding rounds. The GPs have an incentive to do this because their share of the profits can be seen as a call option on the venture capital fund, and they therefore gain disproportionately from increasing the risk of the portfolio at the expense of diversification; (5) is designed to prevent GPs from devoting excessive time to the firms they have personal investments in, and to avoid that they do not terminate funding to firms they have personal investments in that are performing poorly; (10) is designed to prevent GPs from investing in public securities, because the average compensation to money managers is an annual fee of about 0.5% of capital under management, while the typical compensation to GPs is 20% of profits and an annual fee of about 2.5% of capital under management.

Two approaches to understanding the determinants of covenants have emerged: (1) 'The costly contracting theory' predicts that because negotiation and enforcement of explicit provisions are costly, covenants are included only when the benefits of restricting activity are greater than the costs. (2) 'The supply and demand hypothesis' predicts that relative supply and demand conditions in the venture capital market affect the number of, and strength of, covenants and restrictions in long-term contracts. This hypothesis is based on the observation that monetary compensation is highly standardized, and barely changes with changing supply and demand conditions in the venture capital market.

Univariate comparisons give support to both theories. Regression analyses show that the proxies for the supply and demand hypothesis are significantly related to all three covenant groups, while the proxies for potential agency problems – the costly contracting hypothesis – are significantly related to covenant groups (i) restricting the management of the fund and (iii) restricting the investment types, but not to covenant group (ii) restricting the activities of the general partners. The regression results therefore give some support to both hypotheses.

7.1.2 Monetary Compensation

Contractually specified compensation is particularly important in the venture capital setting, because LPs cannot utilize many of the methods of disciplining managers found in corporations and must avoid direct involvement in the fund's activities; removing a GP is a difficult and costly procedure. Consequently, compensation is one of the most contentious issues between LPs and GPs of venture capital funds.

Gompers and Lerner found that 81% of the funds pay 20-21% of the profits to GPs. Although seemingly homogeneous, there are subtle differences in the profit sharing agreements; compensation for older and larger venture capital organizations is more sensitive to performance and more variable than the compensation of other venture capital organizations; the fixed component of compensation is higher for smaller, younger funds and funds focusing on high-technology or early-stage investments; however, no relationship is found between incentive compensation and actual performance.

Monetary compensation to GPs comprise of one part fixed annual fees and one part variable profit sharing. Two models have been developed to explain the compensation schemes to GPs in venture capital funds: the learning model, and the signaling model. The signaling model says that GPs will attempt to signal their abilities to potential investors through their compensation schemes in the contracts they offer, which means that GPs must know their level of ability beforehand. The learning model, on the other hand, is based on the theory that neither GPs nor investors know the GPs' abilities in new organizations. As GPs' abilities become known, compensation schemes can reflect the updated information about ability.

The empirical results related to variable compensation show that older and larger venture capital organizations command about a 1 percentage point greater share of profits than less established, smaller funds. This is significant at the 5% level and is consistent with the learning model. Funds focusing on high-tech and early-stage investments – investments with higher investment and monitoring costs – receive a larger share of profits, which is also significant at the 5% level. Larger and older venture capital organizations also have significantly greater variance in the share of profits that they receive, again consistent with the learning model.

The empirical results related to fixed compensation show that older and larger venture capital organizations receive a lower fixed compensation than younger, smaller venture capital organizations, which is the opposite of what the signaling model predicted, while the learning model did not have a prediction about this result. Furthermore, funds focusing on high-technology and early stage investments – investments with higher investment and monitoring costs – have higher fixed compensation, which is predicted by both the learning model and the signaling model.

The empirical results of the elasticity of compensation to fund performance are consistent with the predictions of the learning model, and not the signaling model; as abilities of GPs become known with greater certainty, explicit incentives, typically in the form of variable performance compensation, replace implicit career concerns. If high-technology and early stage funds differ from other funds only in the level of effort necessary to monitor the portfolio, fixed fees should be higher, but performance sensitivity should not differ, which is precisely what the empirical results show.

The two models provide different predictions on whether performance-sensitive compensation negotiated at the time of the partnership agreement (ex-ante) will be associated with higher returns (ex-post). The learning model suggests that there will not necessarily be any relationship between pay sensitivity and performance; reputational concerns lead young GPs with little explicit incentive compensation to work hard and perform well. The signaling model suggests a positive relationship between pay sensitivity and success; higher ability GPs signal their ability by taking more risk and then work harder. There is no statistically significant relationship between compensation and performance, which is then consistent with the learning model. This also indicates that new GP entrants may not have superior information about their own investment abilities, and may be concerned about establishing a reputation. At the same time, investors are mostly sophisticated institutions that closely track performance, and it is reasonable to expect that novice GPs do not know their own investment abilities any better than their investors do.

Most empirical results support the learning model where the two models differ in their predictions, and it is natural to conclude that the learning model is the most accurate model in explaining GPs' monetary compensation.

7.1.3 Does The Venture Capital Organizational Structure Matter?

The reliance on limited partnerships of finite life with substantial profit sharing has been claimed to be critical to the success of venture investments. This can be tested by comparing limited partnerships with venture funds sponsored by corporations and venture funds associated with commercial and investment banks. The corporate venture funds have similar missions and are staffed by professionals with similar backgrounds and experience, but the organizational and incentive structures in corporate venture funds are very different; they are usually structured as subsidiaries (not finite), and have much lower incentive-based compensation. The venture funds associated with commercial and investment banks usually retain the autonomous partnership structure employed by independent venture organizations, albeit with lower share of the profits accruing to the GPs. If the claim is true, then these corporate venture funds and bank associated venture funds should perform below the independent, limited partnership based venture funds. Either their process of selecting or overseeing investments would be distorted or the programs would prove unstable. It may be, however, that corporate and bank venture funds enjoy benefits associated with closely related activities that might offset some of these costs – this is called the complementarities hypothesis. To test this hypothesis and the claim that independent venture capital organizations are superior to other venture capital organizations, it is necessary to distinguish between independent venture capital organizations, corporate venture capital organizations with a strong strategic fit to the corporate parent, and corporate venture capital organizations without a strong strategic fit. Venture capital organizations related to banks are disregarded as they closely resemble independent venture capital organizations.

The results from the analyses show that (1) corporate venture investments in entrepreneurial firms appear to be at least as successful, using the probability of the portfolio firms going public as a measure of success, as those backed by independent venture organizations, particularly when there is a strategic overlap between the corporate parent and the portfolio firm. (2) Although corporate GPs overall tend to invest at a premium to other venture groups, this premium appears to be no higher in investments with a strong strategic fit. (3) Corporate venture programs without a strong strategic focus appear to be much less stable, frequently ceasing operations after only a few investments and a few years, but strategically focused programs appear to be as stable as independent venture organizations.

The evidence suggests that the presence of a strong strategic focus is critical to the success of corporate venture funds. This subset of corporate funds appears to have been quite successful, despite having very different structures from traditional venture capital funds. This appears to challenge the emphasis in the finance literature on the importance of the partnership structure employed by independent venture organizations. The evidence is also consistent with the existence of complementarities that allow corporations to effectively select and add value to portfolio firms, but somewhat at odds with the suggestions that the structure of corporate funds introduces distortions and limits their effectiveness.

7.2.0 Investing

7.2.1 Staged Investments

Staged capital infusions are the most potent control mechanism GPs can employ; the role of staged capital infusion is analogous to that of debt in highly leveraged transactions, keeping the owner/manager on a "tight leash" and reducing potential losses from bad decisions. GPs' stated concern is that entrepreneurs have private information about the future viability of the firm, and that they always want to continue the firm, and may want to enrich their reputation through activities at investors' expense.

Staged capital infusions is an investment design to ensure that prospects for the firm are periodically reevaluated and that the option to abandon the project and limiting losses is maintained. The greater the need to gather information, the shorter the duration of an individual round of financing, and the more frequently the GPs monitor the entrepreneur's progress.

GPs weigh potential agency and monitoring costs when determining how frequently they should reevaluate projects and supply capital, and thus, how long the duration of an individual round of financing should be. Agency costs increase as the tangibility of assets declines, the share of growth options in firm value rises, and asset specificity grows (the more specific assets are, the fewer alternative uses they have, and the lower liquidation value they have). Hence, the duration of funding should be negatively related to expected agency costs.

Gompers and Lerner used a sample of 792 firms that received venture capital financing between January 1961 and July 1992 for their empirical analyses.

The average industry ratio of R&D to sales is 3.43 percent (median is 3.82 percent), while the average for all COMPUSTAT industries during the time period 1972-1992 was 1.3 percent. Asymmetric information and agency costs are a major concern in R&D-intensive firms, which may require specialized knowledge to monitor. This confirms the suggestion about venture capital investments in chapter 3 that GPs specialize in industries in which monitoring and information evaluation is important and therefore most valuable.

Regression analyses on the financing duration show that: (1) the duration of early- and middle-financing rounds are not significantly different from late-financing rounds. (2) Financing duration declines with decreasing industry ratio of tangible assets to total assets, decreases in the market-to-book ratio, and greater R&D intensity (they are significant between the 7 and 1 percent confidence level). These factors are associated with greater agency costs and lower liquidation values, and hence increase the value of monitoring, and therefore lead to tighter monitoring. The analyses also show that the ratio of tangible assets to total assets remains the most significant variable in measuring the impact of asset specificity on financing duration. This result indicates that tangible assets may be particularly important in lowering expected agency costs. (3) The age of venture capital-backed firms at the time of financing is positively and significantly related to financing duration; more information may be available for GPs to evaluate. (4) None of the coefficients on amount of venture capital financing are significantly related to funding duration, so that larger financing rounds do not lead to longer funding duration. (5) The duration increases with increased commitments of capital to the venture industry.

Regression analyses on the financing size show that: (1) the ratio of tangible assets to total assets has the greatest effect on the amount of financing, i.e. increases in asset tangibility increase the amount of financing per round. (2) More R&D intensive industries also appear to receive more financing per round controlling for asset tangibility. (3) The stage of development does affect the amount of financing per round; average early-financing round investments are between $1.30 and $2.03 million smaller than comparable late-financing round investments; average middle-financing round investments are between $0.70 and $1.21 million smaller than comparable late-financing round investments. The increasing size of investment per round reflects the growing scale of a firm when a firm matures through the various stages; greater investment is needed to expand the firm. (4) The financing amount increases with increased commitments of capital to the venture industry.

Regression analyses on total venture financing show that: (1) firms that go public receive between $3.36 and $5.67 million more venture capital financing than firms that remain private. (2) There are no significant differences in total venture capital received between firms that are acquired or merged and those that are liquidated compared to those firms that remain private. (3) Even controlling for the number of funding rounds, firms that eventually go public receive more total financing. (4) Industry factors appear to have an important impact on total venture financing received; firms with more tangible assets receive less total financing; firms in industries with high market-to-book ratios receive more total financing; R&D intensive industries receive significantly greater amounts of financing. (5) However, the most important factor in determining the total amount of venture capital financing received is the number of funding rounds received. In fact, when the number of funding rounds is included in regressions with industry variables, tangibility of assets and R&D intensity are no longer significant for total venture capital financing, but the coefficient on industry market-to-book ratio is unchanged. (6) Even controlling for the number of funding rounds, firms in industries with high market-to-book ratios receive more total venture capital financing.

If the market-to-book ratio correctly measures potential profitability of investments and growth opportunities, then total venture capital financing in these firms should be relatively higher. Alternatively, firms in these industries may have more difficulties obtaining debt financing, and may rely more heavily on venture capital financing.

Regression analyses on the number of rounds show that: (1) firms that go public receive more financing rounds than those that remain private. (2) Firms that are acquired or go bankrupt do not receive more rounds on average than those that remain private. (3) Firms in industries with greater fraction of tangible assets receive fewer rounds of venture financing. (4) Firms in R&D intensive industries receive more rounds of financing.

A plausible explanation for (1) and (2) is that GPs gather information about the potential profitability of projects over time. If GPs receive favorable information about the firm, strengthening the belief in the firm's potential to go public, GPs continue to fund the project. If the project is viable but has little potential to go public, GPs start searching for a corporate buyer. Firms that have little potential are liquidated.

7.2.2 How General Partners Oversee Firms

GPs take at least one board seat on the board of directors in their portfolio firms and thereby engage in the day-to-day operation of the firm. GPs' oversight of new firms involves substantial costs; the transaction costs associated with frequent visits and intensive involvement are likely to be reduced if GPs are proximate to the firms they oversee. Venture capital organizations with offices within 5 miles of the venture-backed firm's headquarter are twice as likely to be board members as those more than 500 miles distant. Over half the firms in the sample have a GP director with an office within sixty miles of their headquarters. This has important implications due to the fact that venture capital organizations are unevenly distributed among various regions[5]; the presence or absence of venture capital organizations may lead to significant differences in the availability and pricing of venture capital across regions. It might also have policy implications for local governments, since a local venture capital organization might be positively related to venture capital investments into the local economy.

If GPs are especially important providers of managerial oversight, their representation on boards should be more extensive at times when the need for oversight is greater, for example at CEO transitions. The replacement of the top manager at an entrepreneurial firm is likely to coincide with an organizational crisis and therefore heighten the need for monitoring. In addition, since the uncertainty about the new person's ability is likely to be high, the CEO's activity may be more intensively monitored. At the funding rounds with CEO turnover, the increase in the representation of each class of board member is slightly higher than between rounds without CEO turnover, but the largest increase, by far, is in the number of GP directors, and this difference is significant at the 1 percent level.

If the provision of oversight is a significant and costly role for GPs, then proximity should be an important determinant of which GPs serve on the board. The results suggest that, for the majority of firms, the nearest GP director is quite close; more than half the firms have a GP director with an office within sixty miles of their headquarters, while 25 percent of the firms have a GP director within seven miles. In a Probit regression the coefficient for distance is highly significant in explaining the service of GPs on boards, even after controlling for ownership and experience.

7.2.3 Syndication of Venture Capital Investments

There have been suggested three reasons for why venture capital organizations share transactions with each other, so called syndication. (1) Syndicating first-round venture investments may lead to better decisions about whether to invest in firms. The first venture capital organization to accept a portfolio firm will make the investment contingent on another venture capital organization agreeing to co-invest in the portfolio firm. Sah and Stiglitz (1986) show that hierarchical organization, in which investments are made only if several independent observers agree, may be superior to one in which projects are funded after one affirmative decision. (2) Syndicating may be the result of information asymmetries between the lead venture capital organization and other potential new investors. Admati and Pfleiderer (1994) develop a rationale for syndication in later venture rounds. A GP involved in the firm's daily operations understands the details of the business. The GP may exploit an

[5] VC organizations have a tendency to cluster, which is evident by the fact that almost 50% of all VC under management, almost 50% of all VC investments, and about 40% of all VC portfolio firms in the USA is located in California, while Massachusetts makes up another large, yet significantly smaller, share of VC (NVCA 2010 Yearbook).

informational advantage, overstating the proper price for the securities in the next financing round. Under the models assumptions, the only way to avoid opportunistic behavior is if the lead venture capital organization maintains a constant share of the firm's equity. This implies that later round financings must be syndicated. (3) Lakonishok, Shleifer, Thaler, and Vishny (1991) suggest a third reason for syndication, "window dressing". Pension funds "window dress" their portfolios, because institutional investors may examine not only quarterly returns but also end-of-period holdings. Consequently, money managers may adjust their portfolios at the end of the quarter by buying the firms whose shares have appreciated and selling "mistakes". Venture capital organizations may similarly make investments in late rounds of promising firms, even if the financial returns are low. This strategy allows them to represent themselves in marketing documents as investors in these successful firms.

(1) If the first reason for venture capital syndication is true, then established venture capital organizations should disproportionately syndicate first round investments with other established venture capital organizations compared to young and inexperienced venture capital organizations. This happens because established venture capital organizations will trust other established venture capital organizations' investment opinions more than they do inexperienced venture capital organizations' investment opinions. In later rounds, they should be much more willing to syndicate investments with less seasoned firms. To test this hypothesis, all venture capital organizations are divided into quintiles based on size as the proxy for experience and reputation, and analyzed for differences in each financing round separately. The smallest quintile of venture capital organizations is disproportionately likely to undertake early round transactions with each other; the smallest quintile of venture capital organizations syndicate 43% of their first round investments with other smallest quintile venture capital organizations. With each subsequent round, this pattern becomes less pronounced (second round 32% and later rounds 24%). It is not obvious, however, why largest quintile venture capital organizations syndicate first round investments more frequently with second quintile venture capital organizations (35%) than other largest quintile venture capital organizations (14%). A Pearson Chi-square-test tests the null hypothesis that each cell is 20% for each financing round separately. For first round investments, the null hypothesis is rejected at the 1 percent confidence level. For second and later round investments, the null hypothesis cannot be rejected at conventional confidence levels. Similar results appear when the age composition of venture capital organizations is used as the measure for experience and reputation.

If the unwillingness of experienced venture capital organizations to invest with small and young venture organizations in the first round stems from a mistrust of inexperienced investors' judgement, then experienced venture capital organizations should also be reluctant to invest in the later rounds of deals begun by their less seasoned counterparts; Inexperienced venture capital organizations should be brought into later round financings by experienced venture capital organizations, but not vice versa. To assess this hypothesis, venture capital organizations investing for the first time in the second or later venture capital funding rounds are examined; later round venture capital investors should be less experienced than the previous investors. The results are consistent with the hypothesis and significant at the 1 percent confidence level; the typical later-round syndication involves less experienced venture capital organizations investing in a deal begun by more established venture capital organizations.

(2) If the second reason for venture capital syndication is true, then venture capital investors should maintain a near constant equity stake in their portfolio firms in all subsequent venture capital funding rounds after their initial investment. The statistics show that in the first financing round outside investors purchase, on average, 33.9% of the portfolio firm. In the second round, first-round investors purchase, on average, 30% of the new shares sold, which corresponds quite closely to their previous ownership position. The total equity stake held by outside investors increases to an average of 51.1% in the second round. In the third round, outside investors purchase, on average, 52.7% of new shares sold, which, once again, corresponds quite closely to their previous ownership position. The total equity stake held by outside investors increases to an average of 57% in the third round. In 21 percent of the cases, the share of the firm held by a venture capital organization changes by less than 5 percent after a venture capital funding round. In 70.5 percent of the cases, the change is less than 25 percent. The results confirm the hypothesis of Admati and Pfleiderer that venture capital organizations strive to maintain a constant equity share in their portfolio firm.

(3) Finally, the suggestion of “window dressing” in the syndication of venture capital investments is examined. An empirical implication of the hypothesis is that experienced venture capital organizations will invest in the later rounds of deals particularly likely to go public. A regression analysis shows that established venture capital organizations are significantly more likely to invest for the first time in later rounds when valuations have increased sharply. At the same time, valuation changes are insignificant in explaining the probability of investments by less established venture capital organizations. The results clearly support the hypothesis.

The empirical findings clearly show that all three suggested reasons for why venture capital organizations syndicate their investments are true.

7.3.0 Exiting

Venture capital funds seek to take public the most successful firms in their portfolios; the historical fraction of venture capital-backed firms that are taken public is 20-35%. Firms exited through IPOs represent the bulk of venture capital funds' returns; even among the firms taken public, typically only a small number of firms make up the bulk of the returns. Other, less successful firms are liquidated, sold to corporate acquirers, or else remain operational at a modest level of activity without additional venture capital funding. A venture Economics study (1988a) found that a $1 investment in a firm that goes public provides an average cash return of $1.95 above the initial investment, with an average holding period of 4.2 years. The second most profitable exit, as estimated by Venture Economics, is by selling the firm to a corporation or another investment fund by means of acquisition, yielding an average cash return of only $0.4 above the initial investment, with an average holding period of 3.7 years.

Successful exits are also critical to raising additional capital through new venture capital funds. After the 1987 market crash IPO activity in Europe and the USA dried up. While the US market recovered in the early 1990s the European market remained depressed. Consequently, European venture capital organizations were unable to exit investments by taking them public. They were required either to continue to hold the firms or to sell them to larger corporations, often at relatively unattractive valuations. While US venture capital organizations – pointing to their successful exits – were able to raise substantial amounts of new capital, European venture capital fundraising during this period remained depressed. Jeng and Wells (1997) examine the factors that influence venture capital fundraising in 21 countries and found that the strength of the IPO market is an important factor in determining venture capital commitments; this relationship is stronger for later-stage funds than for early-stage funds. In here lies another important policy implication; if a country wants a strong venture capital industry to support its entrepreneurial activities, then they need to create and maintain a strong IPO market.

The exiting of venture capital investments also has important implications for social welfare. If venture capital organizations cannot foresee how a company will be mature enough to take public or to sell at the end of a decade (when the fund closes), they are unlikely to invest in the firm. Furthermore, if it was equally easy to exit investments of all types at all times, this might not be a problem, but interest in certain technologies by public investors appear to be subject to wide swings. Concerns about the ability to exit investments may have led to too many venture capital transactions being undertaken in "hot" industries. At the same time, insufficient capital may have been devoted to industries not in the public limelight. Promising technologies might not be developed if they are currently "out of favor".

Concerns about exiting may also adversely affect portfolio firms once they are financed by, and under the influence of, venture capital organizations. Less scrupulous investors may occasionally encourage companies in their portfolio to undertake actions to boost the probability of a successful IPO, even if they jeopardize the firm's long-term health; for example, increasing earnings by cutting back on vital research spending.

Some institutions and features have evolved to improve the efficiency of the venture capital investment process, while others have sprung up primarily to shift more of the economic benefits to particular parties. Many of the features of the exiting of venture capital investments can be understood as responses to environmental uncertainties. An example is the "lock-up" provisions that prohibit corporate insiders and venture capital investors from selling their shares at the time of the offering. This helps avoid situations in which the officers and directors exploit their inside knowledge that a newly enlisted company is overvalued by rapidly liquidating their positions. Other features of the exiting process can be seen as attempts to transfer wealth between parties. For example, venture capital funds sometimes distribute shares to their investors immediately prior to a drop in price. Even if the price at which the investors ultimately sell the shares is far less, GPs use the share price before the distribution to calculate their fund's rate of return and to determine when they can begin profit sharing (GPs only take part in profit sharing after the initial capital commitments by the LPs have been paid back). The efficiency and attractiveness of exiting venture capital investments will be determined by the relative strength of these two forces. Over time, an attractive environment for exits can exist only when formal and informal safeguards prevent opportunistic behavior.

7.3.1 How Market Conditions Affect the Decision to Go Public

GPs generate the bulk of their profits from firms that go public. Successful timing of the IPO market provides significant benefits to GPs, even though they rarely sell shares at the time of the offering; taking companies public when equity values are high minimizes the dilution of the venture investors' ownership stake.

To assess the ability of venture capital organizations to time public and private financings, the equity values of publicly traded biotechnology firms around these transactions are examined by constructing an equity value index. The IPOs coincide with the peaks in equity valuations, while no clear pattern appears in the private financings; in particular, the high valuations of 1983, 1986, and 1991-92 were accompanied by intense IPO activity. These patterns suggest that venture capital organizations are able to time the market, taking firms public at times when industry valuations are highest.

The mean equity index at the time of IPOs is 4.05, compared to 3.05 at the time of private financings, and a nonparametric Wilcoxon test shows that the difference is significant at the 1 percent level; IPOs are far more likely to occur when the equity values are high. Since the bunching of IPOs and private financings implies that many of the sixty trading-day windows over which returns are calculated overlap, tests of equality of mean returns will overestimate the confidence levels. Instead, a regression framework is applied to test for differences in valuation. Returns in the three months before an IPO is significantly higher, at the 1 percent level, than returns in the three months after an IPO. Returns three months before and after private financings display no such difference. Returns prior to public and private financings do not differ at conventional confidence levels. However, returns after public and private financings differ at the 5 percent level.

The results support the hypothesis that venture capital organizations are able to time the IPO market, and, thus, it is reasonable to assume that experienced venture capital organizations are better at timing the IPO market than inexperienced venture capital organizations. To test this hypothesis, the age of venture capital organizations is used as a proxy for experience and tested for differences. The average portfolio firm backed by venture capital organizations above the median age level went public when the equity index was at 4.31, compared to 3.8 for the average portfolio firm backed by venture capital organizations below the median age level. Similarly, the index run-up in the three months before an IPO and the run-down in the three months after are both larger for the average portfolio firm of more experienced venture capital organizations. These results suggest that firms backed by established venture capital organizations are more successful at timing their IPOs. Several analyses assess the robustness of the results to alternative measures of venture experience and the presence of control variables. They have little effect on the qualitative and quantitative results.

The empirical evidence show that venture capital organizations take their portfolio firms public at market peaks, relying on private financings when valuations are lower. Furthermore, experienced venture capital organizations appear more proficient at timing IPOs to market peaks than do inexperienced venture capital organizations. The biotechnology industry was used as a sample. In other industries, the need for oversight, or lumpy demands for capital, as the firm matures may affect the decision to go public more dramatically.

7.3.4 How Reputation Affects the Decision to Go Public

Most LPs in venture capital funds are institutional investors whose role in the day-to-day operations of the fund is restricted by law if they are to retain limited liability. Evaluating a venture capital organization is therefore difficult, and investors search for signals of ability when evaluating venture capital organizations. Past performance is the simplest way of evaluating ability, and it therefore has a great impact on venture capital organizations' ability to raise new funds. Since young venture firms have little past performance, they have incentives to grandstand, that is, to take actions to signal their ability to make successful investments to current and potential new investors. Grandstanding would cause young venture capital organizations to bring portfolio firms public earlier than older, established venture capital organizations in an effort to establish a reputation in order to successfully raise new capital for new, subsequent funds. Remember that most of the returns to venture capital funds come from taking firms public. On the other hand, established venture capital organizations will have a longer track record, and one additional IPO is likely to have a small impact on their perceived ability to raise new funds. Since there are significant costs associated with a rushed IPO, in the form of underpricing of the portfolio firm, only young venture capital organizations will be willing to incur those costs, hurting the returns to their current venture capital funds.

Predictions by the grandstanding hypothesis is: (1) the effect of recent performance in the IPO market on the amount of capital raised is stronger for young venture capital organizations, providing them with greater incentive to bring portfolio firms public earlier. (2) New venture capital organizations raise new funds sooner after an IPO than do established venture capital organizations. (3) If young venture capital organizations rush portfolio firms to the IPO market, they should have a shorter duration of representation on the portfolio firm's board of directors and (4) have a smaller equity stake in the portfolio firm at the time of the IPO compared to portfolio firms going public backed by more established venture capital organizations. (5) Portfolio firms going public backed by young venture capital organizations should be more underpriced than others, because rushing them to the IPO market should mean the portfolio firms are younger, with a shorter history, and therefore more uncertainty.

To test the grandstanding hypothesis, the sample of venture capital backed IPOs is divided into two groups by age, where the age of the lead venture capital organizations at IPO serves as a proxy for reputation. All lead venture capital organizations that are under six years old at the IPO date are classified as young. Although this is an imperfect measure of reputation, because experienced partners sometimes leave to start new venture capital organizations, it would tend to bias the result away from seeing any difference between young and old venture capital organizations. In addition, old venture capital organizations raise new funds every 2-4 years, while young venture capital organizations raise new funds every 5-6 years, meaning that the average IPO for old venture capital organizations should be closer to its next fund than the average IPO for young venture capital organizations, and should therefore also tend to bias the result away from seeing any difference. Despite of these two biases, young venture capital organizations raise new funds closer to their IPOs than do old venture capital organizations. Furthermore, the results show that; the average size of young venture capital organization's next fund is smaller; IPO firms backed by young venture capital organizations are younger on average; young venture capital organizations have sat on the board of directors of portfolio firms going public for a shorter period of time; portfolio firms backed by young venture capital organizations are more underpriced at their IPO; the average offering size is smaller for IPOs brought to market by young venture capital organizations; young venture capital organizations have financed fewer portfolio firms that have gone public; in portfolio firms that go public with young lead venture capital organizations the total equity stake held by venture capital funds is smaller; and the market value of the lead venture capital organization's equity stake is lower for young venture capital organizations.

All of these results are consistent with the grandstanding hypothesis; young venture capital organizations bring portfolio firms public earlier and bear real costs through greater underpricing and lower valued equity stakes. These costs are shared with their current LPs, but the portfolio firm going public also bears some of the costs. More than 400 new venture capital organizations entered the venture capital industry after 1978, and the incentives to grandstand potentially explain some of the declining returns on venture capital in the 1980s. Reduced fixed fees and increased profit sharing might better align the incentives of GPs with the value maximizing goals of their LPs.

7.3.5 Distribution of Shares by Venture Capital Organizations

Venture capital organizations raise money from investors and make equity investments in young, high-risk, high-growth companies. Many successful venture capital backed companies eventually go public in an underwritten IPO. Venture capital organizations can liquidate their position in the company by selling shares on the open market after the IPO and then pay those proceeds to their LPs in cash, or they can distribute shares to their LPs directly. These distributions have several features that make them an interesting testing ground for an examination of the impact of transactions by informed insiders on securities prices; they are not considered to be "sales", and are therefore exempt from the antifraud and anti-manipulation provisions of the securities laws.

There have been developed three hypotheses about why stock prices fall after a distribution in kind by venture capital organizations: (1) the corporate control hypothesis, (2) the liquidity hypothesis, and (3) the insider trading hypothesis. (1) When the venture capital organization declares a distribution, an active, large-block shareholder is essentially dissolved. Jensen and Meckling (1976) and Schleifer and Vishny (1986) have shown that large block shareholders, who are often willing to incur the costs of monitoring management, can play an important role in increasing firm value. The unanticipated dissolution of a large block holding provides one alternative explanation for stock price declines at the time of the distribution. (2) A large block of shares may trade at a lower price because the market for the company's equity is not very liquid. If liquidity is the primary reason for price movements, stock prices should decline around distributions but quickly recover thereafter. (3) If the markets are reacting to insider trading by the venture capital organizations, distributions by more experienced venture capital organizations should produce more negative price reactions than distributions by inexperienced venture capital organizations; more experienced venture capital organizations should be better at monitoring than inexperienced venture capital organizations and should have better information about the company.

The regression analysis shows that after increases of +7.4% in stock prices in the 60 trading days prior to distribution, abnormal returns during the event window (from the event to three days after the event) are a negative and significant -2.0%, comparable to the market reaction to publicly announced secondary stock sales. Distributions that occur in settings where information asymmetries may be greatest, where the firm has been taken public by a lower-tier underwriter and the distribution is soon after the IPO, have even larger immediate price declines. The results from the event window analysis are consistent with venture capital organizations possessing inside information and of the partial adjustment of the market to that information. Neither the corporate control hypothesis nor the liquidity hypothesis receives much support from the regression results.

The magnitudes of price movements may be biased by cumulating abnormal returns over long horizons, so it could be informative to look at longer time horizons instead of just the event window. Using the nominal buy-and-hold returns for the firms from twelve calendar months prior to distributions to twelve months after distributions, returns increase sharply starting four months prior to the distribution. From the month after the distribution to month +8, nominal returns are quite modest. The pre-distribution run-up is not biased upwards by first-day returns of IPOs. Venture-backed firms, like other IPOs, are typically underpriced and gain on average 8.4 percent on their first day (Barry, Muscarella, Peavy, and Vetsuypens 1990). If prices fully reacted to the informational content of the distribution, long-run excess returns should be zero on average in the months after the distribution. If the market underreacts or it takes time to learn that the venture capital organization has distributed shares, then long-run drifts in prices may occur. Using market-adjusted returns, the distribution shares lose 5.4% of their value in the next year. The use of portfolios matched by book-to-market, size or industry groupings as a benchmark, however, leads to positive excess returns. Furthermore, long-run excess returns are positively correlated with underwriter rank, just as in the analysis of abnormal returns in the event window, and sorting firms based on valuation at the close of the first trading day reveals that smaller firms have lower returns than their larger counterparts.

The event window analysis clearly supported the insider trading hypothesis, but the long-run, post-distribution returns are more ambiguous; although the extent and significance of the market reaction appears to vary with the benchmark employed, at least some evidence suggests that the market does not fully incorporate information at the time of the distribution.

7.3.6 The Performance of Venture-Backed Offerings

One of the central puzzles of finance – documented by Ritter (1991) and Loughran and Ritter (1995) – is the severe underperformance of companies after their first IPOs during the past twenty years. These findings suggest that investors may systematically be too optimistic about the prospects of firms that are issuing equity for the first time. Recent work has shown that underperformance extends to other countries as well as to seasoned equity offerings (i.e. secondary offerings).

If venture capital backed firms are better on average than non-venture capital backed firms, the market should incorporate these expectations into the price of the IPO and long-run stock price performance should be similar for the two groups. Barry, Muscarella, Peavy, and Vetsuypens (1990) and Megginson and Weiss (1991) find evidence that markets react favorably to the presence of venture capital financing at the time of an IPO. If the market underestimates the importance of a venture capital organization in the pricing of new issues, long-run stock price performance may differ.

Gompers and Lerner found that the underperformance of IPOs documented by Ritter (1991) and Loughran and Ritter (1995) comes primarily from small, non-venture capital backed IPOs. Returns on non-venture capital backed IPOs are significantly below those of venture capital backed IPOs and below relevant benchmarks when returns are weighted equally. There are several reasons why the presence of venture capital may affect a stock's long run price movements after its IPO. (1) venture capital organizations have contacts with top-tier, national investment banks and may be able to entice more and higher quality analysts to follow their firms, thus lowering potential information asymmetries. (2) Because institutional investors are the primary source of capital for venture capital funds, institutions may be more willing to hold equity in firms that have been taken public by venture capital organizations with whom they have invested. (3) The greater availability of information and the higher institutional shareholding may make venture capital-backed companies' prices less susceptible to investor sentiment. (4) Seeing as venture capital organizations repeatedly bring firms public they may be less willing to hype a stock or overprice it, because if they become associated with failures in the public market they may tarnish their reputation and ability to bring firms public in the future.

To test the robustness of the results IPO performance was tested against several broad market indexes, Fama-French industry portfolios, and matched size and book-to-market portfolios. Differences in performance among groups of firms and the level of underperformance were reduced once returns were value-weighted. Furthermore, underperformance documented by Loughran and Ritter is not unique to firms issuing equity; removing IPOs and SEOs from size and book-to-market portfolios demonstrates that IPOs perform no worse than similar non-issuing firms. This suggests that we should look more broadly at types of firms that underperform and not treat IPO firms as a separate group.

The underperformance of small, low book-to-market firms may have various explanations. (1) Unexpected shocks may particularly have hurt small growth companies in the early and mid-1980s. The correlation of returns in calendar time may argue in favor of this explanation. Fama and French (1995) show that the earnings of small firms declined in the early 1980s recession but did not recover when those of large firms did. It is possible that small growth firms were constrained either in capital or product markets after the recession, which is an argument for not viewing each IPO as an independent event, and that correcting for cross-sectional correlation is critical. (2) Investor sentiment may impact small, growth firms relatively more. The evidence from the Fama-French three factor model with and without the change in closed-end fund discount supports this alternative (the closed-end fund discount was used as a proxy for investor sentiment – decreasing average discounts imply that investors are more optimistic and should be correlated with higher returns for small issuers). The equity of small, growth firms are held primarily by individuals, who are more likely to be subject to fads. Asymmetric information is also likely to be more prevalent for small firms. Individuals spend considerably less time tracking returns than institutional investors. (3) Small non-venture capital backed firms go public with lower tier underwriters than similar venture capital backed firms, and they may have fewer and lower quality analysts following the firm after the IPO and therefore be subject to more information asymmetry. Michaely and Shaw (1991) provide evidence that underwriter reputation is positively related to the long-run performance of IPOs. It might not pay for sophisticated investors to research a small firm because they cannot recoup the costs of information gathering and trading; the absolute return that investors can make is small because the dollar size of the stake they can take is limited by firm size. (4) Individuals might derive utility form buying the shares of small, low book-to-market firms because they value them like a lottery ticket; returns on small non-venture capital backed IPO firms are more highly skewed than returns on either large IPO firms or similar sized venture capital backed IPO firms.

To conclude, small non-venture capital backed IPOs perform significantly worse than similar venture capital backed IPOs, which indicates that investors are systematically too optimistic about the future prospects of small non-venture capital backed IPO firms. Although, the results also show that IPO firms on average perform no worse than similar non-issuing firms, which indicates that it is the size and growth prospects of the firms that explains the underperformance and not whether or not they are IPO firms.

What are the implications of these results? Most institutional investors will not be significantly hurt by investing in IPOs because they usually do not buy the small issues that perform worst. Furthermore, underperformance of small, growth companies may impact capital allocation negatively, because if the cost of capital for small, growth companies is periodically distorted, their investment behavior may be adversely affected. If any of these small firms are future industry leaders, then we should be concerned about this mispricing.

8.0.0 Venture Capital's Impact on Economic Performance and Innovation

8.1.0 Venture Capital – Driver of Innovation or Only Commercialization?

Michael Peneder's (2009) study "Venture capital and innovation at the firm level" aims at identifying the impact of venture capital on economic performance and innovation. He refers to three possible transmission mechanisms (or functions) through which venture capital has an impact on economic performance: (1) the financing function, (2) the selection function, and (3) the value adding function. (1) In the financing function, venture capital provides basic access to external capital to firms that would otherwise not have access to financial markets. This function refers to venture capital as a financial intermediary, similar to banks and pension funds, only with specialized capital to serve startup, high-risk, growth firms. (2) The selection function refers to the extensive due diligence venture capital funds perform on their prospective investments before they select which firms to invest their capital in. The purpose of the due diligence is to ensure that they allocate their scarce resources to the most promising firms. (3) The value adding function assumes that venture capital has a causal impact on their portfolio firms' performance, thereby increasing their probability of success and their value beyond the financing and selection functions. This is based on the fact that venture capital funds provide more than just capital to their firms, they also provide managerial expertise and experience, professional business models, and access to informal business networks.

After building a suitable database of firms, Peneder performed a survey on the group of firms receiving venture capital and the control group of firms not receiving venture capital about their motives for choosing venture capital and opting out of venture capital respectively. The empirical results of the survey clearly supported the financing function; a large fraction of firms receiving venture capital either had no other alternative sources of capital, or their sources were insufficient to fully finance their projects. In addition, the managers of about a third of these firms responded that the (continued) existence of their firm would not have been possible without venture capital. In contrast, a large majority of the firms not receiving venture capital responded that they had sufficient self-financing or loans to fully finance their projects. The survey also asked the managers of the venture capital backed firms how their firm's activities changed as a result of the venture capital backing. Financial management was named the most important area of change, followed by three typical growth strategies; expanding the variety ('diversification') of existing products, expanding the geographical sales area ('internationalization') of existing products, and introducing new goods and services ('product innovation').

Peneder found that venture capital financed firms were on average more innovate and grew faster both in terms of turnover and employment than other firms, but the difficult question is whether this was due to the selection function or the value adding function. This can be said in another way, it might be that firms that are more innovate and have more promising products are chosen for venture capital financing rather than venture capital financing making them more innovative and more promising. Peneder used the difference in means between the control group and the test group of the various independent variables as a measure of selection bias, and by carefully selecting the control group Peneder was able to make the difference in their means statistically insignificant. The result was that the observed difference in innovation became insignificant and he concluded that it must have been related to the selection function. On the other hand, the venture capital financed firms still showed significant higher growth in terms of turnover and employment, and Peneder thus concluded that there were indications of a positive value adding function in the commercialization process of venture capital-backed firms. The problem is that one can never be sure to have controlled for all selection effects, and the observed difference in performance can still be the result of one or more unobserved variables.

Kortum and Lerner (2000) examined venture capital impact on innovation on an aggregated level taking advantage of a major policy change affecting the venture capital industry, namely the clarification to the "prudent man" rule in 1979, which led to a massive influx of new capital commitments to the venture capital industry. This type of exogenous shock should identify the aggregate role of venture capital, because it is unlikely to be related to the arrival of new entrepreneurial (technological) opportunities or a change in investors' confidence about the future. They found that a dollar of venture capital appears to be three to four times more potent in stimulating patenting than a dollar of traditional corporate R&D.

In contrast to Kortum and Lerner's findings, Stuck and Weingarten (2005) found that GPs thwart innovation by forcing their portfolio firms to become more business oriented for three main reasons: firstly, GPs are not the risk takers they are often made out to be, secondly, the short life cycle of venture capital funds does not allow for innovations to mature, thirdly, GPs are more business oriented than science oriented.

Further support to this view is given by Engel and Keilbach (2007) who found that while venture capital-funded firms have a higher number of patent applications than comparable firms before receiving venture capital; this difference vanishes after the venture capital investment is made. Growth rates of venture capital-funded firms, however, were still significantly larger than comparable non-venture capital-funded firms after the venture capital investment. They conclude that patents attract venture capital while venture capital backing does not improve firms' patenting output. If anything GPs seem to focus on the commercialization of existing patents and on the growth of invested firms.

Further support is given to these findings by two “venture capital insiders”. Sonnek (2006), from SEB Venture capital, explains that “venture capitalists dislike having to finance R&D. For us to be interested in financing a project, most of the R&D should be in place already”. Wadhwa (2008), a technological entrepreneur who received venture capital, explained “we perfected our innovative technology long before we raised venture capital. (…) After receiving venture capital, our only focus was on sales and marketing”. These quotes are a strong indication that venture capital follows innovation, and do not make firms more innovate.

Pere Arqué Castells (2010) studied the relationship between venture capital and innovation at the firm level. He, also, did not find evidence that venture capital financing spurred firm’s patenting activity, he did however, find that venture capital financed firms have higher sales growth rates. He, thus, concluded that R&D and patenting occurs prior to venture capital entry and that GPs mainly focus on the commercialization of already developed products. He also found one very important difference in subsamples of venture capital investments; early-stage investments were more effective at spurring sales growth rates than late-stage investments, which then indicates that it is better for venture capital funds to invest in early-stage firms. Armed with this new knowledge, there is reason to be suspicious of the historical increase in expansion and late-stage investments by venture capital funds shown in figure 11 for the USA, while the development in Norway has been much better, as shown in figure 17, with regard to these findings. In his study, Castells refers to several other studies on the relationship between venture capital and innovation, giving support to both sides of the argument.

The conclusion is that venture capital researchers have yet to come to a consensus on whether GPs spur innovation or only select more innovative and promising firms.

8.2.0 Venture Capital – Driver of Job and Revenue Growth

As mentioned above, there are indications in empirical research that venture capital funds do not increase innovation, although that is still a contested issue, there seems to be consensus regarding venture capital fund’s ability to increase growth in jobs and revenues in the commercialization face of young firms. In that case, venture capital still has a very important impact on the aggregate economy. “Representing just 0.2 percent of U.S. gross domestic product in 2008, venture capital remains a relatively small asset class. Yet, the companies it funds impact America’s economy in large ways” (NVCA Venture Impact 5th edition). In 2008 US venture capital investments corresponded to

0.19% of GDP, US venture capital capital commitments corresponded to 0.20% of GDP, and US venture capital capital under management corresponded to 1.42% of GDP (NVCA 2010 Yearbook). For those modest amounts the venture capital industry's portfolio firms achieved job growth of 1.6% between 2006 and 2008 compared to a total private sector job growth of only 0.2%, and they achieved a revenue growth of 5.3% compared to a total private sector revenue growth of 3.5% (NVCA Venture Impact 5th edition). The NVCA report goes on to say that the venture capital industry's portfolio firms account for 12.1 million jobs, 11% of all private sector jobs and $2.9 trillion in revenue, 21% of all private sector revenue in the US economy. That means that each job in venture capital-backed firms generated on average almost twice as much in revenue as the average private sector job. Clearly the venture capital industry is important in driving job and revenue growth in the aggregate economy.

venture capital has played an important role in building entirely new industries since the 1970s, for example: the biotech industry in the 1970s, the software and semiconductor industries in the 1980s, and online retailing in the 1990s. "Venture capital's impact on these industries is reflected in the continued dominance of venture-backed companies in generating employment and revenue within them" (See table 2) (NVCA Venture Impact 5th Edition). The fact that venture capital-backed companies account for such large shares of total employment and revenue creation in these industries shows that venture capital has been instrumental in leading the growth in these industries.

These industries started out as small and relatively insignificant in the aggregate economy, but because of their tremendous growth they have become the most important drivers of economic growth in the aggregate economy. Another high-tech industry in its infants today is the clean-tech industry, with firms developing new technologies within areas such as renewable energy, electric cars, recycling, and power-grid management. These firms need capital and time to realize and commercialize these technologies, and venture capital investments into the clean-tech industry has increased ten-fold, growing from a meager $ 400 million in 2004 to $ 4.1 billion in 2008, making it the fastest growing sector within venture capital (NVCA Venture Impact 5th edition). It seems the clean-tech industry will become another high growth, high impact industry, with venture capital, once again, playing an important role.

Venture-Backed Company Employment as a Percentage of Total Industry Employment Top Five Industry Sectors - 2008

Industry	Venture-Backed Employment	Total Employment	Venture-Backed Companies Share of Employment
Software	817,166	1,008,929	80.99%
Telecommunications	736,961	994,862	74.08%
Semiconductors	309,437	418,998	73.85%
Networking and Equipment	392,505	668,058	58.75%
Electronics/Instrumentation	271,224	528,148	51.35%

Venture-Backed Company Revenue as a Percentage of Industry Revenue Top Five Industry Sectors - 2008

Industry	Venture-Backed Revenue (millions)	Total Sector Revenue (millions)	Venture-Backed Companies Share of Revenue
Electronics/Instrumentation	$129,597	$193,427	67.00%
Semiconductors	$86,776	$157,660	55.04%
Telecommunications	$256,136	$501,729	51.05%
Biotechnology	$209,358	$444,028	47.15%
Computers and Peripherals	$315,054	$711,331	44.29%

Table 2 – Source: NVCA Venture Impact 5th edition

9.0.0 The Role of Government in the Venture Capital Industry

9.1.0 Stimulating the Venture Capital Industry

"The venture capital industry advocates for public policies that support the entrepreneur. These include intellectual property protection, open trade provisions, immigration support for highly-skilled workers and encouragement of capital formation. In these areas, government can play a vital role in maximizing venture capital's impact on the economy" (NVCA Venture Impact 5th edition).

Since venture capital investments are long-term investments with high risks, a stable and predictable regulatory regime is particularly important to these investors. Democracies with a strong tendency to see shifting ideology and policy intentions, combined with what is often slow moving bureaucracies, can make even the most promising innovations seem so risky that they remain unfunded. Governments can stimulate the venture capital industry by providing efficient and stable regulatory environments for entrepreneurial firms.

Capital formation to the venture capital industry can be supported "…with a tax policy that rewards long-term investment and encourages calculated, entrepreneurial risk taking. Tax differentials, such as favorable rates for capital gains and carried interest, serve as important tools for encouraging investment in emerging growth companies. In our current financial system, venture capital is the only source of long-term, institutional funding for such companies. When government increases the tax burden on venture capital, however, it inhibits the flow of dollars to innovative young start-ups" (NVCA Venture Impact 5th edition). Furthermore, as mentioned in chapter 7.3.0, Jeng and Wells (1997) found that the strength of the IPO market is an important factor in determining venture capital commitments, so that governments should also encourage a strong stock market in its efforts to support capital formation to the venture capital industry.

Traditionally, many superior innovations have started out as basic research in university labs leading to scientific advances, which have then been commercialized through applied research projects backed by venture capital (NVCA Venture Impact 5th edition). Basic research is a type of research with almost entirely external effects, and is therefore a type of research the private sector will not engage in on its own. Governments can, therefore, also stimulate the venture capital industry by funding basic research.

9.2.0 Government as a Venture Capital Investor

In Castells' (2010) study, he also sought to explain what the impact of his findings is on the structure of government support for innovation. If it is so that venture capital makes firms more innovative, then governments can rely on and support private venture capital funds to spur innovation in the economy. His findings, as reported in chapter 8.1.0, do not support this hypothesis. On the other hand, governments can still rely on public venture capital funds to increase innovation in firms and projects that would otherwise not be funded by private venture capital funds. This, however, is contingent on two other factors; (1) a significant selection effect, and (2) a no treatment effect. The selection effect means that public venture capital funds should increase the equilibrium quantity of venture capital to the socially efficient level by investing in firms that are not profitable to private venture capital funds. We should, hence, observe public venture capital funds investing in inferior firms rather than competing for projects that are attractive to private venture capital funds. If public venture capital funds compete with private venture capital funds, then it will, at least partly, replace (crowd out) private venture capital in projects that would otherwise be funded by private venture capital funds. Similarly, we should also expect public venture capital funds to invest in more innovative firms in order to promote the creation of spillovers. The no treatment effect implies that once we control for selection, public venture capital funds should be equally effective as private venture capital funds at stimulating both firms' innovation and sales growth rates.

Castells only found a moderate selection effect, giving a strong indication of a crowding out effect, and he found a sizeable treatment effect, meaning that public venture capital funds are not as effective as private venture capital funds at stimulating firms' innovation and sales growth rates after controlling for the selection effect.

The policy implication is that if public venture capital funds are, for whatever reason, unable to select firms with higher social effects (positive externalities), and are also less efficient than private venture capital funds after controlling for selection effects, then the government might be better off investing through private venture capital funds rather than establishing public venture capital funds. If governments insist on investing through public venture capital funds, they have to improve their selection methods and efficiency. Alternatively, governments should not be engaged in venture capital investments at all, but merely stimulate the venture capital industry as described in the previous section.

9.3.0 The Long Run Effectiveness of Government Support for Early Stage Financing

In his 1999 paper, Josh Lerner analyzed the results of the American Small Business Innovation Research (SBIR) investment program, which provided over $6 billion to small high tech firms between 1983 and 1995.

Lerner identified two premises on which government support to start-ups rested on; "(*i*) that the private sector provides insufficient capital to new firms, and (*ii*) that the government can identify firms where investments will ultimately yield high social and/or private returns." These two premises are the same, albeit more eloquently stated, that Castells discussed in his 2010 paper referred to in chapter 9.2.0.

Lerner identified several rationales why the SBIR program may or may not have had a positive effect; (1) each venture capital portfolio firm must be closely scrutinized due to moral hazard being particularly prominent for typical venture capital portfolio firms, which costs money, venture capital funds prefer to make relatively large capital infusions, and the amount that firms can raise from individual angel investors is usually much less than the minimum financing that a venture capital fund would consider, small firms with the need for capital infusions between these two constraints are effectively unable to raise their needed level of capital; (2) "Government officials are unlikely to have the expertise or resources to effectively monitor entrepreneurs", leading to money being squandered on less promising and unprofitable projects; (3) since institutional investors tend to engage in "herding", where they make too similar investments by basically supporting "hot" sectors, "public investments in sectors and regions less heavily supported by venture capitalists might lead to superior returns, because value-creating investments in less popular areas may have been ignored"; (4) on the other hand, if knowledge spillovers, specialized labor markets, and the presence of critical intermediaries, such as venture capitalists, lawyers, and accountants, are important factors in facilitating successful clusters, one may expect public investments to be more successful if invested in the same geographical clusters as other venture capitalists.

The results of Lerner's study were that "SBIR awardees grew significantly faster than a matched set of firms over a ten-year period. The positive effects of SBIR awards were confined to firms based in zip codes with substantial venture capital activity." He did not find statistically higher growth rates than the matched set of firms in zip codes without substantial venture capital activity. The results, therefore, support rationale 4 described above, and, consequently, not rationale 3.

Lerner went on to describe some concerns regarding the SBIR program; firstly, that political pressures may "lead to a deterioration of the SBIR program's effectiveness over time"; secondly, that the sharp increase in the size of the venture capital pool has eliminated the capital constraints faced by young firms, so that the basis for the SBIR's success and the need for public support has disappeared; thirdly, that the results only considered private returns and that the social returns from the SBIR program "might be particularly large, because many of them involve very early-stage technologies (where spillovers to other firms may be more frequent)", and, fifthly, "that the SBIR setaside has led to a reduction in funding for academic research, which may have even greater social benefits".

9.4.0 Norwegian Government Interventions

The Norwegian government intervenes quite actively in the market for risk capital through various R&D grants and tax credit schemes, through Argentum as a fund of funds investor specializing in private equity funds, and through Investinor as a government funded venture capital fund (see chapter 6.3.0 for a more detailed description of Argentum and Investinor). All of these efforts are aimed at increasing the funding for private firms' R&D efforts as well as to provide risk capital for high potential Norwegian firms.

Argentum, as a fund of funds investor investing through private venture capital funds, is in accordance with the recommendations by Castells as seen in the conclusion of chapter 9.2.0. Investinor, on the other hand, operates more or less as any private venture capital fund, which may not be the best possible solution considering the discussion in chapter 9.2.0, where Castells' arguments indicate that it would be better to allow Investinor to target less profitable and more innovative firms than would private venture capital funds. This, Castells argues, would raise the equilibrium quantity of venture capital in the economy to the socially efficient level, as opposed to only crowding out private venture capital investments in projects that would otherwise have been financed by private venture capital funds.

Investinor is also more controversial than Argentum, precisely because it operates in a way that makes it a competitor to private venture capital funds. The precursor to Investinor, which was established in 1993 under the name *SNDs Egenkapitaldivisjon* until it was separated from SND in 1998 and renamed *SND Invest*[6], was also a venture capital firm. Its investment mandate differed somewhat from that of Investinor in that it also incorporated some controversial political goals such as rural development. This probably contributed to its unpopularity with the right wing parties, and it ended up being sold in 2003 to a private venture capital firm under the instructions of a new right leaning government, which started the sales process quickly after coming into office in 2001. The sales process in itself became controversial; the board of directors of SND Invest wrote a letter[7] to the Ministry of Trade and Industry advising it to reject the bids arguing that the offers were far too low compared to the underlying assets. The sale went ahead with an acceptance of the highest bid, seemingly for ideological reasons, and it was later claimed that the government forfeited one billion

[6] http://www.regjeringen.no/nb/dep/nhd/dok/regpubl/stmeld/20012002/stmeld-nr-22-2001-2002-/7/9.html?id=327032
[7] http://www.stortinget.no/no/Saker-og-publikasjoner/Publikasjoner/Innstillinger/Stortinget/2003-2004/inns-200304-272/7/

NOK by selling SND Invest instead of breaking it up and selling the individual investments over time; the buyer of SND Invest did precisely that and made great profits on its acquisition of SND Invest[8].

Unlike the American SBIR investment program, where "the government receives no equity in the firm and does not have any ownership claim on the intellectual property that the firm develops with these funds" (Lerner 1996), Argentum and Investinor do provide the Norwegian government with equity in the firm. This has at least one clear advantage over the SBIR program; the government only has to raise the capital for Argentum and Investinor once and the funds can be reinvested indefinitely, assuming that the programs at least break even after adjusting for inflation. Investinor is too young to make any judgment on their results, but Argentum has, in fact, had a much higher annual return on its investments than the all-PE European top quartile benchmark between 2006 and 2009 (Argentum web site), which then leads to increasingly higher funds for supporting target firms and sectors over time without the government having to inject more capital into the programs.

[8] http://arkiv.sv.no/partiet/stortingsgruppen/kontroll/regnskap/dbaFile61690.html

Part 3: An Empirical Study on the Additionality of Venture Capital on Total R&D in Norway

The hypothesis related to this empirical study is that firms receiving venture capital have a tendency to also receive other types of external capital, that there is an additionality effect of venture capital on total R&D. This is an interesting research question because if the hypothesis is correct it means that there is an indication of a causal relationship between receiving venture capital and receiving other types of external capital. Since venture capital funds are particularly focused on performing thorough due diligence before selecting their target firms, it seems intuitive to assume that their approval of a firm might have a trigger effect on other types of investors who's process of due diligence is simpler and more superficial. Other investors and financial intermediaries may therefore be influenced by a venture capital fund's approval of a firm when making their own investment decisions.

10.0.0 The Data

The basis for this study is an annual R&D survey by Statistics Norway (SSB), which means that the data from the survey translates into longitudinal data, also called panel data; "Longitudinal research: a study involving data collection at several periods in time which enables trends over time to be examined. " (Alan Wilson 2003 – Marketing Research An integrated approach). Statistics Norway (SSB) performs an R&D survey of all firms with at least 50 employees and all firms with 10-49 employees which reported R&D activity in the previous year's survey. Among all other firms with 10-49 employees a random selection decides which firms are included in the survey, and the selection percentage is normally 35%. In 2006 and 2008, also firms with 5-9 employees were included in the survey. The sample size, thus, varies between 5000 and 6800. Participation percentage is about 95%, and of those who respond, about 5-10% of the survey questions are unanswered, but these are corrected through a review process. The survey asks questions about R&D personnel, R&D expenses, R&D financing, types of R&D projects, R&D project partners, etc. The survey also asks non R&D related questions such as turnover, export revenues, number of employees, and so on. Since 2001, they began including a separate question about the amount of venture capital financing, which will be the basis for this empirical study. The dataset then becomes a panel dataset of the survey answers from 2001 until 2008. The panel dataset is unbalanced, which means it has missing years for at least some cross-sectional units (firms) in the sample.

The total number of firm year observations in the sample is 37 193 spanning years 2001-2008. The total number of firm year observations where the firm has at some point in time received venture capital (venture capital firms) is 903, where the number of firm year observations prior to the firm receiving venture capital is 376 and the number of firm year observations after the firm received venture capital is 527, which also means that the number of firm year observations where the firm has never received venture capital (non-venture capital firms) is 36 290. Since the sample is an unbalanced panel dataset, all variables have not been measured in every year, which means that the number of observations for any given variable may be less than 903 for venture capital firms and 36 290 for non-venture capital firms. The table below shows the number of firm year observations relative to the number of employees:

Firm year observations			
if VC at some point in time	Total	No	Yes
no or missing employees	-	-	-
1-9 employees	3 152	3 103	49
10-19 employees	10 305	10 031	274
20-49 employees	8 952	8 706	246
50-99 employees	6 668	6 524	144
100-199 employees	4 230	4 162	68
200-499 employees	2 442	2 378	64
500-999 employees	900	851	49
1000 employees or more	544	535	9
Total	37 193	36 290	903

Table 3

All variables noted in money terms have been deflated in one of two ways; (1) all non-R&D related variables have been deflated using the Norwegian Consumer Price Index[9]; (2) and all R&D related variables have been deflated using a custom-made price Index. This price index was based on the R&D costs reported by Forskningsrådet[10] (the Norwegian research council) and weighted according to the data used in this study.

One clarification may be needed before reporting the results, venture capital financing in this survey was defined as venture capital specifically used to finance R&D, which means that some firms may have received venture capital without reporting it as part of its R&D financing, in which case they would have been categorized as non-venture capital firms. Further problems regarding this question will be raised in chapter 11.1.3 about construct validity.

[9] http://www.ssb.no/kpi/tab-01.html

[10] http://www.forskningsradet.no/servlet/Satellite?c=Page&cid=1224698192993&pagename=indikatorrapporten%2FHovedsidemal

Another potential problem is measurement errors; when using an FE regression model, a measurement error has a relatively greater impact than it does when using an OLS model. This is because the FE method bases its regression on deviations from the firm average, while the OLS method bases the regression on absolute values (or deviations from zero if you will). A measurement error's share of the total deviation is greater when it is measured from the average than when it is measured from zero, since the measurement error is the same in absolute terms independent of which method is being used. The consequence of measurement error in independent variables is that the coefficients become biased towards zero, i.e. are "drawn" towards zero. Measurement error in the dependent variable, on the other hand, is not a threat when using the FE method because the measurement errors simply end up in the error term. The potential for measurement error is affected by the construct validity, which will be discussed in greater detail in chapter 11.1.3.

10.1.0 Descriptive Statistics – Tests of Difference

It is interesting to first look at whether there are significant differences between firms receiving venture capital and firms not receiving venture capital. Differences were measured both at their means and their medians for a large number of variables. Both means and medians were tested for differences to make the comparisons more robust. To test for differences in means, the two sample t-test with equal variances was applied, and to test for differences in medians the non-parametric equality of medians test with a chi-squared test statistic was applied. These tests were used to test differences in means and medians between (A) firms that received venture capital at some point in time (venture capital firms) and (B) firms that never received venture capital, and the difference in mean and median between (C) venture capital firms after receiving venture capital and (D) venture capital firms prior to receiving venture capital. Table 4 shows the results.

10.1.1 Industry

Given what is known from previous research about what types of firms venture capital funds tend to invest in as well as the theory about venture capital, one would expect to see systematic differences in terms of industries between venture capital firms (A) and non-venture capital firms (B), and that is exactly what the data shows. Firms were separated into a total of six industries; Telecom; Pharmaceuticals; IT; Biotech; Machinery; and other industries (see variables 63-68 in table 4).

The most striking result is that almost ¼ of all venture capital firms (A) belong to the IT industry, a much higher frequency than the average for non-venture capital firms (B), which was expected (see variable 66 in table 4). Furthermore, venture capital firms (A) more often belong to the machinery industry than do non-venture capital firms (B), which can possibly be explained by a large oil service sector in Norway where many firms introduce technological improvements, some having the potential to be disruptive technologies, which is attractive to venture capital funds (see variable 68 in table 4). Venture capital firms (A) tend also to belong more often to the telecom, pharmaceuticals, and biotech industries, although the differences here are small (see variables 64, 65, and 67 in table 4). Consequently, venture capital firms (A) far less often belong to other industries than do non-venture capital firms (B) (see variable 63 in table 4). All differences were significant at the 1% significance level measured both at their means and their medians, except for the difference in the biotech industry, which was only significant at the 5% significance level measured both at their means and their medians.

10.1.2 Size and Growth

Size and growth of the firms were measured in two ways, the number of employees and firm revenues. A total of nine variables were tested; the size in terms of the number of employees; and in terms of firm revenues; whether the firm had average annual revenues below the 20th percentile; between the 20th and 40th percentiles; between the 40th and 60th percentiles; between the 60th and 80th percentiles; or higher than the 80th percentiles. The growth was measured in terms of the number of employees and in terms of firm revenues (see variables 1-4, and 69-73 in table 4).

The results show that there does not seem to be a strong difference in firm size between venture capital firms (A) and non-venture capital firms (B) based on revenues. A significant difference in size only showed up, favoring non-venture capital firms (B), when testing for differences in firm revenues measured at their medians with a 5% significance level, while no significant difference was found measured at their means (see variable 3 in table 4). Also, no significant difference was found when testing for difference in the number of employees measured at the means or their medians (see variable 1 in table 4). On the other hand, when testing for differences in the size groups two important differences showed up; venture capital firms (A) tend to belong more frequently to the smallest group (see variable 69 in table 4), and less frequently to the largest group (see variable 73 in table 4). These differences were not very large, but they were all significant at the 1% significance level measured both at their means and their medians. For the three size groups in between, no significant differences were found (see variables 70-72 in table 4).

The conclusion is that, although there are no large differences in size between venture capital firms (A) and non-venture capital firms (B), the differences are significant and the direction of the differences is as expected. What is surprising is how small the differences are.

When considering the difference in size between venture capital firms after receiving venture capital (C) and venture capital firms prior to receiving venture capital (D) a surprising result shows up; it appears that venture capital firms after receiving venture capital (C) have lower firm revenues than do venture capital firms prior to receiving venture capital (D), and the difference is quite large and significant at the 5% significance level when measured at their medians, while no significant difference was found measured at their means (see variable 3 in table 4). The findings are supported by the test of difference in the number of employees, which shows that venture capital firms after receiving venture capital (C) have quite a lower number of employees than do venture capital firms prior to receiving venture capital (D), but this time the difference was significant at the 5% significance level measured at their means, while no significant difference was found measured at their medians (see variable 1 in table 4).

It is highly surprising to find that firms appears to be smaller both in terms of employees and revenues after receiving venture capital, given that previous research has concluded that venture capital funds tend to focus on the commercialization processes of its portfolio firms, which should at least have led to higher firm revenues.

In terms of firm growth, the picture is ambiguous. The results show that when testing for differences in growth in employment, venture capital firms (A) tend to grow about twice as fast as non-venture capital firms (B), measured at their means, with a significance level of 5%, but no significant difference was found when testing for differences in their medians (see variable 2 in table 4). This suggests that the difference in growth is driven by a few outliers. On the other hand, when testing for differences in growth in firm revenues, the results show that venture capital firms (A) tend to grow almost twice as fast as non-venture capital firms (B), measured at their medians, with a significance level of 1%, but, this time, no significant difference was found when testing for differences in their means (see variable 4 in table 4).

These results give some, albeit ambiguous, support to the hypothesis that venture capital firms grow faster than non-venture capital firms, presumably because venture capital funds tend to focus on the commercialization and professionalization processes of its portfolio firms.

Furthermore, the results also show that venture capital firms after receiving venture capital (C) tend to grow much faster than venture capital firms prior to receiving venture capital (D) when considering growth in revenues, although it was only significant at a 1% significance level when testing for differences in their medians (see variable 4 in table 4), and no significant difference was found when considering growth in employees (see variable 2 in table 4).

This result gives some support to the hypothesis that venture capital funds focus on commercialization and professionalization, and consequently improve on their portfolio firms' growth and operations.

10.1.3 Export Orientation

Differences in firms' export orientation was tested in two ways, by looking at differences in export revenues, and by looking at what markets the firms sell to. Furthermore, the survey also asked which of these markets were of greatest importance to the firm. A total of 12 variables were tested; whether or not the firm had exports; export revenues; export ratio measured as export revenues relative to total revenues; whether the firm had high export ratio, i.e. firms with an export ratio higher than the median observation of export ratio; whether the firm sold to the region in Norway where the firm was located; to other regions in Norway; to other parts of Europe; or to other parts of the world; whether the firm responded that the region in Norway where the firm was located was the most important market; if other regions in Norway was most important; if other parts of Europe was most important; or if other parts of the world was most important (see variables 5-16 in table 4).

Firstly, the results show that venture capital firms (A) had a greater tendency to have exports than did non-venture capital firms (B), where the difference was significant at the 1% significance level both measured at their means and their medians (see variable 5 in table 4). In terms of the amount of export revenues, there was no significant difference measured at their means, but venture capital firms (A) had higher export revenues measured at their medians than did non-venture capital firms (B), which was significant at the 1% significance level (see variable 6 in table 4). Export revenues, however, is influenced by the size of the firm as measured by the total revenues, so that larger firms are expected to have, on average, larger export revenues whether or not they are venture capital firms. The ratio of export revenues to total revenues, on the other hand, supported that result, where the difference measured at their medians was significant at the 1% significance level, but no significant difference was found when measured at their means (see variable 7 in table 4). By testing whether there was a difference between the two groups in terms of whether or not they had a high degree of export orientation, the results show that venture capital firms (A) more often tend to have a high degree of export orientation, where the differences became significant at the 1% level measured both at their means and their medians (see variable 8 in table 4).

There appears to be strong evidence that venture capital firms (A) have a higher degree of exports than do non-venture capital firms (B).

With regards to which markets the firms sell to, the results show that venture capital firms (A) have a much lower focus on their local region, and a much higher focus on all other regions than do non-venture capital firms (B). The differences were all large and significant at the 1% significance level (except for one in which the medians test failed in Stata) (see variables 9, 10, 11, and 12 in table 4). With regards to which of these markets were of greatest importance to the firm, once again, the results are unambiguous; the local region is frequently of less importance to venture capital firms (A) and all the other regions are frequently of greater importance to venture capital firms (A) compared to non-venture capital firms (B), and the difference is particularly prominent for other parts of the world. The differences for the local region, other parts of Europe, and other parts of the world were all large and significant at the 1% significance level measured both at their means and their medians, while the difference for other regions in Norway was relatively little and only significant at the 10% significance level (see variables 13, 14, 15, and 16 in table 4).

10.1.4 R&D Financing

Differences in R&D financing were measured using four variables; whether or not the firms received public financing; the amount of public financing; private financing; and total financing (see variables 25-29 in table 4).

The results show that venture capital firms (A) tend to spend almost three times as much on R&D compared to non-venture capital firms (B) when measuring differences at their medians, which was significant at the 1% significance level, while no significant difference was found measured at their means (see variable 25 in table 4). When considering a breakdown between private and public financing, the results show that venture capital firms (A) tend to receive public financing more often than do non-venture capital firms (B), where the difference measured both at their means and their medians had a 1% significance level (see variable 27 in table 4). In terms of the amount of public financing there was a small difference measured at their medians with a 1% significance level indicating that venture capital firms (A) also tend to receive more public financing than do non-venture capital firms (B), although the evidence for this is weak given that no significant difference was found measured at their means (see variable 28 in table 4). The same was true of private financing, where a huge difference was found measured at their medians with a 1% significance level, indicating that venture capital firms (A) tend to also receive more private financing than do non-venture capital firms (B), although the evidence for this is weak since no significant difference was found measured at their means (see variable 29 in table 4).

When focusing on the difference between venture capital firms after receiving venture capital (C) and venture capital firms prior to receiving venture capital (D), the results show that venture capital firms after receiving venture capital (C) tend to spend a little more on R&D compared to venture capital firms prior to receiving venture capital (D) when measuring the difference at their medians, which was significant at the 5% significance level, but no significant difference was found when measuring their means (see variable 25 in table 4). Considering the breakdown between private and public financing, however, no significant difference was found for neither (see variables 27-29 in table 4).

10.1.5 R&D Intensity

R&D intensity was measured as the ratio of R&D expenses to firm revenues. Differences were tested along two variables; the R&D intensity; and the ratio of firms with high R&D intensity, i.e. firms with R&D intensity higher than the mean R&D intensity across all firms in the sample (see variables 45 and 46 in table 4).

The results show a stark difference between venture capital firms (A) and non-venture capital firms (B) in terms of R&D intensity; in fact, venture capital firms (A) spent on average more than 6 times their revenues on R&D, while the corresponding number for non-venture capital firms (B) is about half of their revenues. Of course, averages can be highly distorted by a few very large observations, so in this case, it is probably more informative to compare their medians, in which case, the numbers are in the few percentage points, which is a far more reasonable figure to consider. Even when comparing medians, venture capital firms' (A) R&D spending was still more than 5 times higher than that of non-venture capital firms (B) relative to their revenues (see variable 45 in table 4). Furthermore, the results show, not surprisingly, that venture capital firms (A), to a much greater extent, belong to the high R&D intensity group than do non-venture capital firms (B) (see variable 46 in table 4). The differences were all significant at the 1% significance level measured both at their means and their medians.

What is even more interesting and somewhat surprising, given that former research has concluded that venture capital funds tend to focus on the commercialization process, is that venture capital firms have a far higher R&D intensity after receiving venture capital (C) than before they receive venture capital (D). The differences are huge even when measured at their medians, and are significant at the 5% and 1% significance level for means and medians respectively (see variable 45in table 4). When considering the second variable, the ratio of venture capital firms with high R&D intensity is also far higher for venture capital firms after they receive venture capital (C) compared to venture capital firms before they receive venture capital (D), which was significant at the 1% significance level when measured both at their means and their medians (see variable 46 in table 4).

These somewhat surprising results can be explained technically by the findings in chapter 10.1.4 showing that venture capital firms after receiving venture capital (C) tend to spend slightly more on R&D in absolute terms, while at the same time the findings in chapter 10.1.2 showed that venture capital firms after receiving venture capital (C) tend to have lower revenues compared to venture capital firms prior to receiving venture capital (D).

10.1.6 R&D Personnel

Although the differences between the two groups in terms of R&D personnel were not very large, they were, on the other hand, highly significant. Five variables were used to test for differences in R&D personnel; their ratio of R&D personnel with PhDs; their ratio of R&D personnel with higher education excl. PhDs; their ratio of R&D personnel with higher education incl. PhDs; their ratio of R&D personnel without higher education; and the ratio of firms with advanced R&D, i.e. firms with a ratio of R&D personnel with PhDs higher than the median observation of the ratio of R&D personnel with PhDs. Although this last measure is surely crude, it should be a strong indication of how advanced the R&D is (see variables 32-36 in table 4).

The results are unambiguous; venture capital firms (A) tend to have a higher ratio of R&D personnel with PhDs and other higher education backgrounds, and lower ratio of R&D personnel without higher education backgrounds than do non-venture capital firms (B). The differences were all significant at the 1% significance level, except for the ratio of R&D personnel with higher education excl. PhDs where the difference measured at their medians was significant at the 5% significance level (see variables 32-35 in table 4). The last variable regarding advanced R&D showed a fairly large difference, with a significance level of 1%, measured both at their means and their medians, indicating that venture capital firms (A) have a strong tendency to perform more advanced R&D compared to non-venture capital firms (B) (see variable 36 in table 4).

10.1.7 R&D Cooperation

Firms can choose to do their internal R&D alone or in cooperation with other entities, such as other firms, consultants, universities, etc. Two variables related to R&D cooperation were tested; whether or not they had cooperation projects; and the ratio of R&D expenses related to cooperation projects relative to total R&D expenses (see variable 19 and 20 in table 4).

With regards to whether or not the firms had R&D cooperation projects, the results show that venture capital firms (A) more often tend to be involved in such projects than do non-venture capital firms (B), where the difference measured both at their means and their medians had a 1% significance level (see variable 19 in table 4). The results also show that that venture capital-firms (A) tend to have a higher ratio of R&D expenses related to R&D cooperation projects compared to non-venture capital firms (B), where the difference was significant at the 1% significance level measured at their medians, although the evidence for this is weak considering that no significant difference was found measured at their means (see variable 20 in table 4).

Considering a breakdown of R&D cooperation into types of R&D cooperation partners, the results show that there is a tendency for venture capital firms (A) to slightly more frequently partner up with

Universities in R&D cooperation projects more often than do non-venture capital firms (B), where the difference was significant at the 10% significance level measured at their means and 1% measured at their medians (see variable 21 in table 4). No significant differences were found between the two groups regarding partnerships with R&D firm, lab or institution or with entities within the same corporation (see variables 22 and 23 in table 4). Furthermore, the results show that venture capital firms (A) tend slightly less frequently to partner up with other types of partners compared to non-venture capital firms (B), where the difference was significant at the 5% significance level measured at their means (the medians test failed in Stata) (see variable 24 in table 4).

The results also show that venture capital firms after receiving venture capital (C) tend far less often to partner up with R&D firm, lab, or institution than do venture capital firms prior to receiving venture capital (D), where the difference was significant at the 1% significance level measured at their means (the medians test failed in Stata) (see variable 22 in table 4). No significant differences were found between these two groups regarding the other variables (see variables 19, 20, 21, 23 and 24 in table 4).

10.1.8 Types of R&D

Types of R&D were distinguished in two different ways; (1) by considering whether the R&D was product or process related; or (2) by considering whether it was basic research, applied research, or development. A total of eleven variables were tested; whether or not the firms had product related R&D; or process related R&D; how much as a percentage of total was spent on product related R&D; or process related R&D; whether or not the firms had basic research; applied research; or development; and how much as a percentage of total R&D expenses was spent on basic research; on applied research; or on development; and lastly, whether the firm had a high percentage of R&D expenses engaged in development, i.e. a higher percentage of R&D expenses than the mean observation of percentages (see variables 47-57 in table 4).

Firstly, regarding the first category of R&D types (1), the results show a weak tendency for venture capital firms (A) to have product related R&D more frequently than do non-venture capital firms (B), but it was only significant at the 10% significance level when measured at their means (the medians test failed in Stata), and no significant difference between the two groups was found when considering process related R&D (see variables 47 and 48 in table 4). In terms of the percentage of R&D expenses going to product or process related R&D, no significant differences were found between venture capital firms (A) and non-venture capital firms (B), although it might be worth noticing that about 75% of R&D expenses went to product related R&D and only 25% to process related R&D (see variables 49 and 50 in table 4).

What is interesting is that venture capital firms after receiving venture capital (C) tend to have product related R&D more frequently and process related R&D less frequently compared to venture capital firms prior to receiving venture capital (D), where both differences were significant at a 5% significance level measured at their means (the medians test for both groups failed in Stata) (see variables 47 and 48 in table 4). Also, venture capital firms after receiving venture capital (C) tend to have a greater percentage of R&D expenses going to product related R&D and a lower percentage going to process related R&D compared to venture capital firms prior to receiving venture capital (D), where the differences measured at their means were significant at a 1% significance level for both product and process related R&D, while the differences measured at their medians were significant at the 10% and 5% significance level for product and process related R&D respectively (see variables 49 and 50 in table 4).

One interpretation of these results is that when venture capital funds get engaged with a firm, they tend to shift the focus more towards product related R&D projects within the firm, presumably because these types of projects have better prospects for profitable commercialization than process related R&D projects.

Secondly, regarding the second category (2) of R&D types, the results show that venture capital firms (A) tend to have a slightly higher frequency of basic research than do non-venture capital firms (B), where the difference was significant at the 5% significance level measured both at their means and their medians (see variable 51 in table 4). Furthermore, venture capital firms (A) tend to have a higher frequency of applied research than do non-venture capital firms (B), where the difference was significant at the 1% significance level measured both at their means and their medians (see variable 52 in table 4). Lastly, the results show no significant difference between the two groups when testing for differences in their frequency to perform development measured at their means or at their medians (see variable 53 in table 4). In terms of the percentage of R&D expenses being spent on the three types of R&D, the results show that venture capital firms (A) tend to spend a much higher percentage on basic research, albeit from a low base, compared to non-venture capital firms (B), where the difference was significant at the 1% significance level measured at their means and the 5% significance level measured at their medians (see variable 54 in table 4). Furthermore, venture capital firms (A) also tend to spend a slightly higher percentage on applied research than do non-venture capital firms (B), where the difference was significant at the 1% significance level measured both at their means and their medians (see variable 55 in table 4). This means, as the results also show, that venture capital firms (A) tend to spend a lower percentage on development than do non-venture capital firms (B), where the difference was significant at the 1% level measured at their means (the medians test failed in Stata) (see variable 56 in table 4). Not surprisingly then, do the results show that venture capital firms (A) tend much less frequently to have a high percentage of R&D expenses engaged in development than do non-venture capital firms (B), where the difference was significant at the 1% significance level measured both at their means and their medians (see variable 57 in table 4).

These results are very surprising given the notion that venture capital funds tend to focus on the commercialization processes and tend to invest in firms that will succeed commercially within a few years. If that was the case, then one would expect to see venture capital funds have a greater emphasis on development as opposed to basic or applied research, but the results show the exact opposite. This may, at least partly, be explained by the results in chapter 10.1.7 which showed that venture capital firms (A) tend slightly more frequently to partner up with Universities in R&D cooperation projects, and Universities perform more basic research.

10.1.9 Types of Innovations

Closely related to the previous paragraph is the question of whether the firms have introduced new or improved products or processes (see variable 58 and 59 in table 4).

The results show that venture capital firms (A) tend much more frequently to have introduced new or improved products and slightly less frequently to have introduce new or improved processes compared to non-venture capital firms (B), where the differences were significant at the 1% significance level and the 5% significance level measured at their means for products and processes respectively (the medians test failed in Stata) (see variables 58 and 59 in table 4).

The results also show that venture capital firms after receiving venture capital (C) tend much more frequently to have introduced new or improved products than do venture capital firms prior to receiving venture capital (D), where the difference was significant at the 5% significance level measured at their means (the medians test failed in Stata) (see variable 58 in table 4). No significant difference was found when comparing their frequency to introduce new or improved processes (see variable 59 in table 4).

These results support the hypothesis that venture capital firms focus on the commercialization processes and invest in firms with a great potential for commercial success. The results may also indicate that venture capital funds are better at commercializing and introducing, new or improved products than they are at commercializing and introducing new or improved processes.

10.1.10 Types of Obstructions to Innovation

The dataset include three variables related to obstructions to firms' innovation efforts; whether a firm experienced obstructions to its innovation efforts; if the obstruction was related to a lack of R&D financing; or related to other obstructions (see variable 60-62 in table 4).

The results show that venture capital firms (A) much more frequently responded that they have experienced obstruction to their innovation efforts compared to non-venture capital firms (B), where the difference is significant at the 1% significance level measured both at their means and their medians (see variable 60 in table 4). More specifically, venture capital firms (A) tend much more frequently to respond that they have experienced obstructions to their innovations efforts due to a lack of financing compared to non-venture capital firms (B), where the difference is also significant at the 1% significance level measured both at their means and their medians (see variable 61 in table 4).

These results are consistent with the findings by Michael Peneder (2009), who found that one of the motivations for venture capital firms to have accepted venture capital was their lack of access to other funding sources.

However, this interpretation is obscured when considering the differences between venture capital firms after receiving venture capital (C) and venture capital firms prior to receiving venture capital (D), which shows that venture capital firms after receiving venture capital (C) more frequently respond that their innovation efforts have been obstructed in general and also by a lack of finance specifically than do venture capital firms prior to receiving venture capital (D), where the differences were significant at the 5% significance level (the medians test for the finance obstruction failed in Stata) (see variables 60 and 61 in table 4).

This might indicate that venture capital funds not only focus on the commercialization processes, but, in fact, go so far as to obstruct further innovations after they have become investors in a portfolio firm; one reason for venture capital funds to do that may be to focus on the most promising innovations that are closest to commercialization and drop all other less promising innovation efforts at the reluctance of the entrepreneur. Another interpretation is that, somehow, the financing need increases by more than the infusion of venture capital.

However, comparing these results to the finding in chapter 10.1.4 that venture capital firms after receiving venture capital (C) tend to spend slightly more on R&D in absolute terms, and the finding in chapter 10.1.5 that venture capital firms after receiving venture capital (C) tend to have a far higher R&D intensity compared to venture capital firms prior to receiving venture capital (D) shows that something strange is going on with the responses related to obstructions to innovations. More research is needed to understand the dynamics in this situation.

10.1.11 Intellectual Protection

There were a total of eight variables related to the subject of intellectual protection; one for whether or not the firm had deployed any initiatives to protect its innovations; protection through patenting; protection through trademarks; protection through secrecy; protection through copyrights; protection through registered designs; protection through design complexity; and protection through lead-time advantage (see variables 37-44 in table 4).

First of all, the results from the tests of difference on whether or not the firms deployed protection initiatives showed a strong tendency for venture capital firms (A) to use intellectual protection more frequently compared to non-venture capital firms (B), where the difference was significant at the 1% significance level measured both at their means and their medians (see variable 37 in table 4). When considering a more detailed breakdown of intellectual protection types, the results, firstly, show no significant difference between the two groups, measured both at their means and their medians, regarding protection through copyright, registered design, or lead-time advantage (see variables 41, 42, and 44 in table 4). Furthermore, the results show that venture capital firms (A) tend to use patenting more frequently than do non-venture capital firms (B), where the difference had a 1% significance level measured both at their means and their medians (see variable 38 in table 4). The results also show a weak tendency for venture capital firms (A) to use trademark protection more frequently, where the difference measured at their means had a 10% significance level, while no significant difference was found for their medians (see variable 39 in table 4). On the other hand, venture capital firms (A) have a strong tendency to use secrecy to protect their innovations more frequently than do non-venture capital firms (B), where the difference was significant at the 1% level, measured both at their means and their medians (see variable 40 in table 4). Lastly and rather surprisingly, given that the results reported in chapter 10.1.6 showed a strong tendency for venture capital firms to perform more advanced R&D, the results showed a very small, yet highly significant, tendency for non-venture capital firms (B) to use design complexity to protect their innovations more frequently than venture capital firms (A), where the difference was significant at the 1% significance level measured both at their means and their medians (see variable 43 in table 4).

One may have expected venture capital funds to be better at protecting their intellectual property, because venture capital funds have a lot of experience in dealing with portfolio firms that tend to be technology intensive firms. However, the only variable that showed any significant difference between venture capital firms after receiving venture capital (C) and venture capital firms prior to receiving venture capital (D) was the variable regarding intellectual protection through lead time advantage, which showed that venture capital firms after receiving venture capital (C) tend more frequently to use lead time advantage to protect their intellectual property, which was significant at the 5% significance level (see variable 44 in table 4).

10.1.12 Summary of the Results

A short summary of the results of the comparisons between venture capital firms and non-venture capital firms is that; venture capital firms tend to belong to the IT, Machinery, Telecom, Pharmaceuticals, and biotech industries; they tend to be somewhat smaller, but grow faster than non-venture capital firms; they tend to be more export oriented; they tend to receive public financing more often, but the evidence of venture capital firms receiving more public financing in monetary terms was weak; they tend to have a far higher R&D intensity; they tend to have a higher ratio of R&D personnel with PhDs and other higher educational backgrounds, and they tend to perform more advanced R&D; they tend to be involved in R&D cooperation with outsiders more often; they tend to have a slightly higher frequency of product related R&D as opposed to process related R&D, and they tend to have a slightly higher frequency of basic and applied research as opposed to development; they tend much more frequently to have introduced new or improved products, and slightly less frequently to have introduced new or improved processes compared to non-venture capital firms; they respond much more frequently to have experienced obstructions to their innovation efforts, particularly financial obstructions; and venture capital firms tend to use patenting, trademark protection, and secrecy to protect their innovations more frequently, but design complexity to protect their innovations less frequently than do non-venture capital firms.

A similar short summary of the results of the comparisons between venture capital firms after receiving venture capital and venture capital firms prior to receiving venture capital is that; venture capital firms after receiving venture capital tend to grow much faster than venture capital firms prior to receiving venture capital; they tend to have a much higher R&D intensity; they tend more frequently to have product related R&D and less frequently to have process related R&D, and they tend to invest a higher ratio of their total R&D expenses in product related R&D; they tend more frequently to have introduced new or improved products; and venture capital firms after receiving venture capital tend more frequently to respond that they have experienced obstructions to their innovation efforts than do venture capital firms prior to receiving venture capital.

One important critique of such tests of difference is that as long as there is an upward trend in the variable over time then significance levels will be exaggerated, potentially leading to false or exaggerated conclusions, but it is possible to correct for this in a regression analysis framework.

Table 4: Tests of difference (see subtext at the end of the table for explanations)

Variable		(A)	(B)	Difference (A-B)	(C)	(D)	Difference (C-D)
1 firma_ansatte	N	903	35404		513	390	
	Mean	116.29	109.96	6.33	99.50	138.38	-38.88 **
	Median	30	32	-2.00	28	36	-8.00
2 firma_ansatte_vekst	N	688	20977		459	229	
	Mean	5.0846	2.7654	2.3192 **	5.1465	4.9606	0.1859
	Median	2.3861	0.2907	2.0954	2.6906	2.2989	0.3917
3 firma_oms	N	903	35404		513	390	
	Mean	213457	380742	-167285	189273	245271	-55998
	Median	36463	44065	-7602 **	31064	45144	-14080 **
4 firma_oms_vekst	N	688	20920		459	229	
	Mean	14.9734	12.3789	2.5945	16.6071	11.6991	4.9080
	Median	10.6176	6.4967	4.1209 ***	13.6598	4.9945	8.6653 ***
5 firma_export_D	N	304	12251		129	175	
	Mean	0.6349	0.4383	0.1966 ***	0.6279	0.6400	-0.0121
	Median	1	0	1 ***	1	1	0 (f)
6 firma_export	N	304	12251		129	175	
	Mean	93261	135294	-42033	24474	143966	-119492 ***
	Median	555	0	555 ***	484	808	-324
7 firma_export_andel	N	301	12126		128	173	
	Mean	0.3867	0.4118	-0.0251	0.3338	0.4259	-0.0921
	Median	0.0299	0.0000	0.0299 ***	0.0299	0.0299	0.0000
8 firma_export_høy_D	N	301	12126		128	173	
	Mean	0.3455	0.2218	0.1237 ***	0.3438	0.3468	-0.0030
	Median	0	0	0 ***	0	0	0
9 firma_export_vekst	N	68	1677		42	26	
	Mean	12.4531	-3.7292	16.1823	13.8475	10.2001	3.6474
	Median	9.3406	1.9673	7.3733	14.1661	-1.1399	15.3060
10 firma_konsern_D	N	181	7772		53	128	
	Mean	0.6354	0.5840	0.0514	0.6604	0.6250	0.0354
	Median	1	1	0 (f)	1	1	0 (f)
11 firma_marked_reg_D	N	390	15786		243	147	
	Mean	0.1564	0.4041	-0.2477 ***	0.1728	0.1293	0.0436
	Median	0	0	0 ***	0	0	0
12 firma_marked_Norge_D	N	390	15786		243	147	
	Mean	0.7872	0.5964	0.1908 ***	0.7778	0.8027	-0.0249
	Median	1	1	0 (f)	1	1	0 (f)
13 firma_marked_EU_D	N	390	15786		243	147	
	Mean	0.6077	0.3163	0.2914 ***	0.6255	0.5782	0.0473
	Median	1	0	1 ***	1	1	0 (f)
14 firma_marked_andre_D	N	390	15786		243	147	
	Mean	0.5077	0.2341	0.2736 ***	0.5144	0.4966	0.0178
	Median	1	0	1 ***	1	0	1
15 firma_viktig_reg_D	N	435	16485		246	189	
	Mean	0.2345	0.4664	-0.2319 ***	0.2195	0.2540	-0.0345
	Median	0	0	0 ***	0	0	0
16 firma_viktig_Norge_D	N	435	16485		246	189	
	Mean	0.3034	0.2635	0.0399 *	0.3171	0.2857	0.0314
	Median	0	0	0 *	0	0	0
17 firma_viktig_EU_D	N	435	16485		246	189	
	Mean	0.2552	0.1737	0.0815 ***	0.2561	0.2540	0.0021
	Median	0	0	0 ***	0	0	0
18 firma_viktig_andre_D	N	435	16485		246	189	
	Mean	0.2069	0.0965	0.1104 ***	0.2073	0.2063	0.0010
	Median	0	0	0 ***	0	0	0
19 sam_D	N	838	12144		493	345	
	Mean	0.4356	0.3699	0.0657 ***	0.4178	0.4609	-0.0430
	Median	0	0	0 ***	0	0	0

Variable		(A)	(B)	Difference (A-B)	(C)	(D)	Difference (C-D)
20 sam_andel	N	256	3431		181	75	
	Mean	12.6875	11.1277	1.5598	12.6464	12.7867	-0.1403
	Median	0.0000	0.0000	0.0000 ***	0.0000	0.0000	0.0000
21 samUni_D	N	365	4492		206	159	
	Mean	0.4767	0.4288	0.0480 *	0.4515	0.5094	-0.0580
	Median	0	0	0 ***	0	1	-1
22 samFOU_D	N	365	4492		206	159	
	Mean	0.5479	0.5456	0.0023	0.4806	0.6352	-0.1546 ***
	Median	1	1	0.0000 (f)	1	1	0.0000 (f)
23 samInn_D	N	47	888		12	35	
	Mean	0.6383	0.6678	-0.0295	0.5833	0.6571	-0.0738
	Median	1	1	0 (f)	1	1	0 (f)
24 samAndre_D	N	365	4492		206	159	
	Mean	0.7260	0.7812	-0.0551 **	0.7039	0.7547	-0.0508
	Median	1	1	0.0000 (f)	1	1	0.0000 (f)
25 foufin_tot	N	799	11590		485	314	
	Mean	7817.18	8463.53	-646.35	8522.68	6727.48	1795.20
	Median	2838.00	1093.49	1744.51 ***	3065.69	2555.96	509.73 **
26 foufin_tot_vekst	N	464	5648		341	123	
	Mean	-2.3119	-0.2523	-2.0596	-12.2087	25.1257	-37.3344 ***
	Median	0.2983	-1.5841	1.8824	-1.2589	5.5291	-6.7880
27 foufin_tot_off_D	N	799	11590		485	314	
	Mean	0.5081	0.3399	0.1682 ***	0.5216	0.4873	0.0343
	Median	1	0	1 ***	1	0	1 (f)
28 foufin_tot_off	N	799	11590		485	314	
	Mean	651.05	712.28	-61.23	673.49	616.39	57.10
	Median	54.28	0.00	54.28 ***	84.65	0.00	84.65
29 foufin_tot_priv	N	799	11590		485	314	
	Mean	7166.13	7751.25	-585.12	7849.20	6111.08	1738.12
	Median	2355.96	903.53	1452.43 ***	2497.10	2023.07	474.03
30 fouinnkj_D	N	903	13273		513	390	
	Mean	0.4241	0.3780	0.0462 ***	0.3899	0.4692	-0.0794 **
	Median	0	0	0 ***	0	0	0 **
31 fouinnkj_tot	N	903	13273		513	390	
	Mean	2264.42	2320.24	-55.82	2598.51	1824.95	773.56
	Median	0	0	0 ***	0	0	0 **
32 foupers_doktor_andel	N	690	8449		409	281	
	Mean	5.6090	4.1458	1.4632 ***	6.5914	4.1792	2.4122 **
	Median	0.0000	0.0000	0.0000 ***	0.0000	0.0000	0.0000
33 foupers_hoyutd_andel	N	690	8449		409	281	
	Mean	65.8964	59.7018	6.1945 ***	65.9610	65.8024	0.1585
	Median	79.7959	66.6667	13.1293 ***	80.0000	79.5918	0.4082
34 foupers_hoymindok_andel	N	690	8449		409	281	
	Mean	60.2874	55.5560	4.7314 ***	59.3696	61.6232	-2.2536
	Median	66.6667	59.5142	7.1525 **	65.8986	66.6667	-0.7680
35 foupers_andre_andel	N	690	8449		409	281	
	Mean	34.1036	40.2982	-6.1946 ***	34.0391	34.1976	-0.1585
	Median	20.2041	33.3333	-13.1293 ***	20.0000	20.4082	-0.4082
36 FOU_avansert_D	N	690	8449		409	281	
	Mean	0.1333	0.0924	0.0409 ***	0.1540	0.1032	0.0508 *
	Median	0	0	0 ***	0	0	0 *
37 protect_D	N	903	13273		513	390	
	Mean	0.3677	0.3097	0.0580 ***	0.3762	0.3564	0.0198
	Median	0	0	0 ***	0	0	0
38 protect_patent_D	N	332	4110		193	139	
	Mean	0.4036	0.3324	0.0713 ***	0.3990	0.4101	-0.0111
	Median	0	0	0 ***	0	0	0

Variable		(A)	(B)	Difference (A-B)	(C)	(D)	Difference (C-D)
39 protect_TM_D	N	332	4110		193	139	
	Mean	0.4096	0.3608	0.0488 *	0.4145	0.4029	0.0116
	Median	0	0	0	0	0	0
40 protect_secrecy_D	N	332	4110		193	139	
	Mean	0.6325	0.5265	0.1060 ***	0.5959	0.6835	-0.0876
	Median	1	1	0 ***	1	1	0
41 protect_CR_D	N	332	4110		193	139	
	Mean	0.2108	0.1883	0.0225	0.2228	0.1942	0.0286
	Median	0	0	0	0	0	0
42 protect_CRdesign_D	N	332	4110		193	139	
	Mean	0.1476	0.1367	0.0109	0.1451	0.1511	-0.0060
	Median	0	0	0	0	0	0
43 protect_designcomplex_D	N	332	4110		193	139	
	Mean	0.3735	0.3861	-0.0126 ***	0.3990	0.3381	0.0608
	Median	0	0	0 ***	0	0	0
44 protect_leadtime_D	N	332	4110		193	139	
	Mean	0.7259	0.6820	0.0439	0.7720	0.6619	0.1102 **
	Median	1	1	0	1	1	0 (f)
45 FOU_intensitet	N	887	13094		506	381	
	Mean	649.65	47.25	602.41 ***	953.92	245.56	708.36 **
	Median	5.88	1.10	4.78 ***	9.23	3.82	5.41 ***
46 FOU_intensitet_høy_D	N	902	13252		512	390	
	Mean	0.2395	0.0398	0.1997 ***	0.2871	0.1769	0.1102 ***
	Median	0	0	0 ***	0	0	0 ***
47 foukost_A_produkt_D	N	366	4660		214	152	
	Mean	0.9372	0.9109	0.0262 *	0.9533	0.9145	0.0388 **
	Median	1	1	0 (f)	1	1	0 (f)
48 foukost_A_prosess_D	N	366	4660		214	152	
	Mean	0.5874	0.6137	-0.0263	0.5327	0.6645	-0.1318 **
	Median	1	1	0 (f)	1	1	0 (f)
49 foukost_A_produkt	N	366	4660		214	152	
	Mean	74.5170	72.1935	2.3235	79.0386	68.1511	10.8875 ***
	Median	90.0000	85.0000	5.0000	90.0000	80.0000	10.0000 *
50 foukost_A_prosess	N	366	4660		214	152	
	Mean	25.4830	27.8050	-2.3220	20.9614	31.8489	-10.8875 ***
	Median	10.0000	15.0000	-5.0000	10.0000	20.0000	-10.0000 **
51 foukost_B_grunn_D	N	366	4660		214	152	
	Mean	0.2158	0.1704	0.0455 **	0.2150	0.2171	-0.0022
	Median	0	0	0 **	0	0	0
52 foukost_B_anvendt_D	N	366	4660		214	152	
	Mean	0.5246	0.4217	0.1029 ***	0.5140	0.5395	-0.0255
	Median	1	0	1 ***	1	1	0 (f)
53 foukost_B_utvikling_D	N	366	4660		214	152	
	Mean	0.9563	0.9667	-0.0105	0.9486	0.9671	-0.0185
	Median	1	1	0 (f)	1	1	0 (f)
54 foukost_B_grunn	N	366	4660		214	152	
	Mean	4.8550	2.9722	1.8828 ***	5.2103	4.3548	0.8554
	Median	0.0000	0.0000	0.0000 **	0.0000	0.0000	0.0000
55 foukost_B_anvendt	N	366	4660		214	152	
	Mean	17.2957	13.8209	3.4749 ***	18.3376	15.8289	2.5087
	Median	5.0000	0.0000	5.0000 ***	7.5000	5.0000	2.5000
56 foukost_B_utvikling	N	366	4660		214	152	
	Mean	77.8493	83.2070	-5.3577 ***	76.4521	79.8162	-3.3641
	Median	90.0000	100.0000	-10.0000 (f)	90.0000	90.0000	0.0000
57 foukost_B_utvikling_høy_D	N	828	11621		488	340	
	Mean	0.2222	0.4586	-0.2363 ***	0.2377	0.2000	0.0377
	Median	0	0	0 ***	0	0	0

Variable		(A)	(B)	Difference (A-B)	(C)	(D)	Difference (C-D)
58 inno_ny_produkt_D	N	386	6675		206	180	
	Mean	0.6451	0.5258	0.1192 ***	0.6942	0.5889	0.1053 **
	Median	1	1	0 (f)	1	1	0 (f)
59 inno_ny_prosess_D	N	386	6675		206	180	
	Mean	0.7358	0.7867	-0.0509 **	0.7233	0.7500	-0.0267
	Median	1	1	0 (f)	1	1	0 (f)
60 inno_hindret_D	N	181	7772		53	128	
	Mean	0.3812	0.1754	0.2058 ***	0.5094	0.3281	0.1813 **
	Median	0	0	0 ***	1	0	1 **
61 inno_hindret_finans_D	N	486	19939		277	209	
	Mean	0.7510	0.4207	0.3303 ***	0.7906	0.6986	0.0920 **
	Median	1	1	0 ***	1	1	0 (f)
62 inno_hindret_andre_D	N	486	19939		277	209	
	Mean	0.7140	0.4003	0.3137 ***	0.7256	0.6986	0.0270
	Median	1	1	0 ***	1	1	0 (f)
63 firma_næring_Annet_D	N	903	35404				
	Mean	0.6611	0.8932	-0.2320 ***			
	Median	1	1	0 (f)			
64 firma_næring_Telekom_D	N	903	35404				
	Mean	0.0377	0.0142	0.0234 ***			
	Median	0	0	0 ***			
65 firma_næring_Farmasi_D	N	903	35404				
	Mean	0.0144	0.0027	0.0117 ***			
	Median	0	0	0 ***			
66 firma_næring_IT_D	N	903	35404				
	Mean	0.2248	0.0668	0.1580 ***			
	Median	0	0	0 ***			
67 firma_næring_Medisin_D	N	903	35404				
	Mean	0.0111	0.0056	0.0055 **			
	Median	0	0	0 **			
68 firma_næring_Maskin_D	N	903	35404				
	Mean	0.0509	0.0175	0.0335 ***			
	Median	0	0	0 ***			
69 size_D1	N	903	35404				
	Mean	0.1650	0.1038	0.0612 ***			
	Median	0	0	0 ***			
70 size_D2	N	901	35232				
	Mean	0.1299	0.1414	-0.0115			
	Median	0	0	0			
71 size_D3	N	901	35232				
	Mean	0.1787	0.1701	0.0086			
	Median	0	0	0			
72 size_D4	N	901	35232				
	Mean	0.2087	0.2276	-0.0189			
	Median	0	0	0			
73 size_D5	N	901	35232				
	Mean	0.3196	0.3615	-0.0419 ***			
	Median	0	0	0 ***			

Table 4 – Shows the results of tests of difference in mean and median for a number of variables. The mean difference test is a two sample t-test with equal variances, and the median difference test is a non-parametric equality of medians test based on a chi-squared test statistic. (A) Firms that have never received venture capital, (B) Firms that have, at some point in time, received venture capital, (C) venture capital firms prior to receiving venture capital (incl. the year they receive venture capital), (D) venture capital firms after receiving venture capital.

***** Significant at the 1% level; ** Significant at the 5% level; * Significant at the 10% level.**

10.2.0 Descriptive Statistics – Graphs

Figure 22 shows the total R&D identified through Statistics Norway's R&D survey. The value for 2004 is missing, but all the other years are based on a number of observations varying from a low number of 854 in 2002 to a high number of 1513 in 2008. Although there are few years included in the figure, it clearly shows an upward sloping trend in total R&D spending in recent years (deflated).

Figure 23, depicting total venture capital spent on R&D per year, is based on a low of 25 observations in 2001 and a high of 68 observations in 2008, with missing observations for 2002 and 2004. Figure 23 also shows an upward sloping trend, but a much steeper slope, quicker increase, than total R&D spending.

Figure 24 combines the two variables into a ratio of venture capital spent on R&D relative to total R&D spending per year. The ratio started out below 1% in 2001, and even after rising quickly still ended up just below 2% in 2008. Most of the R&D spending is, thus, not financed by venture capital, but by other sources of financing. This is based on only a few years of observations, so the interesting question is whether the upward sloping trend will continue in the following years, especially considering the financial crisis.

Figure 25 shows how much venture capital was spent on R&D relative to total venture capital investments in Norway; the value for 2004 is missing. This ratio has fluctuated between a low of 3.43% in 2007 and a high of 8.91% in 2005 (the data does not include absolutely all R&D in Norway, so the percentages are under-exaggerated). If a pattern can be deduced from the figure, based on the low number of years, it would be that the ratio seems to be varying between a floor of 3.43% and a ceiling of 8.91% without a clear trend saying otherwise. Based on what we know about venture capital funds' investment behavior and preferences for focusing on the commercialization process, it might explain the low ratio and that there would logically be a ceiling to the ratio. Comparing these results with the estimates by Bob Zider (1998) shows that the ratios for Norway reported above are quite realistic. Bob Zider estimated that out of the $10 billion of venture capital investments in 1997 less than $1 billion was spent funding R&D, i.e. a ratio of less than 10%, while more than 80% went to finance investments in manufacturing, marketing, and sales.

Figure 26 shows the ratio of R&D spending relative to firm revenues. It is based on a number of observations ranging from a low of 847 in 2002 and a high of 1516 in 2008. The trend in this ratio is clearly downward sloping, and bodes ill for the prospects of reaching the target of 3% of GDP being spent on R&D. Albeit, this ratio is not directly comparable with the 3% target, as firm revenues is not the same as a firm's contribution to GDP, but it is sufficiently close to the real numbers to allow the deduction that a downward sloping trend in the ratio of R&D spending to firm revenue points to a downward sloping trend in firms' contribution to R&D spending relative to GDP.

Figure 27 shows the ratio of R&D spending relative to firm revenues subdivided into six industry classifications. The IT & Electronics industry ratio is based on a number of observations ranging from 37 in 2001 to 298 in 2006; the Machinery industry ratio from 34 in 2002 to 65 in 2008; the Medical Devices industry from 5 in 2001 to 8 in 2006; the Pharmaceuticals industry from 8 in 2007 to 12 in 2008; the Telecom industry from 10 in 2001 to 43 in 2008; and Other industries from 666 in 2002 to 1103 in 2003. The extremely high ratio in 2001 for the Telecom industry may be caused by the low number of observations and specific firm or industry events, or it may be remnants of the dot com bubble. Whatever the reason, the ratio settled down and remained fairly stable at levels about half of the IT & Electronics, Machinery, and Pharmaceuticals industries. Figure 27 clearly shows that all the specific industries are much more R&D intensive than the Other industries category, with the Medical Devices industry as the industry with the highest R&D intensity and the IT & Electronics, Machinery, and Pharmaceuticals industries following closely behind. It certainly is a good argument for including these five industries as industry dummies in the regression analysis.

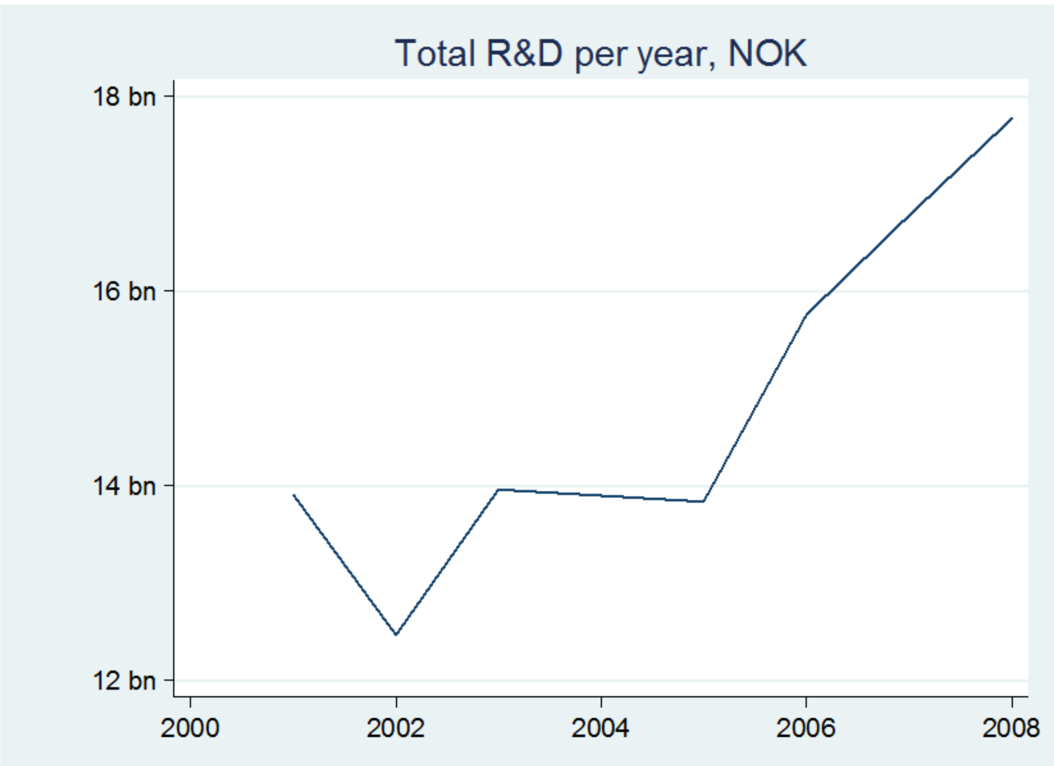

Figure 22 – Total R&D per year, NOK

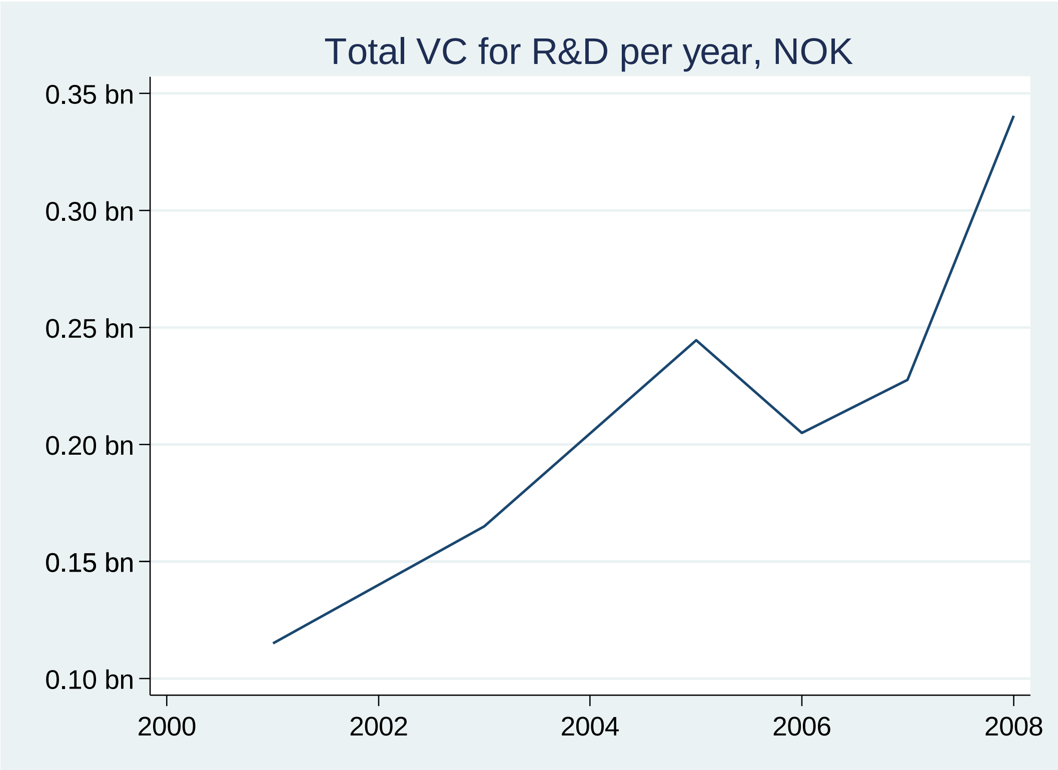

Figure 23 – Total venture capital for R&D per year, NOK

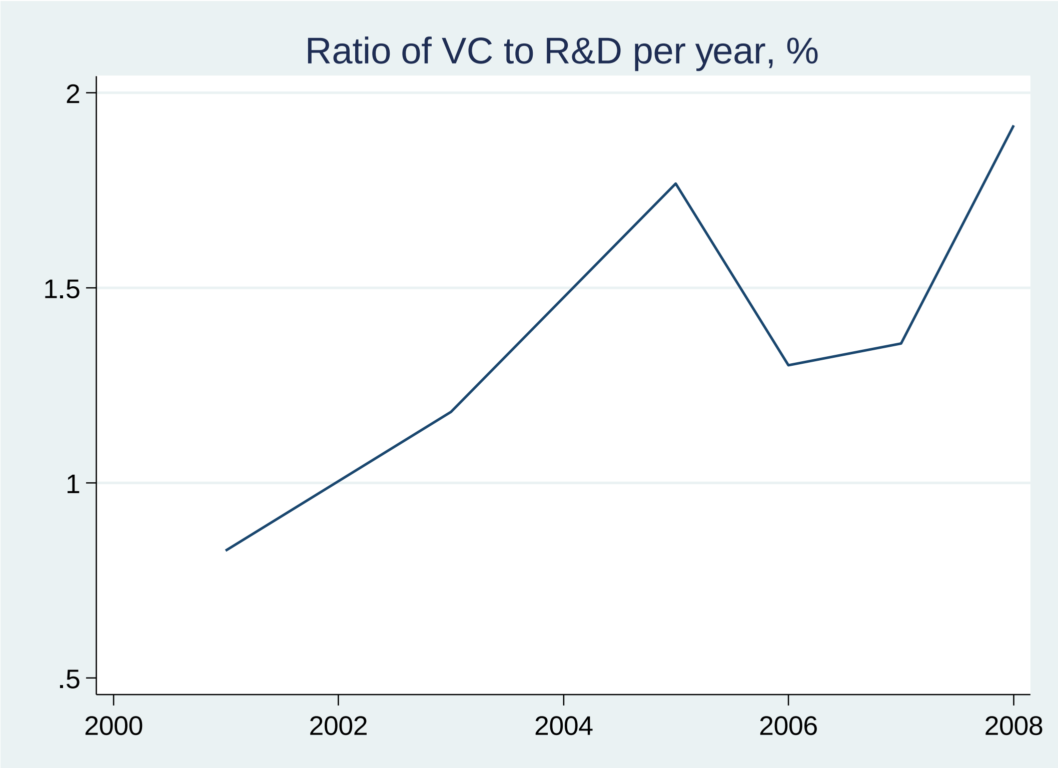

Figure 24 – Ratio of venture capital to R&D per year, %

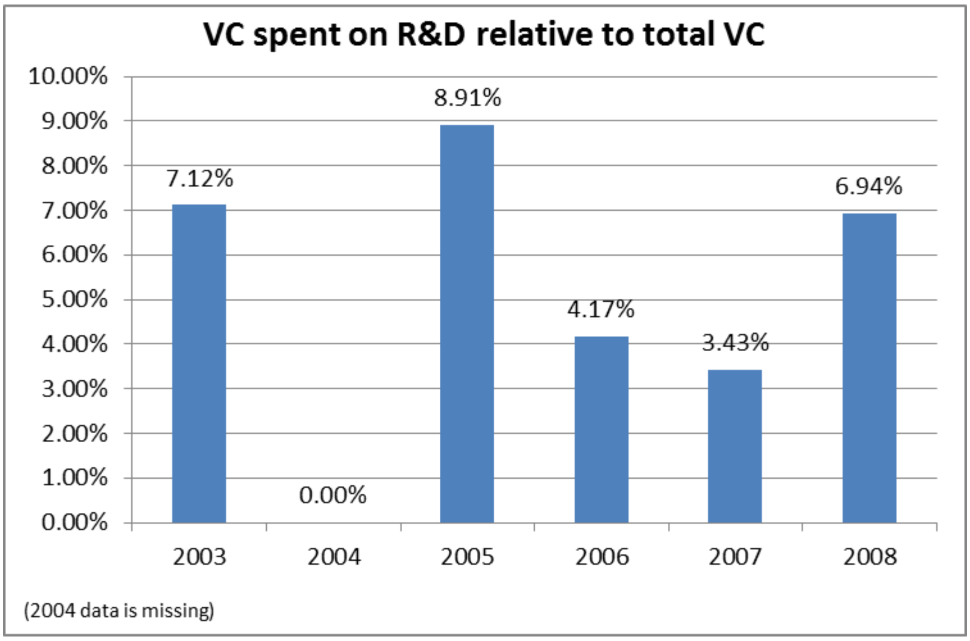

Figure 25 – venture capital spent on R&D relative to total venture capital

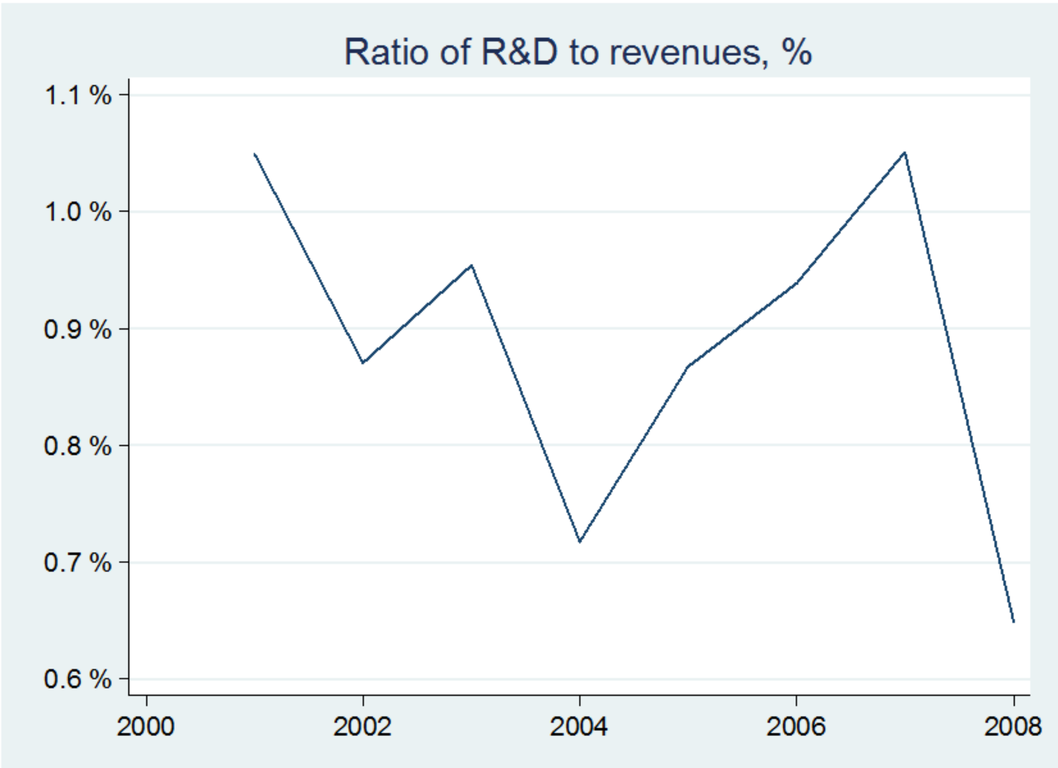

Figure 26 – Ratio of R&D to revenues, %

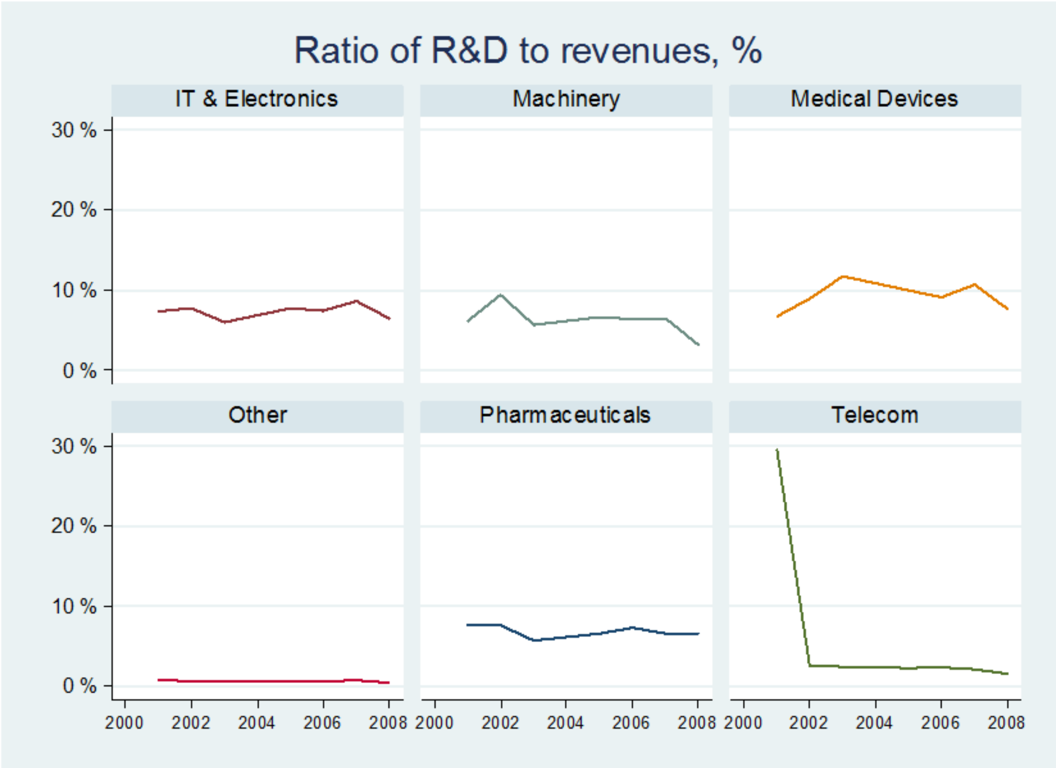

Figure 27 – Ratio of R&D to revenues, %

11.0.0 Method of Analysis – Research Design

The purpose of this empirical analysis is to attempt to confirm the hypothesis that firms receiving venture capital for R&D tend to also receive other forms of financing for R&D, i.e. if there is a causal relationship between receiving venture capital and receiving other forms of financing. One possible rationale for such a relationship is that venture capital funds' approval of a firm acts as a strong signal to other financial intermediaries about the prospects of a firm; venture capital funds scrutinize their candidate firms before selecting them, and subsequently spend a lot of resources on monitoring as well as on providing managerial expertise to their portfolio firms, no other types of financial intermediaries are as thorough as venture capital funds. Another rationale is that by providing managerial expertise, venture capital funds also provide their portfolio firms with access to professional networks, including networks to other financial intermediaries, thereby increasing the likelihood of being approved for support by other financial intermediaries.

Two types of empirical analyses will be applied in this study; the first part will attempt to explain empirically what characteristics are typical for firms receiving venture capital by applying a probit regression analysis, and the second part will attempt to explain empirically the relationship between venture capital financing and other types of external financing in relation to R&D spending, or, more specifically, attempt to identify the additionality effect of venture capital on total R&D.

11.1.0 Probit Regression

In order to explain empirically what characteristics are typical for firms receiving venture capital, it is useful to apply a Probit regression analysis. The Probit analysis is based on a binomial dependent variable, which is given a value of one if a firm receives venture capital and a value of zero if a firm does not receive venture capital, and a vector of independent variables, which are assumed to influence the outcome of the dependent variable. After estimating the marginal effects, we are left with a model that tells us how much a one unit change in each independent variable increases the probability of the dependent variable being one, i.e. that the firm receives venture capital. The marginal effect that will be estimated is the average marginal effect, that is, the average of the marginal effects computed at each individual in the sample. The alternative would be to estimate the marginal effect for an average observation, that is, the marginal effect computed at the sample mean. "Increasingly, current practice is moving to looking at the distribution of the marginal effects computed for each individual in the sample" (Baum 2006).

The following independent variables were controlled for in the probit regression analysis; whether or not the firm previously received venture capital (variable 1 in table 5); growth in firm revenues (variable 2 in table 5); growth in R&D financing (variable 3 in table 5); whether the firm performs IT related R&D (variable 4 in table 5), biotech related R&D (variable 5 in table 5), or materials related R&D (variable 6 in table 5); whether the firm performs product related R&D (variable 7 in table 5) or process related R&D (variable 8 in table 5); whether the firm belongs to the group with a high ratio of development efforts as opposed to basic or applied research (variable 9 in table 5); whether the firm belongs to the group with high R&D intensity (variable 10 in table 5); whether the firm belongs to the group with advanced R&D (variable 11 in table 5); whether the firm is involved in R&D cooperation projects (variable 12 in table 5); whether the firm is buying external R&D services (variable 13 in table 5); whether the firm belongs to the size for those with average revenues below the 20^{th} percentile (variable 14 in table 5); between the 20^{th} and 40^{th} percentiles (variable 15 in table 5), between the 40^{th} and 60^{th} percentiles (see variable 16 in table 5), between the 60^{th} and 80^{th} percentiles (variable 17 in table 5), or above the 80^{th} percentile (variable 18 in table 5).

11.2.0 FE Regression

The method chosen to identify the additionality effect of venture capital on total R&D is multiple regression analysis adjusted for fixed effects, a Fixed Effects (FE) regression analysis. First I will explain the concept of additionality, and then the concept of the FE regression framework.

A situation with no additionality and no crowding out effect in this study would be if one dollar of venture capital received and spent on R&D leads to a one dollar increase in total R&D. Full crowding out would be if the venture capital simply replaces other types of R&D financing, so that one dollar of venture capital received and spent on R&D results in exactly a zero increase in total R&D. Hence, some crowding out would be if one dollar of venture capital spent on R&D leads to less than a one dollar increase in total R&D. Positive additionality would be if the venture capital is matched with an increase in other types of R&D financing, so that one dollar of venture capital leads to more than a one dollar increase in total R&D (Klette & Møen 2011).

The purpose of the empirical analysis is to identify the additionality effect of venture capital on total R&D, i.e. the causal effect of venture capital. This requires the identification of the counterfactual, i.e. what would have happened in the absence of the venture capital infusion. Predicting with perfect clarity what would have happened to a firm receiving venture capital if it had not received venture capital in the first place is quite challenging. The recipients of venture capital are a carefully selected group, so finding a control group of similar firms that have not received venture capital is difficult, but it would go a long way towards allowing the identification of the counterfactual. The FE regression framework is one way of getting closer to a counterfactual, and the sample used for the regression analyses was also limited to firms that have received venture capital at some point in time, which should account for most of the selection effects making a causal study possible.

An FE regression analysis is different from an OLS regression analysis in that it allows different constant terms (intercepts) for different groups, but the slope (i.e. the beta coefficients) of the regression lines must be equal across groups. What this means in practical term is that every firm is compared to its own average over time, so that the FE test with respect to the venture capital coefficient answers the question by how much do the firms increase their total R&D spending when they receive more venture capital than they do on average. Hence, the selection effect related to firm specificities that are constant over time is accounted for.

Hence, unlike the OLS regression analysis, the FE regression analysis produces one regression line for each group instead of one regression line for all observations combined. The practical implication of this is that the FE framework allows there to be an unobserved individual specific effect in the error term which is correlated with the independent variables without resulting in biased estimates of coefficients, as long as the effect is constant, i.e. time invariant. Such individual effects could be differences in managerial effectiveness, firm productivity, quality of R&D personnel, better networks to venture capital funds, etc. By adjusting for such individual effects, much of the selection effect inherent in firms that are selected to receive venture capital should be accounted for, thus, making the control group better suited to identify the counterfactual.

With respect to control variables, I will draw on the framework and reasoning of Klette & Møen in their 2011 paper, where they draw on Swenson (1992). Current revenues are used as a proxy for expected revenues to control for the possibility that expected revenues are important if development costs of new products or processes are fixed. The square of revenues is included to account for possible non-linearity in size. Time dummies and firm specific fixed effects are included to control for technological opportunities and the degree of appropriability. Industry dummies are included to control for the fact that some industries are more R&D intensive than others, although the industry dummies are disregarded with the FE regression analyses as the FE method requires at least two observations with at least some variation of each independent variable. And lastly, an independent variable for public subsidy is included as a consequence of Hægeland and Møen's 2007 study where they identified an additionality effect from public subsidies on R&D spending.

The specification described above may not control for all variables that influence the outcome of the dependent variable, which means that some influencing effects may remain in the error term potentially leading to biased coefficients. It is not, however, possible to ever be certain about this, and, in any case, the potential bias may go in either direction.

Furthermore, to open up to the possibility that the functional form of the relationship between venture capital and total R&D spending is not linear, but rather log-linear, both functional forms are tested. If the signs of the coefficients are the same and significance levels are more or less the same, then the results of the regression analyses based on a linear functional form are considered to be robust with regards to functional form.

In order to test the appropriateness of the assumptions of the FE regression framework in this study, First Differencing (FD) regression analyses were also performed. If the error term is not serially correlated the FE method is most efficient, but if the error term follows a random walk the FD method is most efficient, i.e. the higher the positive serial correlation the stronger is the case for using the FD method over the FE method. Differences between the two methods in their results can also signal endogeneity problems as they deal with contemporaneous correlation differently.

11.1.0 Potential Threats to the Validity of the Study

11.1.1 Internal Validity

Definition of internal validity: "Extent to which findings can be attributed to interventions rather than any flaws in your research design" (Saunders, Lewis & Thornhill 2009).

"Internal Validity is the approximate truth about inferences regarding cause-effect or causal relationships. Thus, internal validity is only relevant in studies that try to establish a causal relationship. It's not relevant in most observational or descriptive studies, for instance" (Trochim 2006). As this study falls under the category of descriptive studies, and does not seek to find a causal relationship, internal validity is not a concern.

11.1.2 External Validity

Definition of external validity: "The extent to which the research results from a particular study are generalizable to all relevant contexts" (Saunders, Lewis & Thornhill 2009).

Another definition of external validity: "…external validity is the degree to which the conclusions in your study would hold for other persons in other places and at other times" (Trochim 2006).

This study is based on Statistics Norway's R&D surveys from 2001 to 2008, which covers all Norwegian firms above 50 employees, and a selection of the smaller firms. It stands to reason that the results of analyses on this sample would at least be generalizable to Norway as a whole, and probably to any sufficiently similar country. Of course, if something structural changes in the business environment, for example R&D tax credits are drastically increased or eliminated it may change the relationship between venture capital and R&D spending, making generalizations across time a potentially dangerous exercise.

11.1.3 Construct Validity

Definition of Construct Validity: "Extent to which your measurement questions actually measure the presence of those constructs you intended them to measure" (Saunders, Lewis & Thornhill 2009). Most of the questions in Statistics Norway's R&D survey are objective and appeared, by first glance, to be fairly straight forward to answer by the respondents. The central variable being examined in this study was the variable concerning venture capital spent on R&D. The precise question was: "State the financing for internal R&D expenses…", which was then subdivided into several categories of financing sources where the central one for this study was "Own funds (income, new equity)" followed by "how much of this was Venture capital?" (author's translation). A straight forward and simple question to answer, perhaps not. The measurement question was intended to measure how much of the internal R&D expenses were financed by venture capital. Let us consider what happens to the venture capital when the firm manages to raise it, presumably from venture capital funds. Venture capital funds' motivation for providing a firm with venture capital is to gain an ownership stake in the firm for a share of the firm's future profits, it is not to provide funds targeted for R&D, at least not directly. The venture capital then goes into the pool of equity, which includes at least one, possibly several, other forms of equity. When the firm later spends its equity on R&D efforts, it is a judgement call how much comes from venture capital and how much comes from other types of equity. One possible answer is that the R&D financing stemming from equity comes from all types of equity proportional to their share of total equity. Another is that the R&D spending was raised dollar for dollar by the infusion of venture capital into the firm so that all venture capital raised went to finance R&D. A third possibility is somewhere in between the two first. However, knowing that venture capitalists don't like financing R&D but prefer investing in firms that are concluding their R&D efforts and getting ready to commercialize the product of their R&D efforts, a fourth possibility is that none of the venture capital went to finance the R&D efforts. These are all valid possibilities, and respondents may make a conscious judgement call on which explanation they prefer, or they may choose one without thinking about it. Either way, the question leaves room for interpretation, probably leading to considerable noise in the data, and the construct validity must be considered weak at best.

11.1.4 Statistical Conclusion Validity

Definition of Statistical Conclusion Validity: "Conclusion validity is the degree to which conclusions we reach about relationships in our data are reasonable" (Trochim 2006). There are two types of errors one can make in conclusions; (type 1) incorrectly conclude that there is a relationship when there is none; (type 2) incorrectly conclude that there is no relationship when there is one.

There are 5 threats to statistical conclusion validity: (1) Low reliability of measures, (2) Random heterogeneity of respondents, (3) Low statistical power, (4) Fishing and the error rate problem, and (5) Violated assumptions of statistical tests (Trochim 2006). (1), (2), and (3) are related to making a type 2 error, (4) is related to making a type 1 error, while (5) can lead to both types of errors and it is often not possible to predict what type of error is likely to be made.

(1) Reliability: "The extent to which data collection technique or techniques will yield consistent findings, similar observations would be made or conclusions reached by other researchers or there is transparency in how sense was made from the raw data" (Saunders, Lewis & Thornhill 2009). There are four threats to reliability: (1a) participant error, (1b) participant bias, (1c) observer error, and (1d) observer bias (ibid).

(1a) One source of threat to reliability is participant error. The participants in the SSB R&D survey are firms, but there are individual persons in the firms that have to answer the questionnaire on behalf of the firm. In the questionnaire from SSB, respondents might understand the questions differently, misinterpret the questions, or their responses might be influenced by their mood for example by the weather or by which day of the week they answer the questionnaire. That would reduce the reliability of their answers; this is known as participant error. In the SSB survey, the questions are mostly based on the firm's accounts, the number of various types of employees, the types of R&D, and only a few questions are of a more subjective type for the consideration of the respondent. Some of the quantitative questions, however, are a little more complex than just looking them up in the firm's accounts, and may require some estimations; therefore the problem of participant error, as a threat to the survey's reliability, could potentially create some noise in the dataset, but it should not be particularly severe.

(1b) Participant bias is another threat to reliability, but one that is probably not very relevant in relation to SSB's R&D survey. Participant bias is when the respondents, for example, say what their bosses wants them to say, or what they think their bosses wants them to say, or if the respondent thinks it might affect their job security they might respond differently than if they had no such concerns. As mentioned earlier, only a few questions from the SSB R&D survey are of a more subjective type, and the problem of participant bias should, thus, be minimal.

(1c) A third threat to reliability is observer error. Just like participants can misinterpret, make errors in judgement, or simply mistype, observers can, likewise, make mistakes that will increase the noise in the data and reduce the reliability of the survey. An example of observer error in relation to questionnaires is if different firms received different questionnaires with slightly different framing or wording of the questions, which could potentially influence the responses from the firms. In SSB's R&D survey, they send a large questionnaire to the large firms in their sample and a small questionnaire, with fewer questions, to the small firms in their sample, but the questions themselves are exactly the same and should not be a source of observer error. Another example is when the observer is manually typing the responses into a computer and simply mistypes. The problem of observer error from mistyping could potentially create some additional noise to the data, but that problem should be very small.

(1d) The fourth and last threat to reliability is observer bias, which arises when there are several ways of interpreting the responses. In this case, the questionnaire is designed in such a way that nothing is left up to the observer to interpret; in those questions where judgement and estimations are necessary, the respondent is asked to make those decisions. Therefore, the threat of observer bias should not be present in this survey.

(2) Random heterogeneity of respondents: "If you have a very diverse group of respondents, they are likely to vary more widely on your measures or observations. Some of their variety may be related to the phenomenon you are looking at, but at least part of it is likely to just constitute individual differences that are irrelevant to the relationship being observed" (Trochim 2006). The sample of firms from the R&D survey is very broad, and goes so far as to include all firms with 50 employees and more, and will, thus, suffer from precisely the disadvantage described by Trochim (2006). On the other hand, if a pattern emerges from a highly diverse sample, it is likely going to be strong and particularly interesting.

(3) All of these threats (1a, 1b, 1c, 1d, and 2) are related to the noise in the data which can potentially mask a relationship between variables, and lead a researcher to make a type 2 error. There is one other factor that can also lead to a type 2 error, the strength of the signal, i.e. the true strength of the relationship being studied. "There is one broad threat to conclusion validity that tends to subsume or encompass all of the noise-producing factors above and also takes into account the strength of the signal, the amount of information you collect, and the amount of risk you're willing to take in making a decision about whether a relationship exists. This threat is called low statistical power" (Trochim 2006). Any statistical test relies on four basic components; (i) sample size, (ii) effect size or treatment effect, (iii) significance level, and (iv) statistical power (ibid). (i) Sample size is the number of units or observations in the data. (ii) Effect size is the effect of the treatment relative to the noise in the data. (iii) Significance level is the probability that the observed result is

purely due to chance. (iv) Statistical power is the probability that a test will reveal a treatment effect when it occurs. By knowing three of these components, it is possible to compute the fourth. Increasing or decreasing the value of one of the components can be reached by manipulating one or more of the other three components, or conversely, changing the value of one of the components will affect one or more of the other components. Note, however, that there is an inverse relationship between the significance level and the statistical power, so if the other two components are fixed, increasing the significance level also entails lowering the statistical power. Increasing the statistical power can be achieved by increasing sample size, increasing effect size, decreasing sample variability, increasing precision of measurement, decreasing significance level (increase α), or using more powerful statistical tests (University of Turin 2010).

In this empirical test the data is derived from the SSB R&D survey, and so the sample size is limited upwards by the number of respondents from the survey, the effect size is fixed, the precision of measurement is fixed, and the most appropriate statistical tests are believed to have already been chosen. Increasing the statistical power can, thus, be achieved by decreasing the significance level, which at the same time increases the probability of making a type 1 error, or by decreasing sample variability. In order to decrease sample variability one can carefully select a control group that is as similar to the test group as possible without receiving treatment, use a repeated measures design (which is precisely what a longitudinal study is), and control for confounding factors (confounding factors will be discussed in greater detail in relation to threat number 5) (University of Turin 2010).

(4) The first three threats to statistical conclusion validity (1, 2, and 3) are related to making a type 2 error, while (4) is related to making a type 1 error. Most researchers will be more susceptible to making a type 1 error; if researchers find a relationship, they will most often be confident in their findings, but if researchers find no relationship, they will spend considerable time analyzing why they did not find a relationship and attempt to make adjustments in order to find the relationship they were looking for. This can lead to fishing: "fishing for a specific result by analyzing the data repeatedly under slightly differing conditions or assumptions" (Trochim 2006). Many researchers use the 5% significance level to determine if a relationship exists or not, which means that there is a 5% probability of finding a relationship by chance when there is none, or conversely, you would expect to find a relationship in one out of 20 statistical tests on the same data when there is no true relationship. If it is reasonable to assume that each test on the same data is sufficiently similar, and therefore not independent of each other, then the significance level should be adjusted to reflect the number of analyses performed; "The probability assumption that underlies most statistical analyses assumes that each analysis is independent of the other. But that may not be true when you conduct multiple analyses of the same data" (ibid). The statistical tests in this paper were only performed

once with one setup, and the problem of fishing is not relevant. That does not, however, eliminate the possibility of making a type 1 error by pure chance.

(5) Violated assumptions of statistical tests is perhaps the most complicated and comprehensive threat to statistical conclusion validity. Violated statistical assumptions enable researchers with competing alternative hypotheses to write articles where they criticize, and sometimes outright vilify, the methodology and assumptions of the other researcher in an attempt to reinforce his/hers own findings. What is more is that academics are usually required to publish a certain number of articles per year, and it is often easier to write an article berating another article and get published than it is to get published based on new research. This "battle" over research findings has the upside of creating important debates and drawing in other researchers to look at the same problems, thus enhancing the effort of finding the best answers to research questions, and it stands to reason that it would make researchers meticulous with their methodology and empirical analyses out of fear of being ridiculed by opposing researchers.

In relation to the tests being applied in this study, there are 4 potential threats to the statistical conclusion validity stemming from violated assumptions of the statistical tests.

(5a) "Fixed effect estimators allow for correlation between the explanatory variables and the unobserved individual specific effect. But, if there is no variation over time in one of the explanatory variables (for instance, a wage-equation where education is one of the explanatory variables) the effect of this non-time varying explanatory variable cannot be identified (you will not get an estimate if you try to estimate the model). The fixed effect estimators are also "consuming" degrees of freedom […] The random effect model cannot be used if there is correlation between the explanatory variables and the unobserved individual specific effect" (Lecture notes on panel data estimation in ECO402 at NHH, Fall 2010). How can they be correlated in this study? For example, the productivity of the firms is not completely captured by the independent variables, and, as a consequence, the error term will include these time independent, unobserved individual specific effects. The error term will, thus, be correlated with the independent (explanatory) variables. This is not a problem in a Fixed Effects model as long as the unobserved individual specific effects are time invariant, i.e. constant over time, however, if the unobserved individual specific effects are *not* time invariant there will still be a problem with the data, potentially leading to biased results.

(5b) Many panel datasets concerning firms have missing years for at least some cross-sectional units in the sample, which then makes it an unbalanced panel. The fixed effects method with an unbalanced panel dataset is not much different from a balanced panel dataset, and Stata (the statistical software program used in this study) makes the necessary adjustments automatically. The reason why the panel dataset is unbalanced, however, can create biased estimates. "If the reason a firm leaves the sample (called attrition) is correlated with the idiosyncratic error […] then the resulting sample section problem can cause biased estimators" (Wooldridge 2009). How can the attrition in this dataset be correlated with the unobserved individual specific effect? As mentioned earlier, Statistics Norway include all major firms, but only a selection of small and medium sized firms. For example, if the reason a firm leaves the sample is bankruptcy, and the unobserved effect is related to productivity, and bankruptcy is clearly correlated with productivity, then the attrition is correlated with the unobserved individual specific effect. However, the fixed effects method allows attrition to be correlated with the unobserved individual specific effect, so we do not have to worry about attrition bias in this case. If, on the other hand, the attrition is correlated to some other factor, there might be a problem with the data.

(5c) One can never be 100% confident that all relevant independent variables, i.e. those independent variables that influence the outcome of the dependent variable, have been controlled for in the model. If one or more relevant independent variables have not been controlled for, then the error term will include the effects from these independent variables. Incorrect inference can be made about the correlation between two variables due to confounding factors (also known as spurious correlation or a spurious regression problem); "Spurious Correlation: A correlation between two variables that is not due to causality, but perhaps to the dependence of the two variables on another unobserved factor […] Spurious Regression Problem: A problem that arises when regression analysis indicates a relationship between two or more unrelated time series processes simply because each has a trend, is an integrated time series (such as random walk), or both" (Wooldridge 2009). There is no way to test for confounding factors, so one must simply keep in mind that there may be relevant independent variables that have not been controlled for, which would lead to biased results.

(5d) "In regression analysis using time series data, autocorrelation of the errors is a problem. Autocorrelation of the errors, which themselves are unobserved, can generally be detected because it produces autocorrelation in the observable residuals. (Errors are also known as "error terms", in econometrics.) Autocorrelation violates the ordinary least squares (OLS) assumption that the error terms are uncorrelated. While it does not bias the OLS coefficient estimates, the standard errors tend to be underestimated (and the t-scores overestimated) when the autocorrelations of the errors at low lags are positive."[11] The implication for this study is that even though there may be serial correlation present in the error term, the coefficients will be unbiased, and it will therefore not affect the conclusion of the results.

[11] http://en.wikipedia.org/wiki/Autocorrelation

12.0.0 Results

12.1.0 What Characterizes Firms Receiving Venture Capital

A Probit regression analysis was applied to attempt to identify what factors or characteristics may explain why a firm receives venture capital. The coefficients of the independent variables, reported in table 5 along with their standard error and significance level, show the effect of the independent variables on the probability of receiving venture capital. It is natural to assume that firms that have received venture capital in the past (variable 1 in table 5) will be much more likely to receive venture capital as venture capital funds tend to provide venture capital in staged financing rounds. This variable may, however, "steal" much of the significance from other variables, so the Probit analysis was performed once without this variable (column E of table 5) and once with this variable (column F of table 5). As the figure shows, the results did not change all that much between (E) and (F). The most surprising part of the results is how few variables proved to be significantly different than zero, but that may be due to the weak construct validity of the venture capital variable described in chapter 11.1.3.

Considering (E), table 5 shows that firms that receive venture capital more frequently belong to the high R&D intensity group (variable 10 in table 5), i.e. those firms with R&D intensity above the mean R&D intensity in the sample. Belonging to the high R&D intensity group has the effect of increasing the probability of receiving venture capital by about 5.3%, which is significant at the 5% significance level. Also, quite interestingly, firms belonging to the second smallest size group (variable 15 in table 5) have about a 4.5% higher probability of receiving venture capital, which is significant at the 10% significance level. While firms belonging to the middle size group (variable 16 in table 5) have about a 3.6% higher probability or receiving venture capital, which is significant at the 5% significance level. Other than those three factors, no significant relationships were found relating to the probability of receiving venture capital.

Now considering (F), table 5 shows that firms that previously received venture capital have about an 8% higher probability of receiving venture capital, which is significant at the 1% significance level. When controlling for the firms that have already received venture capital, the coefficients of the variables identified to be significant when considering (E) changed. Firms belonging to the high R&D intensity group (variable 10 in table 5) now have about a 4% higher probability of receiving venture capital, which is significant at the 5% significance level. Firms belonging to the second smallest size group (variable 15 in table 5) have about a 5% higher probability of receiving venture capital and firms belonging to the middle size group (variable 16 in table 5) have about a 3.8% higher probability of receiving venture capital, both of which are significant at the 5% significance level. Again, no other variables were found to have a significant impact on the probability of receiving venture capital.

Probit regression	(E)	(F)
1 foufin_VC_før_D		0.080388 *** (0.030142)
2 firma_oms_vekst	-0.000014 (0.000056)	-0.000020 (0.000054)
3 foufin_tot_vekst	-0.000006 (0.000037)	0.000002 (0.000037)
4 fouomr_IT_D	0.006950 (0.006779)	0.003116 (0.006622)
5 fouomr_biotech_D	0.000591 (0.012299)	-0.002616 (0.010992)
6 fouomr_materialer_D	-0.002380 (0.007864)	-0.002422 (0.007658)
7 foukost_A_produkt_D	0.010418 (0.011095)	0.011814 (0.010407)
8 foukost_A_prosess_D	-0.009527 (0.006926)	-0.006839 (0.006680)
9 foukost_B_utvikling_høy_D	-0.007760 (0.006701)	-0.005722 (0.006725)
10 FOU_intensitet_høy_D	0.053126 ** (0.022889)	0.040017 ** (0.020193)
11 FOU_avansert_D	0.016405 (0.013511)	0.017037 (0.013495)
12 sam_D	-0.003103 (0.006850)	-0.000764 (0.006740)
13 fouinnkj_D	-0.000035 (0.006851)	0.000079 (0.006646)
14 size_D1	0.043740 (0.032043)	0.025752 (0.025643)
15 size_D2	0.045265 * (0.023060)	0.049782 ** (0.024035)
16 size_D3	0.036257 ** (0.016501)	0.037535 ** (0.016857)
17 size_D4	0.009428 (0.010862)	0.012043 (0.011198)
18 size_D5	(omitted)	(omitted)
Pseudo R-sq	0.1486	0.1870
# of obs	2167	2167

Table 5 – Shows the results of the Probit regression analysis. The dependent variable is a dummy for receiving venture capital. (E) Probit analysis without variable 1; (F) Probit analysis with variable 1 (variable 1 controls for firms that have received venture capital in the past)

***** Significant at the 1% level; ** Significant at the 5% level; * Significant at the 10% level.**

12.2.0 Additionality of Venture Capital on Total R&D Financing

An FE regression analysis was applied to attempt to identify the additionality of venture capital on total R&D spending, or in other words, to see if there is a tendency for firms receiving venture capital to also supplement total R&D spending from other financing sources. The results are reported in tables 6-17, with a summary of the coefficients for the venture capital variable and their significance levels from all the different regression analyses reported in table 18. Each table has five columns (G-K) representing five different limitations on the sample being analyzed; (G) is limited to all firms with R&D at some point in time; (H) is limited to all firms with a minimum of two firm observations and firms that had financed R&D with venture capital at some point in time; (I) has the same limitations as H but also excludes all firms with average annual R&D expenditures of 40 million NOK or more, a total of five firms; (J) has the same limitations as (I) and, additionally, only includes the biggest half of the remaining firms in the sample based on their average annual R&D financing; (K) has the same limitations as (I) and, additionally, only includes the smallest half of the remaining firms in the sample based on their average annual R&D financing. The most interesting results are therefore found in (J) and (K), which is the analysis on only big firms and only small firms respectively. (H) Is the limitations that the Fixed Effects (FE) method and the First Differencing (FD) method do automatically, so only when performing an OLS regression will (G) have any results to report, which are then only comparable with other OLS regressions in the (G) column and not with FE or FD regressions.

In tables 6-8 a dummy variable for whether or not the firm receives venture capital is used in combination with a linear functional form. In tables 9-11 the dummy variable is used in combination with a log-linear functional form. In tables 12-14 a linear functional form is applied in combination with the normal continuous venture capital variable. In tables 15-17 a log-linear functional form is applied in combination with the natural logarithm of venture capital.

Table 6 reports OLS regression analyses with a dummy variable for venture capital as the independent variable for venture capital. The venture capital coefficients are not significantly different from zero in (G) or (H). (I) excludes only the five biggest firms from the sample relative to (H), but already you can see a huge difference in the venture capital coefficient. Suddenly the venture capital coefficient is twice as high and significant at the 1% significance level. Separating the sample of (I) into its biggest half of firms (J) and smallest half of firms (K) shows that the biggest half of firms spend about five times as much venture capital on R&D than do the smallest half of firms, and both venture capital coefficients are significant at the 1% significance level. Based on all of these findings it is evident that, based on the venture capital coefficients in (H), (I), (J), and (K), the biggest firms are driving the results, thereby validating the split in the sample between big firms and small firms presented in (J) and (K).

OLS regression: VC (dummy) on total R&D

Conditions:	(G)	(H)	(I)	(J)	(K)
VC (dummy)	472.0682 (1115.7080)	1091.9780 (1020.8880)	2102.1890 *** (642.0382)	2686.4170 *** (1027.4710)	524.0579 *** (147.2049)
Public funding	1.8340 *** (0.0920)	5.9166 *** (1.7410)	2.6781 *** (0.4021)	1.7790 *** (0.4915)	2.1243 *** (0.2544)
Firm revenues	0.0037 *** (0.0005)	-0.0022 (0.0052)	0.0052 *** (0.0020)	0.0059 ** (0.0028)	0.0016 *** (0.0006)
Firm revenues - sq	-3.84E-12 *** (9.63E-13)	4.28E-09 *** (1.10E-09)	-1.32E-09 ** (5.40E-10)	-1.73E-09 ** (7.51E-10)	-3.04E-10 (2.45E-10)
Adj. R-sq (within)	0.4416	0.4305	0.2790	0.1920	0.4911
# of observations	11195	695	672	342	330

Table 6 – OLS regression analyses (venture capital dummy regressed on total R&D)

The same pattern and conclusion found in table 6 is evident when considering the results presented in table 7 and table 8, where the FE and FD methods are applied respectively.

FE regression: VC (dummy) on total R&D

Conditions:	(G)	(H)	(I)	(J)	(K)
VC (dummy)		914.3950 (856.3999)	1286.7220 ** (510.9637)	1765.1170 * (999.9215)	634.9213 *** (125.0554)
Public funding		0.5871 (0.4965)	1.1882 *** (0.3086)	1.1901 *** (0.4601)	1.9118 *** (0.1727)
Firm revenues		-0.0059 * (0.0035)	0.0041 (0.0028)	0.0067 (0.0050)	-0.0000 (0.0010)
Firm revenues - sq		4.28E-09 *** (4.82E-10)	-1.08E-09 * (6.26E-10)	-1.54E-09 (1.03E-09)	-1.33E-10 (3.74E-10)
Adj. R-sq (within)		0.3887	0.0751	0.0855	0.4770
# of observations		695	672	342	330
# of firms (groups)		176	171	86	85

Table 7 – FE regression analyses (venture capital dummy regressed on total R&D)

FD regression: VC (dummy) on total R&D

Conditions:	(G)	(H)	(I)	(J)	(K)
VC (dummy)		868.1434 * (512.6836)	1223.7210 *** (381.8834)	1547.4180 ** (653.0941)	582.8182 *** (156.2483)
Public funding		0.3371 (0.5583)	-0.0442 (0.4678)	-0.0832 (0.4553)	1.7670 *** (0.5051)
Firm revenues		0.0051 (0.0118)	0.0004 (0.0020)	0.0002 (0.0028)	0.0011 (0.0013)
Firm revenues - sq		3.34E-10 (9.39E-10)	-3.01E-10 (2.72E-10)	-3.04E-10 (3.82E-10)	4.30E-11 (3.01E-10)
Adj. R-sq (within)		0.0787	0.0382	0.0554	0.2988
# of observations		347	335	185	150

Table 8 – FD regression analyses (venture capital dummy regressed on total R&D)

Tables 9-12 show the results of using the venture capital dummy variable in combination with a log-linear functional form. When comparing the results shown in these tables to the results discussed in relation to tables 6-8 it is apparent that, although the signs of the venture capital coefficients are the same, the significance levels are somewhat different. This may indicate that the true functional form is, in fact, log-linear.

OLS regression: foufin_VC_D on lnFOU_tot

Conditions:	(G)	(H)	(I)	(J)	(K)
VC (dummy)	1.5749 *** (0.1296)	1.5565 *** (0.1770)	1.6061 *** (0.1799)	0.9664 *** (0.2101)	2.1633 *** (0.2518)
ln(Public funding)	0.6330 *** (0.0105)	0.4846 *** (0.0401)	0.4604 *** (0.0392)	0.2673 *** (0.0611)	0.5137 *** (0.0488)
ln(Firm revenues)	(omitted) (0.0000)	(omitted) (0.0000)	(omitted) (0.0000)	(omitted) (0.0000)	(omitted) (0.0000)
ln(Firm revenues - sq)	8.08E-02 *** (0.0104)	8.88E-02 *** (0.0276)	7.13E-02 *** (0.0277)	3.35E-02 (0.0308)	2.00E-01 *** (0.0492)
Adj. R-sq (within)	0.3245	0.3845	0.3704	0.2184	0.3726
# of observations	11195	695	672	342	330

Table 9 – OLS regression analyses (venture capital dummy regressed on the logarithm of total R&D)

FE regression: foufin_VC_D on lnFOU_tot

Conditions:	(G)	(H)	(I)	(J)	(K)
VC (dummy)		1.5784 *** (0.1980)	1.6170 *** (0.2040)	0.8002 *** (0.2711)	2.4879 *** (0.3043)
ln(Public funding)		0.3529 *** (0.0395)	0.3564 *** (0.0407)	0.2920 *** (0.0563)	0.4209 *** (0.0599)
ln(Firm revenues)		(omitted) (0.0000)	(omitted) (0.0000)	(omitted) (0.0000)	(omitted) (0.0000)
ln(Firm revenues - sq)		6.74E-02 * (0.0366)	7.01E-02 * (0.0373)	5.80E-02 (0.0419)	1.01E-01 (0.0755)
Adj. R-sq (within)		0.2874	0.2939	0.1818	0.4448
# of observations		695	672	342	330
# of firms (groups)		176	171	86	85

Table 10 – FE regression analyses (venture capital dummy regressed on the logarithm of total R&D)

FD regression: foufin_VC_D on lnFOU_tot

Conditions:	(G)	(H)	(I)	(J)	(K)
VC (dummy)		1.1771 *** (0.2114)	1.2131 *** (0.2180)	0.6511 *** (0.2436)	1.9191 *** (0.3722)
ln(Public funding)		0.3618 *** (0.0631)	0.3635 *** (0.0640)	0.2618 *** (0.0848)	0.4548 *** (0.0906)
ln(Firm revenues)		(omitted) (0.0000)	(omitted) (0.0000)	(omitted) (0.0000)	(omitted) (0.0000)
ln(Firm revenues - sq)		-1.46E-03 (0.0252)	1.71E-03 (0.0255)	-5.63E-03 (0.0283)	2.16E-02 (0.0294)
Adj. R-sq (within)		0.2601	0.2633	0.1972	0.3821
# of observations		347	335	185	150

Table 11 – FD regression analyses (venture capital dummy regressed on the logarithm of total R&D)

Table 12 reports OLS regressions with a linear functional form. The venture capital coefficients show an additionality effect of 0.6789 for the sample consisting of all firms with venture capital at some point in time (H), 0.8049 for the sample without the five biggest firms (I), 0.7149 for the sample with the biggest half of the remaining sample (J), and 0.6258 for the smallest half of the remaining sample (K), and all of these venture capital coefficients are significant at the 1% significance level. First of all, the difference between the venture capital coefficients reported in (H) and (I) is startling considering that the only difference in their samples is the exclusion of the five biggest firms in terms of R&D spending in (I) relative to (H). Clearly there is a great deal of heteroscedasticity in the sample, and the big firms appear to be driving the results. The big firms will have a smaller influence on the results when a log-linear functional form is applied. Furthermore, the venture capital coefficients imply that for every krone of venture capital spent on R&D, total R&D increases by less than one krone, i.e. there is a crowding out effect where venture capital partly replaces some other forms of R&D financing. Furthermore, OLS regressions show that the crowding out effect is greater for the smallest half of the sample (K), resulting in a lower venture capital coefficient, than it is for the biggest half of the sample (J).

However, by studying the results more closely one can discover that something is not quite right with the OLS regression results in table 12. The OLS method assumes and forces one common constant term for every firm in its sample. If the "true" constant terms of the two groups in (J) and (K) are equal and the smallest group has a greater crowding out effect, resulting in a lower venture capital coefficient, then their combined venture capital coefficient reported in (I) should have been in between the venture capital coefficients reported in (J) and (K). This is not the case, however, and, in fact, the constant terms in the OLS regression analyses for the two groups reported in (J) and (K) differ widely. This is a strong indication that the FE method would be more appropriate, as it allows every firm in the sample to have its own constant term.

OLS regression: VC on total R&D

Conditions:	(G)	(H)	(I)	(J)	(K)
VC	0.6264 ***	0.6789 ***	0.8049 ***	0.7149 ***	0.6258 ***
	(0.2210)	(0.1050)	(0.0863)	(0.0976)	(0.0832)
Public funding	1.8331 ***	5.2372 ***	2.3125 ***	1.6728 ***	2.0690 ***
	(0.0912)	(1.8343)	(0.3775)	(0.4933)	(0.2337)
Firm revenues	0.0037 ***	-0.0019	0.0061 ***	0.0074 ***	0.0016 ***
	(0.0005)	(0.0049)	(0.0019)	(0.0028)	(0.0005)
Firm revenues - sq	-3.85E-12 ***	4.22E-09 ***	-1.56E-09 ***	-2.04E-09 ***	-3.54E-10
	(9.63E-13)	(1.17E-09)	(5.39E-10)	(7.64E-10)	(2.17E-10)
Adj. R-sq (within)	0.4421	0.4668	0.4083	0.3160	0.5516
# of observations	11195	695	672	342	330

Table 12 – OLS regression analyses (venture capital regressed on total R&D)

Table 13 reports the results of the FE regressions with a linear functional form. The venture capital coefficients show an additionality effect of 0.2312 for the sample consisting of all firms with venture capital at some point in time (H), 0.4731 for the sample without the five biggest firms (I), 0.4635 for the sample with the biggest half of the remaining sample (J), and 0.6557 for the smallest half of the remaining sample (K), and all of these venture capital coefficients are significant at the 1% significance level, except for the venture capital coefficient in (H), which is significant at the 5% significance level. The conclusion about heterogeneity from the previous paragraph remains robust. Furthermore, the results, once again, show a partial crowding out effect of venture capital on total R&D financing, and the crowding out effect is even greater under the FE assumptions compared to that of the OLS assumptions, resulting in lower venture capital coefficients. This is consistent with the measurement error effect described in chapter 10.0.0, and it also indicates a positive selection effect with respect to receiving venture capital. The difference between the biggest half of the sample (J) and the smallest half of the sample (K), however, is opposite of that reported in the OLS regression analyses; the crowding out effect is greater for the biggest half of the sample (J), resulting in a lower venture capital coefficient. This last result may be more appealing, though, because bigger firms are probably less capital constraint, and therefore have less of a need to supplement the R&D spending with venture capital.

FE regression: VC on total R&D

Conditions:	(G)	(H)	(I)	(J)	(K)
VC		0.2312 **	0.4731 ***	0.4635 ***	0.6557 ***
		(0.1036)	(0.0702)	(0.0990)	(0.0841)
Public funding		0.7079	1.3192 ***	1.3004 ***	1.8814 ***
		(0.4952)	(0.2958)	(0.4430)	(0.1597)
Firm revenues		-0.0058 *	0.0042	0.0067	-0.0001
		(0.0034)	(0.0027)	(0.0048)	(0.0009)
Firm revenues - sq		4.31E-09 ***	-1.10E-09 *	-1.55E-09	-6.36E-11
		(4.80E-10)	(6.03E-10)	(9.89E-10)	(3.51E-10)
Adj. R-sq (within)		0.3933	0.1429	0.1505	0.5394
# of observations		695	672	342	330
# of firms (groups)		176	171	86	85

Table 13 – FE regression analyses (venture capital on total R&D)

Table 14 reports the results of the FD regressions with a linear functional form. The purpose of performing the FD regressions is to verify the robustness of the FE assumptions. Without going into more detail, both the sign of the venture capital coefficients and their significance levels are quite similar, inspiring confidence in the appropriateness of the FE method.

FD regression: VC on total R&D

Conditions:	(G)	(H)		(I)		(J)		(K)	
VC		0.1594 (0.1891)		0.5079 (0.1384)	***	0.5053 (0.1388)	***	0.5633 (0.1155)	***
Public funding		0.3964 (0.5569)		-0.0389 (0.4498)		-0.0832 (0.4473)		1.7930 (0.4806)	***
Firm revenues		0.0054 (0.0119)		-0.0009 (0.0021)		-0.0017 (0.0029)		0.0012 (0.0012)	
Firm revenues - sq		3.07E-10 (9.56E-10)		-7.16E-11 (2.95E-10)		-9.36E-13 (3.92E-10)		5.85E-11 (2.77E-10)	
Adj. R-sq (within)		0.0861		0.2113		0.2284		0.3885	
# of observations		347		335		185		150	

Table 14 – FD regression analyses (venture capital regressed on total R&D)

Table 16 shows the results of the FE regressions with a log-linear functional form. The purpose of analyzing both a linear functional form and a log-linear functional form is to verify the results in case the true relationship between venture capital and total R&D is not a linear relationship but rather a log-linear relationship. Applying regression analyses with a log-linear functional form also has the added benefit of reducing the problem of heteroscedasticity. If venture capital coefficients of the same sign and with similar significance levels are found for a log-linear functional form as for a linear functional form, then the results are considered to be robust in relation to the functional form. Without going into more detail, both the sign of the venture capital coefficients and the significance levels are quite similar, inspiring confidence in the venture capital coefficients and significance levels reported in table 13.

OLS regression: ln(VC) on ln(total R&D)

Conditions:	(G)		(H)		(I)		(J)		(K)	
ln(VC)	0.2090 (0.0177)	***	0.2146 (0.0241)	***	0.2212 (0.0248)	***	0.1248 (0.0256)	***	0.3403 (0.0376)	***
ln(Public funding)	0.6323 (0.0105)	***	0.4783 (0.0399)	***	0.4549 (0.0391)	***	0.2643 (0.0612)	***	0.5188 (0.0492)	***
ln(Firm revenues)	(omitted)		(omitted)		(omitted)		(omitted)		(omitted)	
ln(Firm revenues - sq)	0.0812 (0.0104)	***	0.0948 (0.0274)	***	0.0779 (0.0276)	***	0.0365 (0.0310)		0.2061 (0.0477)	***
Adj. R-sq (within)	0.3244		0.3892		0.3742		0.2225		0.3786	
# of observations	11195		695		672		342		330	

Table 15 – OLS regression analyses (the logarithm of venture capital regressed on the logarithm of total R&D)

The same conclusions that were drawn when comparing table 16 with table 13 are also evident when comparing tables 12 and 14 with tables 15 and 17 respectively.

FE regression: ln(VC) on ln(total R&D)

Conditions:	(G)	(H)		(I)		(J)		(K)	
ln(VC)		0.1959	***	0.2044	***	0.1033	***	0.3793	***
		(0.0273)		(0.0284)		(0.0341)		(0.0473)	
ln(Public funding)		0.3631	***	0.3652	***	0.2890	***	0.4334	***
		(0.0398)		(0.0412)		(0.0564)		(0.0598)	
ln(Firm revenues)		(omitted)		(omitted)		(omitted)		(omitted)	
ln(Firm revenues - sq)		0.0715	*	0.0750	**	0.0603		0.1015	
		(0.0369)		(0.0376)		(0.0419)		(0.0758)	
Adj. R-sq (within)		0.2722		0.2796		0.1832		0.4400	
# of observations		695		672		342		330	
# of firms (groups)		176		171		86		85	

Table 16 – FE regression analyses (the logarithm of venture capital regressed on the logarithm of total R&D)

FD regression: ln(VC) on ln(total R&D)

Conditions:	(G)	(H)		(I)		(J)		(K)	
ln(VC)		0.1421	***	0.1508	***	0.0854	**	0.2827	***
		(0.0298)		(0.0313)		(0.0343)		(0.0567)	
ln(Public funding)		0.3670	***	0.3675	***	0.2561	***	0.4682	***
		(0.0649)		(0.0656)		(0.0843)		(0.0902)	
ln(Firm revenues)		(omitted)		(omitted)		(omitted)		(omitted)	
ln(Firm revenues - sq)		0.0008		0.0050		-0.0030		0.0177	
		(0.0252)		(0.0254)		(0.0277)		(0.0276)	
Adj. R-sq (within)		0.2456		0.2505		0.1986		0.3778	
# of observations		347		335		185		150	

Table 17 – FD regression analyses (the logarithm of venture capital regressed on the logarithm of total R&D)

The conclusion of all of these regression analyses is that there appears to be a crowding out effect from venture capital on total R&D financing, so that every krone of venture capital spent on R&D increases total R&D by less than one krone, which is not what the hypothesis going into the study was. The results show that the additionality effect is 0.6557 for smaller firms and 0.4635 for bigger firms. Hence, the crowding out effect appears to be greater for bigger firms than for smaller firms, implying that venture capital may be more important as a way to finance R&D for small firms than it is for big firms and that small firms are more capital constraint.

Another interesting result which has not been mentioned due to it not being central to this study is that the coefficients for public funding clearly and fairly consistently point to a positive additionality effect on total R&D financing, although there appears to be great differences between smaller and bigger firms as reported in columns (J) and (K) in the tables. This simply confirms the findings of Klette & Møen in their 2011 study on the additionality effects of R&D subsidies on total R&D spending.

Summary table	(G)		(H)		(I)		(J)		(K)	
OLS regression: VC (dummy) on total R&D	472.0682		1091.9780		2102.1890	***	2686.4170	***	524.0579	***
FE regression: VC (dummy) on total R&D			914.3950		1286.7220	**	1765.1170	*	634.9213	***
FD regression: VC (dummy) on total R&D			868.1434	*	1223.7210	***	1547.4180	**	582.8182	***
OLS regression: VC (dummy) on ln(total R&D)	1.5749	***	1.5565	***	1.6061	***	0.9664	***	2.1633	***
FE regression: VC (dummy) on ln(total R&D)			1.5784	***	1.6170	***	0.8002	***	2.4879	***
FD regression: VC (dummy) on ln(total R&D)			1.1771	***	1.2131	***	0.6511	***	1.9191	***
OLS regression: VC on total R&D	0.6264	***	0.6789	***	0.8049	***	0.7149	***	0.6258	***
FE regression: VC on total R&D			0.2312	**	0.4731	***	0.4635	***	0.6557	***
FD regression: VC on total R&D			0.1594		0.5079	***	0.5053	***	0.5633	***
OLS regression: ln(VC) on ln(total R&D)	0.2090	***	0.2146	***	0.2212	***	0.1248	***	0.3403	***
FE regression: ln(VC) on ln(total R&D)			0.1959	***	0.2044	***	0.1033	***	0.3793	***
FD regression: ln(VC) on ln(total R&D)			0.1421	***	0.1508	***	0.0854	**	0.2827	***

Table 18 - Shows the venture capital coefficients and their significance levels from tables 6-17

13.0.0 Conclusion

The purpose of this paper is to identify what characterizes firms receiving venture capital, and what the additionality effect of venture capital is on total R&D financing. The hypothesis was that firms receiving venture capital have a tendency to also receive other forms of financing for R&D. Some rationales for why such a relationship might exist was described.

Tests of difference between venture capital firms and non-venture capital firms for a long range of variables showed the following results: venture capital firms tend to belong to the IT, Machinery, Telecom, Pharmaceuticals, and biotech industries; they tend to be somewhat smaller, but grow faster than non-venture capital firms; they tend to be more export oriented; they tend to receive public financing more often, but the evidence of venture capital firms receiving more public financing was weak; they tend to have a far higher R&D intensity; they tend to have a higher ratio of R&D personnel with PhDs and other higher educational backgrounds, and they tend to perform more advanced R&D; they tend to be involved in R&D cooperation with outsiders more often; they tend to have a slightly higher frequency of product related R&D as opposed to process related R&D, and they tend to have a slightly higher frequency of basic and applied research as opposed to development; they tend much more frequently to have introduced new or improved products, and slightly less frequently to have introduced new or improved processes compared to non-venture capital firms; they respond much more frequently to have experienced obstructions to their innovation efforts, particularly financial obstructions; and venture capital firms tend to use patenting, trademark protection, and secrecy to protect their innovations more frequently, but design complexity to protect their innovations less frequently than do non-venture capital firms.

Tests of difference between venture capital firms after receiving venture capital and venture capital firms prior to receiving venture capital showed the following results: venture capital firms after receiving venture capital tend to grow much faster than venture capital firms prior to receiving venture capital; they tend to have a much higher R&D intensity; they tend more frequently to have product related R&D and less frequently to have process related R&D, and they tend to invest a higher ratio of their total R&D expenses in product related R&D; they tend more frequently to have introduced new or improved products; and venture capital firms after receiving venture capital tend more frequently to respond that they have experienced obstructions to their innovation efforts than do venture capital firms prior to receiving venture capital.

Such tests of difference are very crude and cannot take into account trends in the variables, which potentially has the unfortunate effect of leading to biased coefficients and exaggerated significance levels. Therefore, a Probit regression analysis was also performed to identify what factors increased the probability of receiving venture capital. The results of the Probit regression analysis showed that firms that previously received venture capital have about an 8% higher probability of receiving venture capital; firms with high R&D intensity have about a 4% higher probability of receiving venture capital; firms belonging to the second smallest size group have about a 5% higher probability of receiving venture capital; and firms belonging to the middle size group have about a 3.8% higher probability of receiving venture capital. No other variables were found to have a significant impact on the probability of receiving venture capital.

In order to identify the additionality effect of venture capital on total R&D financing the Fixed Effects (FE) regression method was applied. The results showed that there appears to be a crowding out effect from venture capital on total R&D financing, meaning that every krone of venture capital spent on R&D increases total R&D by less than one krone. The implication is that the decision makers tend to use venture capital to finance R&D and at the same time reduce the amount of R&D financing from other financing sources. Furthermore, this crowding out effect appears to be greater for bigger firms than for smaller firms, implying that venture capital may be more important as a way to finance R&D for small firms than it is for big firms and that small firms are more capital constraint. The results remained robust when applying an FD regression method, which indicated the appropriateness of using the FE regression method, as well as to changes in the functional form used in the model specification.

One very important insight was discovered when analyzing the potential threats to the validity of the results; the construct validity was found to be weak. The weakness lies in the survey question regarding venture capital in the R&D survey from Statistics Norway, which was found to be an inadequate way of measuring the amount of venture capital spent on R&D. The big elephant in the room is related to whether it is even possible to make an objective distinction between what sources of firm equity can be considered to have financed R&D efforts. Four different ways of making such a distinction was identified, and which is more correct is debatable. We can, therefore, assume that the survey respondents may have answered the question on venture capital in different ways.

The measurement errors related to the weak construct validity would bias the coefficients towards zero, meaning that the estimated coefficients are conservative estimates. However, there may be other relevant variables that have not been accounted for that could potentially pull the coefficients in the positive direction, and it is difficult to say what the net results would be. The results of this study should, therefore, be used with caution.

14.0.0 References

14.1.0 Articles and Books

Baum, C. (2006). *An Introduction to Modern Econometrics Using Stata*, Stata Press, ISBN 1597180130

Zider, B. (1998). *How Venture Capital Works*, Harvard Business Review, Reprint 98611, http://www.meneghini.it/Harvard%20Business%20Review%20-%20How%20Venture%20Capital%20Works%20(s.12).pdf

Castells, P. (2010). *Venture capital and Innovation at the Firm Level*, Document de treball de l'IEB 2010/12, dialnet.unirioja.es/servlet/fichero_articulo?codigo=3167913&orden=0

Department of psychology, University of Turin, Italy (2010) *How to increase statistical power*, www.psych.unito.it/csc/pers/delgiudice/pdf/increase_power.pdf

Engel, D. & Keilbach, M. (2007). *Firm Level Implications of Early Stage Venture capital Investment – An Empirical Investigation*, Journal of Empirical Finance 14 (2) (2007) 150-167, http://ideas.repec.org/a/eee/empfin/v14y2007i2p150-167.html

Gompers, P. & Lerner, J. (1999). *The Venture capital Cycle, Second Edition*, The MIT Press, ISBN 0262071940

Hall, B. & Lerner, J. (2009). *The Financing of R&D and Innovation*, National Bureau of Economic Research, Working paper 15325, http://www.nber.org/papers/w15325

Hægeland, T. & Møen, J. (2007). *The relationship between the Norwegian R&D tax credit scheme and other innovation policy instruments*, Statistics Norway (SSB), Report 2007/45, http://www.ssb.no/english/subjects/10/02/rapp_200745_en/

Investinor (2009). *Annual Report 2009,* http://www.investinor.no/uploads/dokumenter/Årsrapport_investinor_print.pdf

Kerr, W., Lerner, J. & Schoar, A. (2010). *The Consequences of Entrepreneurial Finance: A Regression Discontinuity Analysis*, Harvard Business School Working Paper, No. 10-086, http://www.hbs.edu/research/pdf/10-086.pdf

Klette, T. & Møen, J. (2010). *R&D investment responses to R&D subsidies: A theoretical analysis and a microeconometric study*, SNF Working paper 2010/33, http://www.snf.no/Default.aspx?ID=12&DWPagingPageNum=3&mode=detail&RowId=43&ViewPID=3&PubID=4419

Kortum, S. & Lerner, J. (2000). *Assessing the Impact of Venture Capital on Innovation*, Rand Journal of Economics 31 (4) (2000) 674-692, http://home.uchicago.edu/~kortum/papers/rje_2000.pdf

Lecture notes on panel data estimation in ECO402 at NHH, Fall 2010

Lecture notes in Corporate Finance FIN402 at NHH, Fall2009

Lerner, J. (1999). *The Government as Venture Capitalist: The Long-Run Impact of the SBIR Program*, Journal of Business, University of Chicago Press, vol. 72(3), pages 285-318, http://ideas.repec.org/a/ucp/jnlbus/v72y1999i3p285-318.html

Metrick, A. (2007). *Venture Capital and the Finance of Innovation*, Wiley 2007, http://ssrn.com/abstract=929145

Peneder, M. (2009). *The Impact of Venture Capital on Innovation Behavior and Firm Growth*, Venture Capital: An International Journal of Entrepreneurial Finance, Vol. 12, No. 2, pp. 83-107 http://ssrn.com/abstract=964954

Saunders, M., Lewis, P. & Thornhill, A. (2009). *Research Methods for Business Students, Fifth Edition*, Prentice Hall, ISBN-13: 978-0-273-71686-0

Sonnek, D. (2006). *Tapping venture capital's horn of plenty*, Innovation Quarterly (2006), www.eirma.org/f3/local_links.php?action=jump&doi=eiq-2006-009-0005

Stuck, B. & Weingarten, M. (2005). *How Venture capital Thwarts Innovation*, IEEE Spectrum, April (2005) 50-55, www.spectrum.ieee.org/computing/hardware/how-venture-capital-thwarts-innovation

The National Venture Capital Association (2010). *2010 National Venture Capital Association Yearbook*, http://www.nvca.org/

The National Venture Capital Association (2010). *Venture capital 101: What is Venture Capital*, http://www.nvca.org/

The National Venture Capital Association (2010). *Venture Impact 5th Edition*, http://www.nvca.org/

The Norwegian Venture Capital & Private Equity Association (2009). *Activity Survey 2009*, http://www.nvca.no/userfiles/Aktivitetsunderskelsen_for_norske_aktive_eierfond_-_Helr_2009.pdf

The Norwegian Venture Capital & Private Equity Association (2008). *Activity Survey 2008*, http://www.nvca.no/userfiles/Activity_Survey_for_Private_Equity_Venture_Capital_and_Seed_Funds_in_Norway_-_2008.pdf

Wadhwa, V. (2008). *Does Venture capital Spur Innovation?,* BusinessWeek, Viewpoint September 30 (2008), www.signallake.com/innovation/VenCapSpurInnovation093008.pdf

Wooldridge, J. (2009). *Introductory Econometrics: A modern approach (International Students Edition)*, South-Western Cengage Learning, ISBN-13: 978-0-324-58548-3

14.2.0 Websites

Argentum. http://www.argentum.no/Main-categories/Argentum/Results/

Argentum. *Annual Report 2009* http://2009.argentum.no/#/tall-og-noter/balanse

Forskningsrådet (The Norwegian Research Council). http://www.forskningsradet.no/servlet/Satellite?c=Page&cid=1224698192993&pagename=indikatorrapporten%2FHovedsidemal

Statistics Norway (SSB) (2011). Description of the R&D survey (in Norwegian) http://www.ssb.no/foun/om.html

Statistics Norway (SSB) (2011). Consumer Price Index http://www.ssb.no/kpi/tab-01.html

Wikipedia on growth capital (2011). http://en.wikipedia.org/wiki/Growth_capital

Wikipedia on autocorrelation (2011). http://en.wikipedia.org/wiki/Autocorrelation

Trochim, W. (2006). http://www.socialresearchmethods.net/kb/