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Corporate Venture Capital: How established firms use external resources to create new competencies

Laura Toschi

Relatori
Prof. Federico Munari
Prof. Raffaele Oriani
Prof. Maurizio Sobrero
Prof. Nalin Kulatilaka

Dipartimento di Scienze Aziendali
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CORPORATE VENTURE CAPITAL: HOW ESTABLISHED FIRMS USE EXTERNAL RESOURCES TO CREATE NEW COMPETENCIES

Presentata da

Laura Toschi

Coordinatore Dottorato
Prof. Federico Munari
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Relatori
Prof. Federico Munari
.....
Prof. Raffaele Oriani
.....
Prof. Maurizio Sobrero
.....
Prof. Nalin Kulatilaka
.....

Esame finale anno 2009

To Emanuele

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ABSTRACT

This Doctoral Dissertation is triggered by an emergent trend: firms are increasingly referring to investments in corporate venture capital (CVC) as means to create new competencies and foster the search for competitive advantage through the use of external resources.

CVC is generally defined as the practice by non-financial firms of placing equity investments in entrepreneurial companies. Thus, CVC can be interpreted (i) as a key component of corporate entrepreneurship - acts of organizational creation, renewal, or innovation that occur within or outside an existing organization– and (ii) as a particular form of venture capital (VC) investment where the investor is not a traditional and financial institution, but an established corporation. My Dissertation, thus, simultaneously refers to two streams of research: corporate strategy and venture capital. In particular, I directed my attention to three topics of particular relevance for better understanding the role of CVC.

In the first study, I moved from the consideration that competitive environments with rapid technological changes increasingly force established corporations to access knowledge from external sources. Firms, thus, extensively engage in external business development activities through different forms of collaboration with partners. While the underlying process common to these mechanisms is one of knowledge access, they are substantially different. The aim of the first study is to figure out how corporations choose among CVC, alliance, joint venture and acquisition. I addressed this issue adopting a multi-theoretical framework where the resource-based view and real options theory are integrated.

While the first study mainly looked into the use of external resources for corporate growth, in the second work, I combined an internal and an external

perspective to figure out the relationship between CVC investments (exploiting external resources) and a more traditional strategy to create competitive advantage, that is, corporate diversification (based on internal resources). Adopting an explorative lens, I investigated how these different modes to renew corporate current capabilities interact to each other. More precisely, is CVC complementary or substitute to corporate diversification?

Finally, the third study focused on the more general field of VC to investigate (i) how VC firms evaluate the patent portfolios of their potential investee companies and (ii) whether the ability to evaluate technology and intellectual property varies depending on the type of investors, in particular for what concern the distinction between specialized versus generalist VCs and independent versus corporate VCs. This topic is motivated by two observations. First, it is not clear yet which determinants of patent value are primarily considered by VCs in their investment decisions. Second, VCs are not all alike in terms of technological experiences and these differences need to be taken into account.

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CHAPTER 1 - INTRODUCTION

1.1 Research Problem

The primary question in the field of strategic management is how firms build and sustain competitive advantage. The general answer proposed by academic studies is that corporations need to leverage on their resources and continuously create new capabilities to face changing in their environments (Barney, 1991; Teece et al., 1997). Following the resource-based view, resources and capabilities are those attributes that enable a firm to conceive of and implement strategies that improve its efficiency and effectiveness (Wernerfelt, 1984, Barney, 1991). Furthermore, the dynamic capabilities approach also suggests that firms' success depends on their ability to maintain competitive advantage in a dynamic market by modifying their resource bases. Accordingly, over the past decade, companies worldwide have used corporate venturing – creation of new businesses within or outside the firm – as a means of revitalizing their operations, building new capabilities, and achieving strategic renewal. In particular, prior research has shown that external business development activities can enhance firm-level performance by tapping into external knowledge sources (Kogut, 1991; Dushnitsky and Lenox, 2005b; Ahuja, 2000; Ahuja and Katila, 2001; Keil et. al, 2008).

This Dissertation investigates how a particular form of investment towards innovative inputs which reside outside the firm's boundaries – commonly referred to as *corporate venture capital* – sustains the firm's strategy for knowledge acquisition. The general definition of corporate venture capital is one of equity investments in entrepreneurial ventures by established corporations, usually motivated by strategic interests. This setting is an interesting phenomenon to study because, since 1990's, the

commitment of resources to corporate venture capital investments has become a popular strategic move for large corporations seeking to accelerate the development of new businesses or renew their existing businesses.

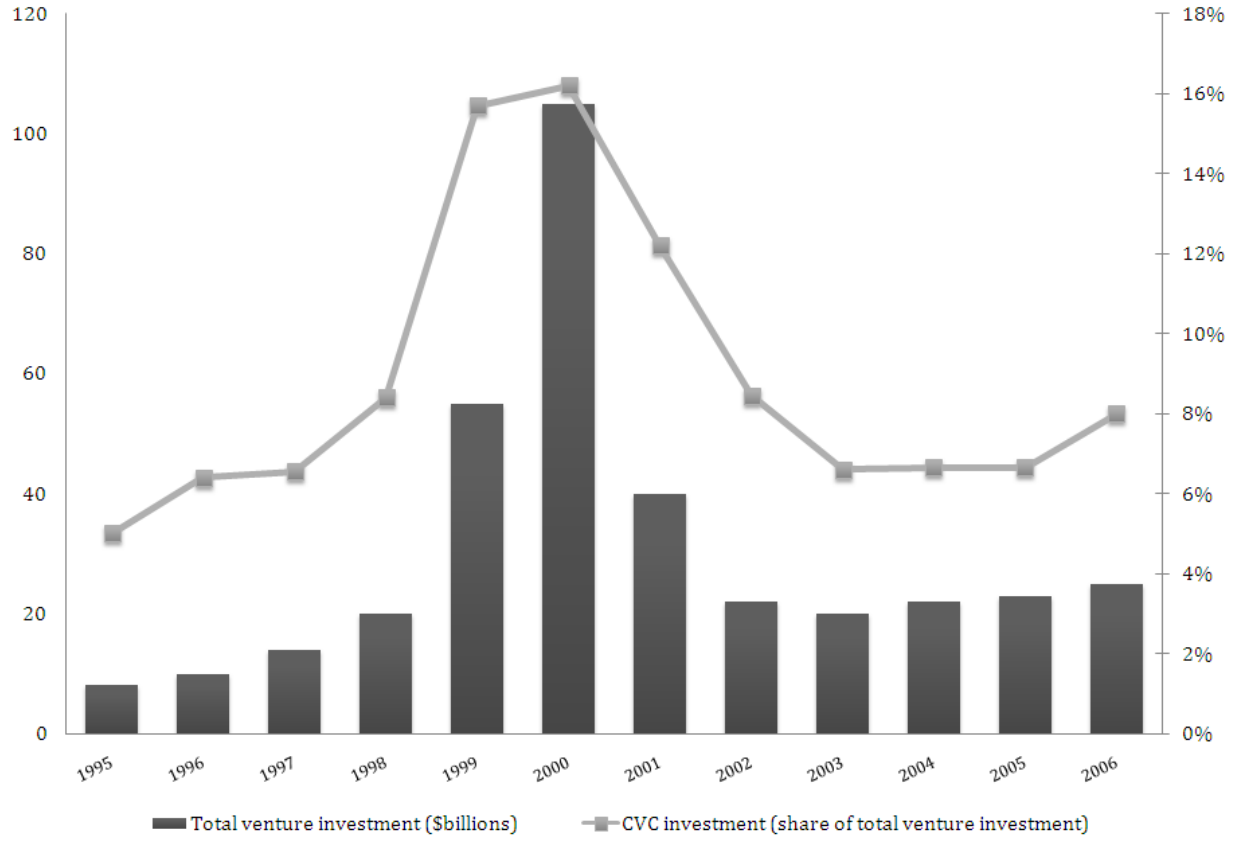

Figure 1.1 Annual volume of venture capital ($billion) and corporate venture capital investments (share of total venture investments) in the U.S. market for the period 1995-2006 (Source: National Venture Capital Association, 2008).

According to the National Venture Capital Association (2008), corporate venture capital has become a significant part of overall venture capital activity. In the year 2000, at the peak of the most recent venture capital cycle, more than $100 billion in venture capital was invested in the U.S. About 16 percent of that investment was from corporate venture capital (as compared to $133 million in 1994). Even though 2000 was a bubble year for corporate and traditional venture capital investments, the levels of corporate

venture capital financing are back to their 1998 levels and once again continue to increase. After 2002, total venture capital investment stabilized at around $25 billion per year, corresponding to 8 percent for corporate venture capital investments (Figure 1.1).

Although corporate venture capital has mirrored the cyclical nature of the venture capital industry, these forms of equity based investments are substantially different. While an independent venture capital fund's sole objective is making financial returns, a corporate venture capital typically needs to achieve a blend of financial objectives allied with strategic goals that contribute to the parent firm's core business. Indeed, a corporation with a strong industry position may find that its unique knowledge of relevant markets and technology enables it to identify attractive opportunities to invest in external companies (Broady and Ehrlich, 1998; Ernst et al., 2005; Kann, 2000; Keil, 2000; Dushnitsky and Lenox, 2005a and 2005b).

Although previous studies highlighted the strategic role of corporate venture capital for engaging in new markets and technologies, less is known about the relationships between this form of strategic investments and other modes available to corporations to create competitive advantage. In order to deeply understand the success of corporate venture capital as a strategic mode of investments, it is important to depict how large firms effectively view corporate venture capital and how they use this form of external investments with the aim to pursue strategic objectives. Thus, the primary focus of this research is to shed new light on the following issue:

Which is the role of corporate venture capital within the broader context of corporate strategy?

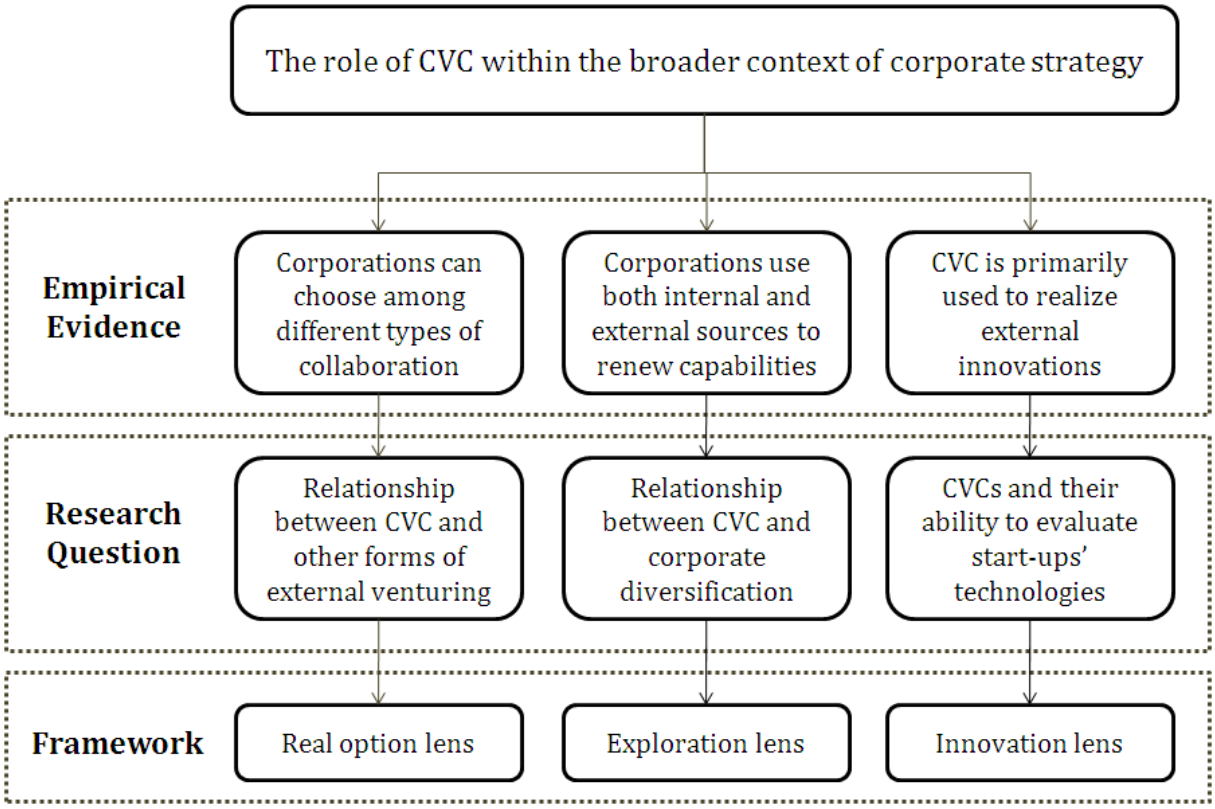

Figure 1.2 Research questions addressed in the Dissertation.

Based on the assumption that corporate venture capital has a strong focus on strategic returns, this Dissertation addresses the abovementioned issue starting from three empirical evidences which suggested three more specific research questions which I intend to analyze through different perspectives (as depicted in Figure 1.2).

1. First, technological complexity and rapid technological change increasingly force established corporations to access knowledge from external sources. To do so, firms extensively engage in external business development activities, often referred to as external corporate venturing (Schildt et al., 2005). While the underlying process common to these mechanisms is one of knowledge access and organizational learning from a partner, the specific mechanisms differ depending on the governance mode (CVC, alliance, joint venture, acquisitions and licensing)

chosen for the relationship between two firms. This consideration suggests the following research question:

How do corporations choose among different forms of external corporate venturing?

2. Second, the evidence that firms have to face increasing competition in their markets led researchers to investigate how corporations can grow improving their set of competencies. The behavioral theory of the firm, developed by Cyert and March (1963), suggests that corporations have the possibility to control their environment through explorative learning processes. In this sense, corporations can rely on two different strategies: investing in external companies, on one hand, and committing resources for the development of internal projects, on the other hand. As a result, direct investments through corporate diversification and corporate venture capital are often considered by corporations as two major ways for renewing their current capabilities. This second consideration suggests the following research question:

   Which type of relationship exists between investments based on internal resources and corporate venture capital? More precisely, does corporate venture capital complement or substitute corporate diversification?

3. Finally, by creating corporate venture capital units, large corporations predominantly pursue strategic objectives, especially with the explicit aim to realize external innovations (Ernst et al., 2005). Technological innovations are,

thus, essential in the understanding of investment decisions based on outside sources. At the same time, the evaluation of technologies developed by external entrepreneurs is not straightforward. The majority of studies on venture capital suggests that patents are a critical signal of a start-up's innovative capabilities and, thus, they represent one of the most important feature considered by investors in the selection of potential new ventures (Kortum and Lerner, 2000; Baum and Silverman, 2004; Mann and Sager, 2007). However, the innovation literature provides a limited understanding of the determinants of patent value that are more directly taken into consideration by investors in their financing decisions. Referring to the broader context of venture capital, our third research question is:

How good are venture capital firms (VCs) at valuing technology? And, do corporate VCs differ from traditional VCs in terms of capabilities required to effectively assess the value of start-ups' technology and intellectual property?

In this Dissertation, the above-mentioned research questions are addressed in three different chapters which constitute the core of this work. In the next sessions of this chapter, I firstly provide a definition of corporate venture capital and, then, I briefly review previous researches on corporate venture capital to highlight the gaps in the literature and discuss how this Dissertation contributes to knowledge in this area. Thus, in reviewing the literature, I focus mainly on those streams of research which are more directly related to the purpose of this Dissertation, avoiding to cover the broader literature on venture capital or corporate venturing which addresses a wider set of issues. In this sense, I mainly identify two macro-topics analyzed by

extant works on corporate venture capital: (a) studies addressing the issue of why corporations make corporate venture capital investments and (b) works comparing corporate venture capital to independent venture capital.

1.2 Literature Review

1.2.1 Definition of corporate venture capital

The pool of investments that significantly contributes to the evolution of a firm's corporate strategy by building new capabilities and businesses that enable renewal and foster strategic change is known as *corporate venturing* (Ireland et al., 2001). The general definition of corporate venturing available in the literature is based on the classification which distinguishes between internal and external venturing, in accordance with whether the new ventures invested reside within or outside the existing corporation (Sharma and Chrisman, 1999). Following this criterion, firms can be split between those nurturing opportunities that are already in-house and primed to leverage corporate competencies (*internal venturing*) and, on the other hand, those financing autonomous organizational entities that reside outside the existing boundaries of the corporation (*external venturing*). A first classification of all the available corporate venturing strategies is presented in Roberts and Berry (1985), where each mechanism differs for the level of corporate involvement, newness and familiarity with a particular type of business and technology.

In line with this literature, *corporate venture capital* investments are viewed as boundary spanning operations (Maula, 2001) and, thus, they belong to the class of external corporate venturing (Keil, 2004). There are several ways to define the concept

of corporate venture capital. The two main alternative approaches view corporate venture capital as a mode of external corporate venturing from the perspective of the corporation (Kann, 2000; Henderson and Leleux, 2002), or as an alternative source of funding from the perspective of an entrepreneur company (Gompers and Lerner, 1998; Maula and Murray, 2002). This study employs the former perspective by defining corporate venture capital as minority equity investments in small, young and independent entrepreneurial ventures where the investors are established, non-financial firms (Chesbrough and Tucci, 2004, Dushnitsky and Lenox, 2005a and 2005b). I thus consider the external corporate venturing in which the mother firm creates a CVC fund beyond its boundaries and directly supplies it with a certain stock of capital to finance a portfolio of new ventures (see Figure 1.3).

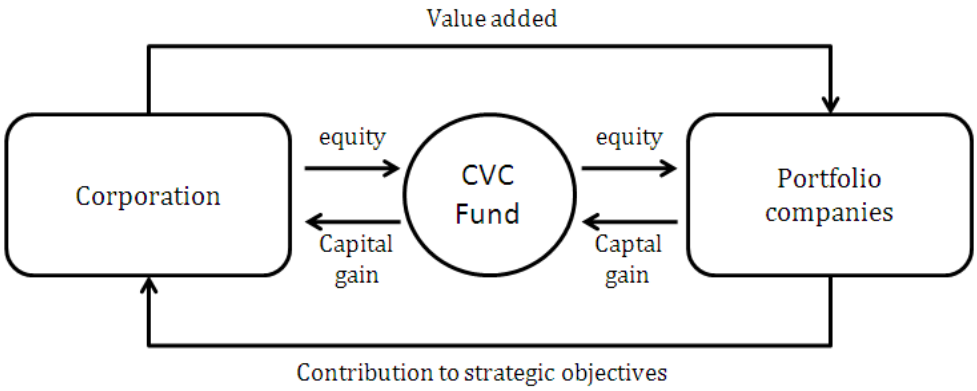

Figure 1.3 Typical structure of a corporate venture capital (adapted by Ernst et al., 2005).

From this representation, I identified some key element to univocally identify corporate venture capital activities:

1. The portfolio companies receiving the investment are separate legal entities from the corporation making the investment.

2. The purpose for the corporate investment is not purely financial, but includes also a strategic purpose.
3. The form of investment in the portfolio companies is equity, rather than debt or other modes of financing.
4. The corporation follows a "staging" process to incrementally increase its involvement in the financing over time.

These criteria circumscribe our context by excluding other forms of activities such as investments in internal divisions, acquisitions of public companies, alliances, joint ventures, or traditional venture capital investments.

1.2.2 Strategic motivations for corporate venture capital

Many anecdotal accounts and empirical works highlight that even though the objectives of large corporations investing in external entrepreneurs may include financial returns, pursuing strategic benefits is the predominant objective (Ernst and Young, 2008; Dushnitsky and Lenox, 2005a and 2005b). Riyanto and Schwienbacher (2006: 2829) suggested that a general remark which born out from their analysis is "*the need for looking at returns of corporate venture finance in a broader sense, not only returns from the fund itself but also the complementarity gains by the large corporation in securing demand*". Big corporations such as Xerox, Lucent, Nokia, Novartis, Pfizer and Intel have explicitly formalized their CVC activities by setting up investment programs motivated by the search for strategic benefits, such as learning and new-knowledge creation. Accordingly, in a recent survey by Ernst and Young (2008), among the respondents (37 CVC units in North America, Europe and Asia), 80% indicates that their programs aim at a pool of strategic and financial goals, 17% merely looks for strategic benefits and only

3% pursues exclusively financial returns. This is confirmed also by some of the largest corporations engaged in CVC activities:

> "*Intel Capital's goal is to achieve both strategic alignment with Intel Corporation and a strong financial return for its investments. The reason is related to the strategic investment focus: if a company furthers the larger strategic goal of advancing computing and communications platforms, then it is also likely to be financially successful. Conversely, if the company fails to develop its market segment, then it will not help Intel's strategic goals.*" (Intel Capital website).

> "*We look forward to continue operating as a financially driven corporate life science investor offering support to those companies which have the potential to lead the next innovation wave in our core therapeutic fields or explore new business areas that will be critical to Novartis, patient care and the healthcare industry in the future.*" (Novartis website).

Although corporations invest in entrepreneurial firms for a variety of reasons, Kann (2000) identified three main types of strategic goals that motivate corporate venture capital investments: (i) external R&D, (ii) accelerated market entry and (iii) demand-enhancement. The first category refers to corporations that aim to enhance their technological capabilities by gaining access to new technologies developed by entrepreneurial companies. This strategic investment goal is widespread in dynamic markets where firms compete on the basis of continued technological innovations. This is the case of Intel Capital, the corporate venture arm of the semiconductor leader, as suggested by its chairman:

"*The aim of our investments is to create a window on novel technologies*" (Intel Capital website).

Also Microsoft follows the same strategic direction as asserted by the corporate vice president of Microsoft's Strategic and Emerging Business Development:

"*Our investments in external sources are designed to foster the success of high-potential software startups on the Microsoft platform. […] Our mission is to identify and focus on new technologies and business models that emerge from early stage startups that we identify as innovative, compelling, disruptive and potentially strategic to Microsoft.*" (Microsoft website).

The second group is common in industries characterized by rapid changes, such as a decline in one market due to the emergence of another market. In this case, technological and commercial skills of corporations may become obsolete pushing them to rapidly acquire different skills and technologies through external companies to enter the new markets. One of Intel Capital's type of investments is labeled "Market development". Investments which belong to this category help Intel to "*accelerate the adoption of technology in emerging markets.*" (Intel Capital website). In particular, two funds have been developed to sustain this goal: "The Intel Capital Middle East and Turkey Fund" for investments in technology companies developing innovative hardware, software, and services throughout the Middle East and Turkey and "The Intel Capital India Technology Fund" that invests in Indian technology companies to help stimulate local technological innovation of India's Information Technology industry. In

both these cases, Intel's goal is to support local development, but also acquire new competencies to enter new markets.

Finally, corporate venture capital investments may be functional to increase demand for corporate products by sponsoring derivative technologies and complementary applications of current technologies developed by entrepreneurial firms. Intel Capital is again a perfect example of a corporate firm nurturing start-ups that develop products complementary to its core technology. In this case, the demand for these products will also have positive effect on the demand of Intel's core products. So, the semiconductor leader invested in companies operating in several sectors such as video, audio, wireless, graphics hardware and software, which required powerful microprocessors for their success. This allows the companies to succeed in their markets and at the same time stimulate sales of Intel Pentium chips. Similarly, Microsoft invested more than $1 billion in early-stage companies that could support and foster its project ".Net", a technology which allows Microsoft Windows platform to provide users with a variety of Internet services (Chesbrough 2002). These investments have a great strategic value for Microsoft as they enable the corporation to shape the standards for the next generation of Internet-based products and services. Investing in companies which exploit its new technology, the leader of the software industry promotes the adoption of its standard creating synergies between its core product (Windows) and correlated applications.

Previous studies analyzing corporate venture capital programs as mechanisms to sustain firms' strategic goals suggested two important results. First, the few corporate venture capital programs investing with purely financial goals typically imitate independent venture capital firms (Gupta and Sapienza, 1992; Gompers, 1995; Wright and Robby, 1998; Brody and Ehrlich, 1998; Kortum and Lerner, 2000; Chesbrough,

2000; Baum and Silverman, 2004; Cressy et al., 2007). Second, corporate venture capital programs investing with purely financial motives have been more short-lived than those that are strategically motivated. Hellman et al. (1995) suggested that, although excellent financial returns, Apple Computer's strategic investment group was ceased due to a lack of strategic focus. Gompers and Lerner (1998), comparing the performance of corporate and independent venture capital investments, found that corporate programs without a strong strategic focus tend to be less successful in the long run than those that are strategically motivated. Finally, Dushnitsky and Lenox (2006) found a positive relationship between corporate venture capital investments and firm value creation, with a greater impact when firms explicitly use these programs to harness entrepreneurial inventions, instead of merely search for financial returns.

Summary and gap in the literature

The previous literature described corporate venture capital as a mechanism that creates competitive advantage by facilitating the acquisition of resources from external companies (Siegel et al., 1988; Kann, 2000; Chesbrough, 2002; Basu et al., 2005; Dushnitsky, 2006; Maula, 2001). However, strategic resources can be developed not only by investing in corporate venture capital, but also through different mechanisms. Generally speaking, resources can be developed in-house or acquired through market-based transactions. On one hand, corporations can develop new resources and capabilities by learning and building knowledge from their business practices, or by conducting internal research and development activities. Conversely, using the market, firms may create competencies by transferring the R&D capabilities from other companies to their organizations through several contractual arrangements such as

alliances, licenses, R&D agreements, and joint ventures, or through acquisitions of other firms that own the desired resources.

Thus, although the extant literature explicitly links corporate venture capital activities to the strategic dimension of external venturing, it misses to investigate whether and how this particular mode of financing differs from other corporate venturing mechanisms. To fill this gap, in the first two papers of the thesis, I do not analyze corporate venture capital in isolation, but I create two tight relations with other mechanisms. First, I focus only on resources which reside outside the firm's boundaries to link corporate venture capital with strategic alliances, joint ventures and acquisitions. All these mechanisms exploit external resources, but they are substantially differ to each others. Second, I merge the internal and external dimensions by relating corporate venture capital to investments developed inside the firm's boundaries. Indeed, corporations engaged in corporate venture capital are firms with well-defined businesses and competencies, internal expertise and specific technological knowledge which decide to support these internal efforts by committing further resources to external companies. It is, thus, critical analyzing the relationship between these two forms of investment in terms of complementarity or substitution. These two perspectives – the former focused on external resources and the latter focused on both internal and external resources - allow to address my first and second research questions about how corporations choose among different collaborative relationships and how corporations integrate corporate venture capital to internal investments.

1.2.3 Traditional venture capital versus corporate venture capital

Venture capital and corporate venture capital have often be considered as similar types of investment in innovative enterprises, where both the risk of loss and the potential for

profit may be considerable (Gompers and Lerner, 1998; Sahlman, 1990). Nevertheless, as discussed in Chesbrough (2000), they differ along several dimensions, showing a high heterogeneity in terms of incentive intensity, monitoring, time horizon, scale of capital invested and objectives. The existence of these differences moved several researches to analyze independent and corporate venture capital as autonomous forms of new ventures financing.

More precisely, the previous literature analyzed the distinct contributions of independent and corporate venture capital firms to the investee ventures. Maula et al. (2004) suggested that the resources controlled by independent and corporate venture capital investors are different but complementary, and that this characteristic impacts on their ability to add value to their portfolio companies. Indeed, while the most value-adding services provided by independent venture capitalists involve finding additional financing, supporting strategic decision making and recruiting key executives (MacMillan et al., 1989; Sapienza et. al, 1994 and 1996; Hellmann and Puri, 2002; Bottazzi and Da Rin, 2002), corporate venture capital seems more able to create knowledge-based learning and endorsement benefits stemming from the parent corporation that sponsors the corporate venture capital fund (Gompers and Lerner, 1998; Maula, 2001; Maula and Murray, 2002).

Gompers and Lerner (1998), in order to test the impact of the organizational structure on investment performance, found that the likelihood of success of a company financed by a corporate investor - measured as undergoing an IPO or obtaining an acquisition at high valuation - is similar to that of an independent venture capital-backed company. Furthermore, this result seems being stronger when the corporation and the investee company are highly related in terms of their lines of businesses and activity domains. The authors proposed the following interpretation for their findings. Although

venture capital firms spur the growth of their investee companies due to their scouting, monitoring and coaching abilities, corporate investors are likely to enjoy some indirect benefits from their involvement with portfolio companies that independent venture firms do not enjoy. When the level of overlap between the corporation and its portfolio companies is higher, also these strategic benefits are higher for both the parties. Indeed, the closer startups are aligned with our business and technology goals, the better opportunity the corporations have to help them be successful.

Opposite results are highlighted by Bertoni and colleagues (2007), who investigated the relationship between venture capital financing and the growth of new technology-based companies. The authors pointed out that, even though both venture capital and corporate venture capital positively affect ventures growth, the benefits of the former considerably exceed those of the latter. Indeed, venture capital firms provide additional services to portfolio companies in fields such as strategic planning, marketing, finance and accounting, and human resources, in which these companies typically lack internal competencies (Hellmann and Puri, 2002; Bottazzi et al., 2004). Furthermore, venture capital financing acts as a signal for the good quality of the investee companies to third parties (Megginson and Weiss, 1991). Conversely, the authors suggested that corporate investors tend to have a minor impact on their portfolio companies due to potential divergences in their objectives and high conflicts of interest.

Anand and Galetovic (2000) used the difference between a venture capitalist or a corporation to analyze how a new venture searching for financing chooses its potential investor. In particular, the focus is on the link between the strength of property rights and the choice between these two types of financiers. The authors showed that when property rights are strong, the venture is funded by the venture capitalist, however

when property rights are weak, the venture may be financed by the corporation, or the venture capitalist, or remains unfunded. Indeed, strong property rights, on one hand, reduce the value of the venture's outside option and increase the corporation's motivation to finance, but, on the other hand, they make the venture vulnerable to potential holdups by the corporation. Similarly, Dushnitsky (2004) studying the conditions under which entrepreneurs choose to obtain financial resources from a corporate or an independent venture capitalists, found that the probability of an investment relationship between a corporate investor and an entrepreneur decreases when the corporate investor is likely to copy the entrepreneurial innovation due to potential substitutive effects between the products of the two.

Summary and gap in the literature

Venture capital investments are characterized by high uncertainty about the outcome of the investment, adverse selection, moral hazard, and hold-up problems associated with post-contractual renegotiation of the agreement (e.g., Sahlman, 1990). Although the existence of these characteristics common to both independent and corporate venture capital, previous studies moved beyond the tendency to consider these investors as all alike. In particular, they investigated potential differences in their organizational structure, ability to provide value to the portfolio companies or overall performance of the funds.

Nevertheless, several issues warrant additional investigation. We know little about the way in which corporate venture capitalists choose a specific investment target. To my knowledge, extant studies on venture capital have only tried to highlight the most important features considered by financial investors in the selection of new

ventures (Tyebjee and Bruno, 1984; Muzyka et al., 1996). Among the evaluation criteria identified - financial aspects, market attractiveness, competitive impact and team features - technological characteristics play a relevant role. However, subsequent works did not broaden this topic by highlighting whether investors are effectively able to evaluate technologies or extending this topic to corporate investors with the aim to assess potential differences with traditional venture capital firms.

To fill this gap, I start from two related evidences suggesting the importance to focus on innovative technologies. First, the economic literature points to a superior ability of venture capitalists in accurately assessing the value of early-stage companies' technological capabilities and patent portfolios. Second, corporate investors are particularly focused on the search of valuable technologies developed by external entrepreneurs. For the perspective of the traditional venture capitalist, patents represent a signal of the ability of the company to generate and protect their innovations with high economic value. A correct evaluation of the technology developed by the entrepreneurial ventures is, indeed, important to reduce the failure rates of the new ventures which in turns impact on the performance of the venture capital fund. On the other hand, technology-based capabilities are also critical for corporations engaged in equity-based investments due to the possibility to exploit external knowledge for their strategic purposes and open a window on novel technologies (Siegel et al., 1988; Chesbrough, 2002; Dushnitsky and Lenox, 2006). This is confirmed by the list of criteria used by Microsoft to identify startups that would make good candidates for the program.

> "*[Our team] evaluates hundreds of technology startups each year to identify those with the strongest potential to succeed in the market, shape the industry's future and enhance the overall value of Microsoft products and services for customers. We*

look at a number of criteria, such as marketability, growth potential, funding, management and management history, platform decisions, and strategic importance to Microsoft. We identify those companies that are aligned with technology areas that Microsoft is focused on, and where we can best develop the relationship" (Interview with the corporate vice president of Microsoft's Strategic and Emerging Business Development).

Thus, a deep understanding of how venture capital firms evaluate start-ups' patent portfolios in their financing decisions and whether traditional and corporate venture capital investors differ in their technological evaluation ability are important issues to investigate.

1.3 Outline of the Dissertation

This Dissertation is realized as a collection of papers which covers the three research questions previously presented. The papers are included in three different chapters (Chapters 2-4). In the last chapter, I discuss the conclusions.

In the following section, I present a brief description of the three research essays which represent the core of this doctoral thesis. The first is a theoretical work, the second and the third ones are empirical papers. For each paper, I report the title (with the co-author), the conferences where it has been presented and an extended abstract which summarizes the key aspects characterizing each study: research question, theoretical framework, sample (for empirical works), results, contributions to the extant literature and main managerial implications.

1.3.1 Chapter 2 – An integration of the resource based view and real options theory for investments in outside opportunities[1]

There is a growing trend by established firms to use a multitude of external corporate venturing mechanisms such as alliances, partnerships, joint ventures, acquisitions, licensing agreements and investments in corporate venture capital to acquire external innovations. However, the traditional interpretation of external corporate venturing is one of a pool of mechanisms with the common aim to obtain knowledge-based and technology-based advantages. As a consequence, the previous literature has often analyzed these forms of exploration separately without searching for possible tradeoffs between them, or thinking about possible peculiarities (Kogut 1991; Ahuja and Katila 2001; Vassolo et al. 2004; Kulatilaka and Lin 2006). However, these mechanisms differ along several dimensions. In this context, we are interested in shedding new light on the following unexplored issue: how do corporations choose among different forms of collaboration?

In this paper, we develop a framework that integrates the resource-based view of the firm with real options theory and draws on insights derived from interviews with managers to address this issue. We suggest that firms choose those external corporate venturing mechanisms that are best aligned with characteristics of the target company. The resource-based view suggests that the level of relatedness between the corporation and the target venture is an important determinant for governance mode choices. However, this is only part of the story. we combine this first dimension with the level of uncertainty surrounding the target company, as suggested by real option theory. Overlaying these two features, we propose a set of propositions and a new framework

[1] This paper is co-authored with Nalin Kulatilaka and it has been accepted at the 2009 Academy of Management Annual Conference (Entrepreneurship Division), Chicago, August 7-11.

for external corporate venturing to help firms in the choice of their corporate development trajectories by determining when and how a collaborative mode is more appropriate than another, as instrument of strategic growth. Through real option theory, we also provide a second contribution to the previous literature by analyzing the evolution of external corporate venturing modes over time. To address this issue, we refer to the different levels of flexibility and reversibility characterizing different forms of collaboration to figure out possible transitional paths of governance modes.

This paper has important managerial implications especially regarding the organizational design of the firm which is better able to identify, manage and exploit external opportunities. Indeed, large corporations tend to lack the flexibility to react easily and transform quickly a new idea into a successful product that provides a corporation with new growth and financial returns. To fill this gap, firms have to build a nimble infrastructure that allows to respond to opportunities with speed and flexibility. The creation of different organizational units inside the same firm dedicated to the search of particular new opportunities is the starting point of the renewal.

1.3.2 Chapter 3 – The search of complementarity in explorative strategies: The relationship between corporate venture capital investments and corporate diversification[2]

The evidence that firms have to face increasing competition in their markets led researchers to investigate how corporations can grow improving their set of competencies.

[2] This paper is co-authored with Federico Munari and it has been accepted at the 2009 Academy of Management Annual Conference (Technology Innovation Management Division), Chicago, August 7-11. This paper has been also accepted at the 2009 EGOS Colloquium, Barcelona, July 2-4.

In this sense, the previous literature on strategic management has historically analyzed the role played by internal investments as the main source of new knowledge. However, scholars increasingly recognized that also considering the inputs which reside outside the firm's boundaries can be a powerful tool to achieve innovative inputs (Keil 2000; Schildt et al. 2005; Ahuja and Katila, 2001; Kogut 1991). In such a context, corporations tend to simultaneously use both internal and external resources as explorative mechanisms to create competitive advantage and acquire new knowledge. However, previous studies analyzed separately how firms leverage on innovative sources within or outside their organizations.

The goal of this work is to merge the above-mentioned two streams of literature to shed new light on the relationship between corporate diversification and corporate venture capital as two modes of investment based on internal and external resources respectively. To achieve this purpose, we apply the exploration lens (March, 1991) to determine whether and when corporate venture capital investments complement or substitute a more traditional explorative search pursued through the diversification of internal activities. We test the presence of complementarity under both a market and technology perspective. Furthermore, we also examine whether the distinction between high- versus low-tech sectors in relation to the main industry in which corporate investors operate impacts on the strategic use of such corporate venture capital investments.

This works uses data on 221 corporate venture capital funds created by 186 U.S. public firms during the period 1996–2006. To construct our sample, we have used three sources. From *VentureXpert* we have identified the CVC funds created in U.S. over the period of analysis, gathering information about the fund size, vintage year, sponsoring firm, stage focus, geographical location and number of portfolio companies. Then, we

have matched this sample to *Worldscope* to gather financial data. Finally, we have referred to the *NBER database* and *Delphion* to obtain technological information.

Results from regression analyses predict the existence of a substitutive relationship between corporate diversification and corporate venture capital investments, if the focus is to explore new markets. Conversely, when the aim is to seek out new technologies, results suggest a complementary relationship between these two strategies. Indeed, "*[w]ith their own R&D activities alone, even large firms cannot actively pursue or even notice all technological developments, which may influence their business or offer new attractive opportunities*" (Ernst et al., 2005: 235). we also find that the core industry in which corporations operate moderates the abovementioned relationships: in high-tech industries, the complementary effect between corporate technological diversification and corporate venture capital is stronger, while the substitutive effect in terms of market exploration becomes weaker.

This paper provides two main contributions to the existing literature on exploration. First, we conceptualize corporate venture capital investments as a tool available by firms to pursue explorative search. Second, we move beyond the simple assumption that corporations search for new opportunities through an explorative search - not more specifically defined - (March, 1991), by showing how different ways to explore are related to each others. In particular, I do not focus on a single explorative domain located either inside or outside organizational boundaries, but we consider possible interactions between these different search processes.

1.3.3 Chapter 4 – How good are VCs at valuing technology? An analysis of patenting and venture capital investments in nanotechnology[3]

The critical role played by technology in the field of entrepreneurship financing is straightforward. The financial literature claims that (a) venture capital financing spurs the growth of new technology-based firms (Sahlman, 1990; Gompers and Lerner, 1998), (b) technological features are one of the most important driver considered by investors to finance a new venture (MacMillan et al., 1985; Tyebjee and Bruno, 1984; Muzyka et al., 1996) and (c) patents have private value to new ventures by helping them to attract venture capital financing (Kortum and Lerner, 2000; Baum and Silverman, 2004; Mann and Sager, 2007). Furthermore, corporate investors pay particular attention to the technological knowledge of external ventures due to their strategic aim of developing backup technologies or explore new technological domains to expand their current set of competencies (Dushnitsky and Lenox, 2005; Chesbrough 2000). As suggested by Ernst et al. (2005: 234) "*the realisation of external innovation is the most important strategic goal of corporate venturing activities.*".

Starting from these initial considerations, the general aim of this paper is to analyze how traditional and corporate venture capital firms evaluate the patent portfolios of start-up companies in their financing decisions and if there are differences in their evaluating capabilities.

This work contributes to the extant literature on venture capital and innovation firstly by analyzing the determinants of patent value that are more directly taken into consideration by venture capital firms in their screening process. More precisely, this paper contributes to the previous literature investigating the relationship between

[3] This paper is co-authored with Federico Munari and it has been presented at the 2008 Academy of Management Annual Conference (Technology Innovation Management Division), Anaheim, August 8-13, where it received the Best Paper Finalist Award for the Technology Innovation Management Division.

patenting and venture capital investments by assessing whether and how venture capital firms take into consideration also the start-up's *patent content* in addition to the simple patent count and patent scope. To address this issue, we introduce the concept of *core technology patent* to distinguish between patents protecting the core technological capabilities of the company (Prahalad and Hamel 1990; Granstrand et al., 1997) and those belonging to other technological domains not directly related to the main technological capabilities of the company. The second contribution of this study is to recognize that venture capital firms are not all alike. Thus, we examine whether the evaluation of patent portfolios varies across venture capital firms, depending on their degree of industry specialization and affiliation. we propose that the investor's ability to assess the patent portfolios of the investee company should be better-off if the venture capitalist is specialized in the same industry of the investee company and if the venture capital is affiliated to a corporation.

We test these hypotheses on a sample of 332 venture capital-backed companies in the nanotechnology sector in the period 1985-2006. We have firstly created the sample of companies operating in nanotechnology and financed by VC funds through *VentureXpert* to gather information about their investors and related affiliation, founding year, year of the first and subsequent stages of investment, amount raised in each round, country and industries. Then, we have integrated these data with all the patent applications at the European Patent Office made by the investee companies to construct their technological portfolios.

Our results confirm that the distinction between patents in terms of fit with specific types of technological capability matters. Indeed, the simple number of patents applied by the company, or the patent scope have not impact on the investment decisions. The company's stock of patents belonging to its core technological

competencies has, instead, a positive impact on the amount of venture capital financing received. This finding suggests that venture capital firms are sophisticated investors which deeply evaluate the nature of the inventions protected by patents, in terms of relatedness with the core technological activities of the start-up.

Moreover, our results also suggest that venture capital firms specialized in the same field of the investee company take more into consideration core technology patents in their financing decisions in respect to generalist venture capitalists. Thus, also specialization matters. Venture capitalists having a strong focus in an industry accumulate a specific knowledge which allows a more accurate evaluation of those patents highly related to a particular domain. Finally, our results only partially support the existence of differences between corporate and independent venture capitalists. A possible explanation sustaining this finding is that corporate investors are able to exploit evaluation advantages only if they have previously developed a strong set of absorptive capacity which enables them to appropriately identify and transfer knowledge from the investee companies (Dushnitsky and Lenox, 2005a).

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CHAPTER 2 - AN INTEGRATION OF THE RESOURCE BASED VIEW AND REAL OPTIONS THEORY FOR INVESTMENTS IN OUTSIDE OPPORTUNITIES[4]

ABSTRACT

There is a growing trend by established firms to use a multitude of External Corporate Venturing (ECV) mechanisms (alliances, partnerships, joint ventures, acquisitions, licensing agreements and investments in corporate venture capital) to acquire external innovations. In this paper, we develop a framework within which firms choose ECV mechanisms that are best aligned with characteristics of the target company. More precisely, we investigate the effect of relatedness and uncertainty on governance mode choices by combining the Resource-based View of the firm and Real Options Theory. We propose a bi-dimensional matrix to show under which conditions of relatedness and uncertainty corporations choose among corporate venture capital, strategic alliance, joint venture and acquisition. Finally, we present a dynamic perspective to assess how these different forms of ECV transit over time, once part of uncertainty is resolved and a certain level of familiarity with the new knowledge is achieved.

Key-words:

External Corporate Venturing, Strategic Real Options, Resource-based View

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2.1 Introduction

Researchers have long understood the importance of investments in internal R&D as source of knowledge and innovation (Childs and Triantis, 1999; McGrath and Nerkar 2004, Oriani and Sobrero 2008). However, these investments provide only a partial contribution to a firm's growth and profitability leading to a "closed innovation system" in which research projects are launched exclusively from the technology base of the firm (Chesbrough, 2003). In a world with strong mobility of highly experienced and skilled people, fast time to market and high levels of uncertainty, however, considering resources that reside outside the firm's boundaries is a vital way to achieve competitive advantages and spawn innovation. Chesbrough (2003: xxiv) pointed out that to shift from a closed to an "open innovation system" "*[…] firms can and should use external ideas as well as internal ideas, and internal and external paths to market, as the firms look to advance their technology.*". This is confirmed by Peter Drucker (2008, p. 799) who suggested that "*[t]he search for innovation needs to be outside of the ongoing managerial business*".

Firms generally resort to a wide range of mechanisms to rejuvenate their business models by exploiting external resources. These ex*ternal corporate venturing* (ECV) mechanisms include alliances, joint ventures, acquisitions, licensing agreements, collaborations with universities and investments in corporate venture capital (Roberts and Berry 1985; Arora and Gambardella, 1990). In presence of this broad variety of governance modes, it is critical for corporations figure out *which ECV mechanism they should choose*.

We propose a framework based on two theoretical perspectives - the Resource Based View (RBV) and Real Options Theory (ROT) - to address this issue. We

complement such perspectives with insights from interviews with some of the bigger corporations engaged in external venturing activities. More precisely, we suggest that the decision making process needs to refer to two attributes characterizing the target company of the collaboration: the level of relatedness with the partner (as suggested by the RBV) and the level of uncertainty surrounding its activities (as suggested by ROT). Overlaying these two dimensions, we formalize a set of propositions and we propose a new representation of ECV to help firms in the choice of their corporate development trajectories by evaluating potential investments and determining when and how a form of external corporate venturing is more appropriate than another, as instrument of strategic growth. Our integrated framework helps explain why certain types of collaboration proliferate under high levels of relatedness and uncertainty, why other types better persist with low relatedness and uncertainty, and why still others make more sense with a combination of low relatedness and high uncertainty, or vice versa.

Finally, we describe the evolution of ECV mechanisms over time. Adopting a dynamic perspective based on real options, corporations can figure out how actively manage their collaborations by changing the design of the initial governance modes in response to changes in the intensity of relatedness and uncertainty characterizing the potential target company. We, thus, help firms answering a second dilemma: *Once an ECV mode is established, should the firm upgrade the relationship into a different mode of collaboration? And if so, how?*

This paper sheds new insights contributing to the previous literature on strategic management in several ways. Previous research discussing governance mode choice was limited for two main reasons. First, most studies focused on a single governance mode (Gulati and Singh, 1998; Folta and Miller, 2002; Kogut, 1991; Hellmann, 2002; Chesbrough, 2002; Dushnitsky and Lenox, 2005a, 2005b and 2006), or on the choice

between two or three different governance modes: acquisition and alliances (Folta, 1998; Vanhaverbeke et al., 2002; Dyer et al., 2004), equity and non-equity alliances (Pisano, 1989; Oxley, 1997), make or buy (Monteverde and Teece, 1982), joint ventures and acquisitions (Folta, 1998), corporate venture capital, strategic alliances and acquisition (van de Vrande et al., 2006). Second, prior research generally examined ECV choices within one theoretical perspective. Kogut (1991), Folta and Leiblein (1994) and Folta (1998) applied the real options perspective; Walker and Weber (1984), Williamson (1991), Gulati and Singh (1998) and Vanhaverbeke et al. (2002) referred to the transaction cost economics; Kogut and Zander (1992) and Zollo et al. (2002) chose the resource-based view.

We fill these two gaps by connecting ROT to the RBV in order to investigate how firms choose among four different types of collaborations - corporate venture capital, strategic alliance, joint venture and acquisition. This multi-theoretical framework provides a richer description of decision making and allows to improve our understanding of when and how firms create competitive advantages through investments in external sources. This addresses the need posed by Reuer and Tong (2007) "*to better articulate real options theory's link to other theories in the field [of strategic management] and to specify the theory's appropriate boundaries.*". In particular, ROT contributes to other theories in two ways: first, it deeply analyzes the impact of uncertainty on investments decisions and, second, it introduces a dynamic perspective by highlighting the sequential nature of external corporate development activities. Thus, a real option theory of governance modes can complement existing theories because ECV mechanisms face uncertainty in different ways, leading firms to use them discriminately to structure their investments. ROT has the potential to depict firms' corporate development trajectories and explain the heterogeneous investment

behaviors of firms when characterized by similar set of resources, but facing different levels of external uncertainty (Tong and Reuer, 2004).

The importance to address the issue on governance mode choices is also driven by the evidence that firms tend to manage external investments through separate units aimed to manage alliances, venture capital investments, joint ventures, licensing agreements and acquisitions. This consideration highlights the need to help firms in deciding which organizational unit is more suitable in order to identify, manage and exploit the collaboration with a potential partner. An "optimal" organizational separation which reflects managers' view of ECV modes as distinct activities is, thus, critical to achieve. In this sense, our paper has important managerial implications about how to build a nimble infrastructure that allows to respond to opportunities with speed and flexibility. The creation of different organizational units to handle different types of opportunities, combined with the development of an efficient communicative systems in order to sustain interactions among them, is a prerequisite to create and manage external opportunities and succeed in uncertain environments.

The rest of the paper is structured as follows. Section 2.2 provides a definition of ECV to circumscribe the context of our analysis. It also reviews the previous literature on ECV based on the RBV to highlight the major contributes and gaps. In particular, we focus on the role of relatedness in governance mode choices. Session 2.3 introduces ROT by examining the role played by uncertainty. This session allows us to characterize ECV modes depending on the level of flexibility and reversibility, characteristics that corporations should consider in their investment decisions, especially when the level of uncertainty is high. Section 2.4 describes a new taxonomy for ECV mechanisms by linking together the RBV and ROT. Section 2.5 depicts an investment in external sources as a multi-stage process based on the creation and management of real options. This

session allows us to highlight the second contributions provided by real option theory, that is the possibility to dynamically analyze the evolution of collaborative modes over time. The last section offers some conclusive observations.

2.2 Theoretical background on external corporate venturing

2.2.1 A definition of external corporate venturing

The interest on corporate venturing (CV) is based on the need of large firms to renovate themselves through the creation of new opportunities and capabilities instead of focusing on the exploitation of their current competencies (Narayanan et al., 2008). The general definition of CV available in the literature is based on the classification which distinguishes between internal and external venturing (Sharma and Chrisman, 1999). Following this criterion, firms can be split between those nurturing opportunities that are already in house (internal venturing) and those financing autonomous organizational entities that reside outside the existing boundaries of the corporation (external venturing). More precisely, Sharma and Chrisman (1999) defined internal venturing as "*corporate venturing activities that result in the creation of organizational entities that reside within an organizational domain*", while external corporate was defined as "*corporate venturing activities that result in the creation of semi-autonomous or autonomous organizational entities that reside outside the existing organizational domain*".

In this paper, we focus on *external corporate venturing* (ECV). We stylize the definition of EVC process as follows. A corporation decides to commit (human and financial) resources in a non-specified mechanism of EVC to obtain value from a target

company and sustain its corporate financial and strategic goals. The corporation represents the active player which settles on the investment, the target company is the opportunity identified by the corporation and the ECV mechanism is the intermediary[5].

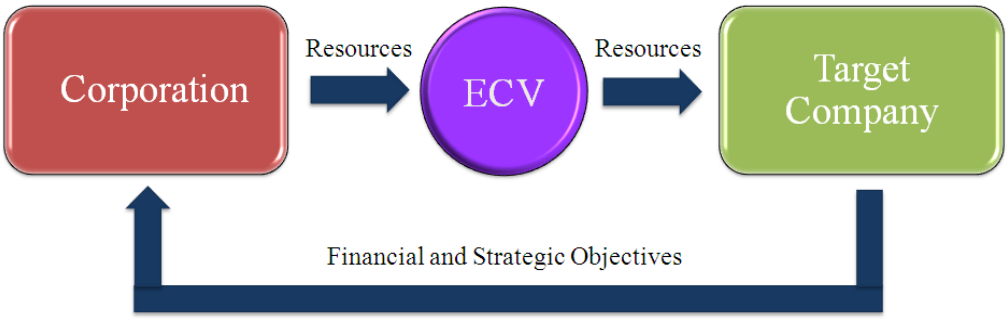

Figure 2.1 Typical structure of external corporate venturing.

Three theoretical approaches have been generally applied to the study of collaborative modes – transaction cost economics, resource-based view and real options theory. Based on these frameworks, Leiblein (2003) identified two main streams of research involving the study of various organizational governance forms. The first investigates the conditions that favor the use of one ECV mechanism in respect to others (i.e. Walker and Weber, 1984; Oxley, 1997); the second describes the relationship between governance mode and performance .e. McGahan and Villalonga, 2003). The former line of research generally follows transaction cost economic theory and argues that the optimal form of organization is primarily driven by efficiency considerations (i.e. Williamson, 1975 and 1985). On the other hand, the prior literature on the performance implications of different types of investment has commonly relied on resource-based reasoning (i.e. Wernerfelt, 1984; Barney, 1986) by identifying those

[5] Note that these forms of collaboration generally create advantage for both the corporate and the target firms. However, in this paper we direct our attention only to the benefits created for the corporation.

resources that are more likely to provide competitive advantage. Finally, real option theory has tried to relate the choice of organizational governance forms to overall firm's performance (i.e. Bowman and Hurry, 1993; Kogut, 1991). However, as Leiblein (2003: 938) pointed out "*little effort has been put forth to link insights from Real Option analysis with insights from transaction cost economics (TCE) or the resource-based view (RBV)*". In this paper we contribute to this stream of research by investigating the link between the RBV and ROT. More precisely, as the choice of organizational governance forms impacts on the corporation's ability to create and appropriate the value embedded in the target company (Leiblein, 2003), we examine the motives and conditions for initiating one form of collaboration rather than another.

We proceed in two steps. First, we analyze the RBV and ROT separately to identify which key-features such perspectives suggest to consider when corporations move toward outside opportunities. From the review on ECV based on the RBV, we identified the *level of relatedness* between the corporation and the target company as key-factor, while from ROT the *degree of uncertainty* surrounding the target company seems playing the most critical role. Second, we point out that only by assessing the heterogeneous nature of potential target companies along these two dimensions simultaneously, corporations can identify the ECV mechanism which better fits with the management of that kind of company.

2.2.2 The role of relatedness in inter-organizational relationships according to the resource-based view

Previous research based on the RBV suggests that inter-organizational relationships offer a significant source of learning as, through collaborations, firms can combine distinct pieces of knowledge by drawing on the resource base of their partners. Thus, the

RBV depicts external corporate venturing activities as a means to acquire resources to maintain competitive advantage in a dynamic market. In this context, the concept of *relatedness* (or *overlap*) defined as the extent to which two entities are similar is critical. This dimension concerns the degree to which the entrepreneurial activities require capabilities and skills that are different from the core capabilities and skills of the corporation (Burgelman, 1984). Generally speaking, when the level of relatedness is low, the level of dissimilarities between the corporation and the target company is high.

This feature which characterizes the relationship between two entities has broadly been used to address two different issues. The first refers to the analysis of whether and how different levels of relatedness between the focal firm (i.e. the corporation) and its external partner (i.e. the target company) affect a certain dependent variable such as innovativeness, learning, or financial performance (Ahuja and Katila, 2001; Sapienza et al., 2004; Keil et al., 2008). These studies suggested an inverted U-shaped relationship between the level of relatedness and the subsequent growth of the focal firm. Indeed, when the knowledge bases of the firms partially overlap to each other there are more possibilities of learning. Thus, both too small and too great an overlap will inhibit growth. The former because limited knowledge overlap limits knowledge assimilation and the latter because great knowledge overlap hampers the creation of new knowledge combinations (Sapienza et al., 2004). The underlying idea is that common skills and shared languages enable partners to efficiently communicate enhancing learning. On the other hand, a knowledge base that is too similar to the focal firm's knowledge base may contribute little to subsequent learning.

The second line of research investigates how firms, given a specific level of relatedness, can capture value from their collaborations. In other words, this stream of research answered the questions about how different levels of relatedness impact on the

firm's choice among several governance modes (Roberts and Berry, 1985; Folta, 1998; Villalonga and McGahn, 2005; Schildt et al., 2005). Roberts and Berry (1985) proposed that when firms decide to entry new and unfamiliar markets or technologies, they should prefer organizational modes with a low level of corporate involvement. Folta (1998), investigating the motives for initiating equity-based collaborations versus acquisitions suggested that partners whose primary business operations are dissimilar should prefer equity collaborations over acquisitions because the former allow firms to learn by exploring multiple opportunities for the cost of a single acquisition. Vanhaverbeke et al. (2002) suggested that a firm has the propensity to acquire the other company if it has similar technological competencies or when it is a member of the same industry. On the other hand, when the partner has completely new technologies to offer, strategic alliances are a more appropriate way to cooperate. Indeed, it is more difficult to assess the value of assets of companies operating in unknown sectors, than in one's own industry (Balakrishnan and Koza, 1993). Also, Villalonga and McGahan (2005), investigating the determinants of the choice among alliances, acquisitions, and divestitures, found that when the level of relatedness between the focal firm and its partner is high, acquisitions are preferred to alliances, and alliances are preferred to divestitures for two reasons. First, greater relatedness implies a lower cost of integration. Second, when the partners' knowledge bases are similar, the level of direct competition between the focal and the target firms becomes greater, thus, enhancing the need for protective (i.e. integrative) governance structures. Schildt et al. (2005), analyzing several forms of collaborations under the dichotomy between explorative and exploitative learning, found that highly integrated forms of collaborations are more likely to lead to exploitative (versus explorative) learning where the knowledge base among the partners is similar. This result derives from a two-step reasoning. First,

starting from the idea that governance modes differ in the degree to which they support explorative and exploitative learning, the authors argue that such differences exist for two reasons: (i) ECV modes differently support transfer of knowledge, and (ii) ECV modes have different costs and time to manage the ventures. These two factors are embedded in the concept of integration between the partners. More precisely, close integration is considered an important requisite for exploitative learning. Second, the level to which external ventures are related to the focal firm determines which type of learning is mainly sustained. The authors suggested a negative relationship between relatedness and explorative learning. The more closely related two firms are, the more similar firms should be and such a similarity should allow two firms to exchange knowledge more easily. Accordingly, van de Vrande et al. (2006) suggested that when the level of technological distance between the partner firms is high, corporations are more likely to use less integrated governance modes in order to increase potential learning effects deriving from the collaboration.

Although these studies contribute to our understanding of ECV, they analyze the effect of relatedness on the choice among governance modes separately from other determinants. The natural outcome is a positioning of different ECV modes along a continuum in which a specific variable (i.e. relatedness or explorative learning) assumes several values. In this sense, the typical hypothesis formulated by such studies sounds as follows: "High levels of the determinant x is associated with the choice of mode 1 over mode 2, and mode 2 over mode 3". For instance, Villalonga and McGahn (2005: 1188) predicted that "*The relatedness between the focal firm and the target (or partner) firm is associated with the choice of acquisitions over alliances, and alliances over divestitures.*". Similarly, van de Vrande et al. (2006: 357) proposed that "*Under conditions of high technological distance between the investing firm and its partner, companies are more*

likely to choose corporate VC over strategic alliances, and strategic alliances over acquisitions". Thus, the previous literature misses to deeply investigate the optimal form of collaboration when multiple determinants are considered simultaneously creating an orthogonal representation. In this paper, we advance that the level of relatedness is not sufficient. We integrate the effect of relatedness with that of uncertainty to figure out which combinations of the two dimensions makes more likely the choice of one ECV mechanism in respect to the others. Indeed, we suggest that each ECV mode can be described in terms of *flexibility* which allows corporations to efficiently manage the collaboration when some conditions of relatedness and uncertainty are satisfied. In the following, we introduce the role played by uncertainty and flexibility for the context of external venturing and, then, we proceed with an integration of the two dimensions into a comprehensive framework.

2.3 External corporate venturing under real option lens: The role of uncertainty and flexibility

Real options theory provides a useful framework for analyzing investments whose structure are similar to financial options. The key concept is the commitment of an upfront payment that provides the opportunity, but not the obligation, to take possession of an asset at a later time. In the context of ECV, the initial investment represents the payment required to purchase the option, while the later decision to increase the commitment of resources, transfer knowledge, enter new markets, develop new technologies (at additional costs) are examples of exercise of the option. One of the most important contribution of ROT is to provide corporations with a different manner to consider the uncertainty surrounding the underlying asset (i.e. the target company).

In contrast to traditional views (i.e. the RBV) suggesting that when uncertainty is high managerial discretion is limited, or that organizational inertia dominates, ROT asserts that firms can use and benefit from uncertainty by investing in options to respond to unstable futures and by managing the investments in a sequential manner once uncertainty is resolved (Kogut, 1991; Dixit and Pindyck, 1994; Kogut and Kulatilaka, 2001). Thus, ROT is appropriate for analyzing investment decisions that are characterized by uncertainty and managerial discretion (Dixit and Pindyck, 1994; Kogut and Kulatilaka, 2001; Huchzermeier and Loch, 2001).

Starting from these considerations, we suggest that the presence of uncertainty should be reflected in investment decisions, that is, in the choice among several ECV mechanisms. More precisely, we assert that ECV modes are differently able to manage uncertainty depending on the level of flexibility and reversibility they provide to corporations. *Flexibility* refers to the possibility to make critical decisions in the future when part of the uncertainty surrounding an investment is resolved. *Reversibility*, instead, can be defined as the extent to which corporations can easily exit from the investment or decrease the involvement in the collaboration if adverse conditions occur. In other words, investments are irreversible when they cannot be fully recovered without incurring some exit costs. High levels of flexibility and reversibility are also generally associated to low levels of *involvement* of the corporation in the collaboration and low levels of *integration* between partners (Burgelman, 1984; Roberts and Berry, 1985; Shildt et al., 2005). The former dimension refers to how many resources the corporation commits toward the collaboration, while the latter can be described as the extent to which the coupling of the operations between the corporate and the target company is strong. High levels of involvement and integration correspond to low levels of flexibility and reversibility and vice versa.

Previous research has pointed out the need for flexible governance modes in case of environmental turbulence. Lambe and Spekman (1997) argued that in presence of discontinuous technological changes the use of alliances is preferred to both acquisitions and traditional internal development. Indeed, the advent of a radical innovation is characterized by low levels of certainty about how the new technology will affect the industry. Because a technological discontinuity radically changes the industry in which it occurs, corporations need to refine the firm's core competencies. On one hand, the increased urgency to acquire new competencies leads corporations to evaluate the attractiveness of an external technology acquisition rather than internally develop such competencies. This allows to decrease the time to market for the development of new products. On the other hand, the increased level of uncertainty deriving from a technological discontinuity leads corporations to prefer alliances over acquisitions in order to limits costs and avoid acquiring superfluous technologies. Only when industry uncertainty decreases and technology and market requirements are relatively stable, this preference changes in favor of acquisitions. Steensma and Corley (2000), investigating the link between attributes of the technology to acquire through external collaborations with the performance outcomes of technology-sourcing partnerships, found that technological dynamism and commercial uncertainty increase the likelihood to create loosely coupled agreements. Indeed, in such environments the risk to be locked into a technology that may not be commercially valuable is high and, thus, corporations should prefer collaborations that create real options to defer higher levels of commitments and share the risk of failure. Licensing agreements, for example, allow firms to avoid huge investments and acquire the possibility to shift to a different technology if the first is not more valuable (Kogut, 1991). Also joint development provides firms with similar benefits. Acquisitions, instead, are positioned at the opposite

end of the spectrum as they represent the highest level of commitment (Roberts and Berry, 1985). In line with these findings, a study by van de Vrande and colleagues (2006) suggested that when a technology is relatively new and its commercial potential is unknown, firms tend to delay commitment by using flexible governance modes. As a result, corporate venture capital investments are chosen over strategic alliances, and strategic alliances are preferred to acquisitions.

The general explanation underlying these results is that committing prematurely resources to a new venture imposes considerable risks because the firm gives up the possibility to wait for new information that might affect the desirability and timing of the investment. In this sense, CVC investments represent the less involved and integrated form of collaboration as the corporation interacts with the investee company by creating a separate fund beyond its boundaries and supplying it with a certain stock of resources which is devoted to the investee companies in small amounts along a sequential process (Schildt et al., 2005). Thus, small participations in CVC investments are like taking an option on know-how of yet uncertain value to exercise if the scenario is profitable (Bowman and Hurry, 1993). This strategy gives the firm high flexibility and reversibility in the management of the decisional process because the corporation can decide step by step its involvement in the collaboration. Thus, high levels of uncertainty are easily managed over time through CVC and the corporation can exploit the benefits of downside risk reduction and upside potential enhancement (Bowman and Hurry, 1993; Kogut and Kulatilaka, 1994; Trigeorgis, 1996; McGrath, 1997; Amram and Kulatilaka, 1999).

Proceeding with this line of reasoning, non-equity (strategic) alliances can be considered less flexible and reversible than CVC. In strategic alliances, cooperation takes place directly with at least a business unit and committing a greater amount of resources

than in CVC, thus increasing the level of integration and involvement of the firms and decreasing the level of flexibility and reversibility in respect to CVC investments. On the other hand, strategic alliances can be described as more flexible and reversible than equity alliances or acquisitions (Folta, 1998). Strategic alliances are cooperative efforts in which separate organizations join forces to share reciprocal inputs, but maintaining their own corporate identities. Joint ventures, instead, occurring when two firms agree to create a new entity by both contributing equity and sharing revenues, expenses, and control of the new enterprise, are characterized by stronger integration and less flexibility under conditions of high uncertainty than the previous two ECV modes. Finally, acquisitions have the strongest level of integration and involvement as they result in the creation of an organizational hierarchy where the corporate firm obtains the majority ownership of the target company. In this case, the corporation commits a vast amount of resources in an unique step and cannot decide to dismiss the investment if it is not more profitable, except that by occurring in high exit costs. Through acquisitions, firms give up high levels of flexibility in place of obtaining the direct control of the target company.

Summarizing, the ability to delay an irreversible investment expenditure is an important source of flexibility and affects the decision about how to invest in a new venture. High uncertainty incentives to postpone huge investments (McDonald and Siegel, 1986) by adopting flexible collaborative modes, while the resolution of uncertainty motivates commitment decisions (Folta and Miller, 2002) through ECV modes that require more involvement.

2.4 Combining resource-based and real options perspectives to analyze external corporate venturing

In the previous sessions we pointed out how corporations invest in external opportunities under specific levels of relatedness or uncertainty. Now, we combine the two dimensions to figure out how corporations invest in external ventures when they are characterized by the same level of relatedness with the target company, but face different levels of exogenous uncertainty, or when in front of the same level of uncertainty they are differently related to the target company.

To this purpose, we refer to the following definitions. *Relatedness* determines the extent to which the target's knowledge in businesses and technologies are "proximate" to those of the corporation. High relatedness implies common skills, shared languages, and similar cognitive structures which enable partners to communicate and make marginal improvements and refinements of their current knowledge base (Lane and Lubatkin, 1998, Ahuja and Katila, 2001; Sapienza et al., 2004) and enhance the firms' ability to evaluate effectively the value of external knowledge and assimilate it within their organizations (Sapienza et al., 2004). Knowledge relatedness is multi-dimensional. Areas of knowledge relatedness include production, technology or marketing (Sorrentino and Williams, 1995; Tanriverdi and Venkatraman, 2005). Put simply, two firms are related if they compete in the same product/market, or if they operate in the same technological fields, or if they serve the same costumers (Cassiman et al., 2005). In this paper, the focus is mainly on the technological side because ECV modes have been often associated to the development of innovations (Ahuja, 2000; Stuart, 2000; Ahuja and Katila, 2001; Dushnitsky and Lenox, 2005b).

Generally speaking, *uncertainty*, instead, is an exogenous variable which is beyond the firm's control and, in particular, refers to the volatility of the expected returns from an investment. This volatility can be ascribed to different sources of uncertainty. (i.e. market and technological uncertainty), As suggested by Oriani and Sobrero (2008: 344) "*[m]arket uncertainty is related to the variability of the expected level of demand for a firm's products. It depends on exogenous factors, such as the economic cycle, the evolution of customer preferences, demographic changes, institutional factors […]. Technological uncertainty exists when it is not clear which technology will emerge to dominate in the industry […]. The established technology, in fact, often competes with one or more alternative technologies. Under these conditions, firms must select which technology to embed in their products and processes to fulfill future market requirements […]*". Although uncertainty may come in many forms, for the purpose of this paper we choose to focus on one form that is particularly relevant within this research setting, that is, uncertainty on technology sourcing decisions.

When looking at ECV as a business development tool, different approaches can be identified. More precisely, various combinations of relatedness and uncertainty produce different design alternatives. The matrix presented in Figure 2.2 shows four different design alternatives to choose depending on the characteristics of the target company. The vertical axis represents the level of relatedness (high or low) between the corporation and the target company, while the horizontal axis indicates if the degree of uncertainty surrounding the target company is low or high. From the intersection of these dimensions, a specific ECV mechanism is identified.

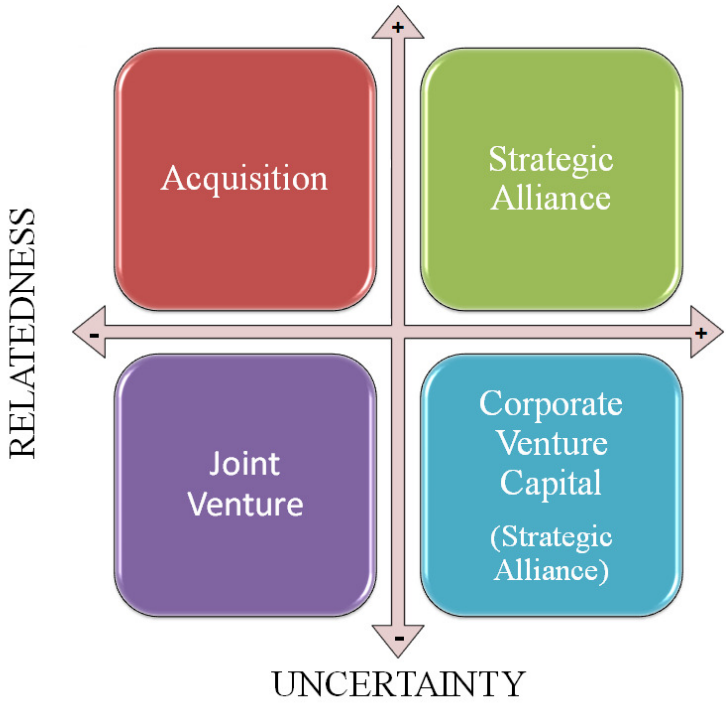

Figure 2.2 A taxonomy for external corporate venturing mechanisms.

The broad literature investigating the conditions under which corporations choose strategic alliances over acquisitions pointed out two important contributions. First, when firms face high uncertainty in their environments tend to prefer less integrated organizations with external parties and more flexible forms of collaborations such as strategic alliances (Harrigan, 1985; Ciborra, 1991; Hagedoorn and Duysters, 2002). Ciborra (1991) suggested that environments that require a large degree of learning and flexibility will see a prevalence of alliances, whereas acquisitions can be expected to be more popular when learning and flexibility is less important. Indeed, under conditions of rapid changes, learning, organizational change and quick strategic response ask for flexible forms of collaboration because new knowledge expires quickly and timely learning from partners appears more appropriate than control through formal, integrated and hierarchical organizations (Hagedoorn, 1993; Folta, 1998). Thus, this stream of research highlights that uncertain environments are characterized by

higher level of learning than stable environments which, instead, are more focused on the immediate exploitation of synergies between corporate and external innovative capabilities.

Second, Hagedoorn and Duysters (2002) also suggested that if firms decide to collaborate with external companies in order to search for capabilities that are related to their core businesses, an acquisition generates the necessary control and power in the decision making process. High levels of integration and control are particularly important when the target company is close to the core business of the corporation in order to allow corporations to directly manage and immediately exploit the benefits deriving from positive synergies and shared resources, competencies and knowledge (Hagedoorn and Duysters, 2002; Vanhaverbeke et al., 2002). Indeed, a crucial advantage of acquisitions is the speed of entry into markets and technological fields. Thus, when the strategic importance of the target company for the corporation is high and has to be immediately exploited, corporations refer to ECV mechanisms providing them with high degrees of control to maintain over the new business development (Burgelman, 1984; Belderbos, 2003).

Joining together these considerations, we suggest that acquisitions are more favorable in low-uncertain environments, where flexibility is not strongly required, and where the level of relatedness is high to easily integrate external know how within the corporation and exploit economies of scale and scope (Hoffmann and Schaper-Rinkel, 2001). This corresponds to the upper left side of our matrix.

Proposition 1: When the level of relatedness between the corporation and the target company is high and the level of uncertainty surrounding the target company is

low, corporations are more likely to choose acquisitions as mechanism of external corporate venturing.

When the level of uncertainty is high, acquisitions are not more suitable as they lack that level of flexibility needed in dynamic contexts. Under these situations, CVC investments or strategic alliances are more appropriate. Indeed, in respect to acquisitions, these ECV modes are characterized by lower levels of control and initial commitment and greater degrees of reversibility and flexibility which enable corporations to decide about the collaboration in a flexible way. In innovative and turbulent environments, governance mode enabling rapid adjustment to changing conditions in subsequent steps is critical (Kogut and Kulatilaka, 1993).

Furthermore, strategic alliances and corporate venture capital are generally deployed to open a window on a new technology or an emerging market where the corporation does not possess the required set of capabilities to compete. Learning, which implies the search for exploration and the absence of direct and immediate exploitative aims (Schildt et al., 2005), is the common feature to these goals. For definition, exploration implies low relatedness and needs flexibility because the corporation invests in something new, unfamiliar and uncertain (Roberts and Berry, 1985). As previously suggested, CVC investments and alliances are the forms of ECV which better fit with this description. Stuart (2000) asserted that when the focus of the collaboration is the search for learning, alliances and CVC can be defined as "*access* relationships" to distinguish them from "acquire relationships". Combining high uncertainty and learning, CVC and strategic alliances prevail in the bottom right side of the matrix.

However, although both strategic alliances and CVC investments have similar characteristics, strategic alliances are more appropriate under high levels of relatedness, while corporate venture capital is preferred to strategic alliances when the level of relatedness decreases. To explain these differences we need to refer to the nature of the relationship and organization characterizing such ECV modes. On one hand, several works highlighted that strategic alliances help firms access to partners' knowledge and resources (Ahuja, 2000; Stuart, 2000; Grant and Baden-Fuller, 2004) through a relation based on mutual dependence and resource commitments. Thus, the creation of a collaboration in which both partners strive toward shared goals and seek to appropriate financial gains and strategic benefits needs the definition of a common goal between partners to support the mutual transfer of knowledge (Kann, 2000; Dushnitsky and Lavie, 2008). This is more likely achievable if a some degree of relatedness and affinity between the partners' capabilities exist. The combination of high relatedness and high uncertainty is depicted in the upper right side of our matrix. Summarizing,

> *Proposition 2: When the level of relatedness between the corporation and the target company is high and the level of uncertainty surrounding the target company is high, corporations are more likely to choose strategic alliances (and corporate venture capital as second alternative) as mechanism of external corporate venturing.*

CVC investments, on the other hand, entail disparity between the corporate investor and the investee company, identifying an unidirectional flow of resources and appropriation claims from the investor to the founded company (Dushinitsky and Lavie, 2008). Thus, a tight similarity between the partners is not necessary to make this form

of ECV successful. As suggested by Kann (2000): "*Most organizational types of strategic alliances center around very specific goals, such as the development of a particular technological capability or the co-marketing of a specific product (e.g., Hagedoorn, 1993). While a corporate venture capital program is typically mandated with a specific strategic investment goal, the individual investments are often less specific and are not necessarily associated with an ex-ante identified strategic purpose. Rather, corporations tend to invest in a relatively diverse portfolio of entrepreneurial firms whose assets or technologies may not reveal an immediately obvious fit with the corporate investor's line of business*". This search for new competencies (Brody and Ehrlich, 1998; Keil, 2004; Ernst et al., 2005; Chesbrough and Tucci, 2004, Dushnitsky and Lenox, 2005a and 2005b) requires that the level of relatedness between the corporation and the target company should be low. Furthermore, to obtain these objectives characterized by high uncertainty, CVC investments generally consist in an initial small equity investment in the new venture which serves as the first link in a chain of subsequent investments. Since CVC investments are typically staged as traditional venture capital investments (Sahlman, 1990), the corporation is not obligated to continue funding the investee venture after the prior financing round. This gives the firm high levels of flexibility in its investment decisions. Indeed, "*[s]taging investment as a series of outlays creates the option to abandon the enterprise in midstream if new information is unfavorable*" (Trigeorgis, 1996:2). Summarizing, the above-mentioned features make CVC investments preferable under conditions of high uncertainty and low relatedness, followed by strategic alliances (lower right side of Figure 2.3).

Proposition 3: When the level of relatedness between the corporation and the target company is low and the level of uncertainty surrounding the target company is

high, corporations are more likely to choose corporate venture capital (and strategic alliances as second alternative) as mechanism of external corporate venturing.

Finally, Hurry et al. (1992) and Folta (1998) view minority investments in joint ventures as efficient modes to explore market and technical domains that are distantly related. Indeed, when firms enter unfamiliar areas of activity, the marginal efficiency of internalizing the target firm diminishes. For this reason, joint ventures, defined as the creation of a new entity in which two firms dedicate equity for the development of new and shared knowledge, are suitable mechanisms in presence of low levels of relatedness as they allow to create a new entry in the market place without incurring in high costs of integration of the new knowledge. Kogut (1991, p. 19) points out that "*[d]ue to its benefits of sharing risk and of reducing overall investment costs, joint ventures serve as an attractive mechanism to invest in an option to expand […]*". Thus, joint ventures can be considered real options as one of the parts acquires the right, but not the obligation, to expand (through an acquisition) in response to future market and technological developments. However, joint ventures can be also considered an alternative form

Proposition 4: When the level of relatedness between the corporation and the target company is low and the level of uncertainty surrounding the target company is low, corporations are more likely to choose joint ventures as mechanism of external corporate venturing.

2.5 The transition of external corporate venturing mechanisms over time

The taxonomy proposed in the previous section depicts under which conditions of relatedness and uncertainty corporations are more likely to choose a form of ECV rather than another. In such representation, we referred to the first contribution ROT provides to the RBV. That is, firms can use and benefit from uncertainty by investing in options to respond to unstable futures. The same matrix can also be interpreted as a dynamic tool to understand how ECV mechanisms transit over time (Figure 2.4). To pursue this goal, we refer to the second contribution ROT introduces to the RBV. By highlighting the sequential nature of external corporate development activities, ROT recognizes two key insights. First, there are opportunity costs associated with irreversible investments under uncertainty. Second, many investments create valuable follow-on opportunities. Combining these features, external corporate venturing activities characterized by high uncertainty can be described as up-front investments which give the management the possibility to both capitalize on favorable opportunities and mitigate negative scenarios by proactively confronting uncertainty over time in a flexible manner (Kogut, 1991; Kogut and Kulatilaka 2001).

2.5.1 External corporate venturing as a multi-stage process based on real options

Most of the existing strategic management literature uses the orthodox discounted cash flow approach to analyze investment decisions. However, this approach is not adapt when investments are characterized by high levels of uncertainty. Under conditions of high uncertainty and instability, a certain level of flexibility available through an active management of the investment process is critical. ROT satisfies this requirement as it

suggests that firms can benefit by investing in options to respond to uncertain futures and by managing the investments in a sequential and flexible manner as uncertainty is resolved (Dixit and Pindyck 1994; Kogut and Kulatilaka 2001). Accordingly, external corporate development activities have been commonly viewed as conferring that discretionary in future opportunities typical of a real option framework (Kogut, 1991; Smith and Triantis, 1995; Reuer and Tong, 2005).

A real option, deriving from the analogy with financial options, can be defined as the right, but not the obligation, to buy or sell the underlying asset at a specified price on or before a given date. However, differently from financial options in which specific contracts determine the exact conditions leading to an optimal exercise, real options have to be analyzed taking into consideration also what happens between the acquisition and the exercise of the option. Indeed, options based on real assets need to be actively managed by the holder from the moment in which the option is acquired till its time of maturity. Recent applications of ROT in the strategy field have examined investment decisions in terms of purchase or exercise of particular types of options. However, these works do not offer specific frameworks to understand whether and how firms correctly manage and capture option value from such investments.

To fill this gap, we describe an investment in external sources as a dynamic multi-stage process based on real options, where each step is functional to the creation and exploitation of growth opportunities. We identify four phases of the process (Kulatilaka and Venkatraman, 2001): assess opportunities by thinking about the possible future outcomes, acquire options by making investments that confer flexibility to make decisions in the future when part of the uncertainty is resolved, nurture options by keeping the options alive, and harness value by exercising the options in a opportune

way (see Figure 2.3). Disclosing our conclusions, we point out that each ECV mechanism manages the phases of this process in a different way.

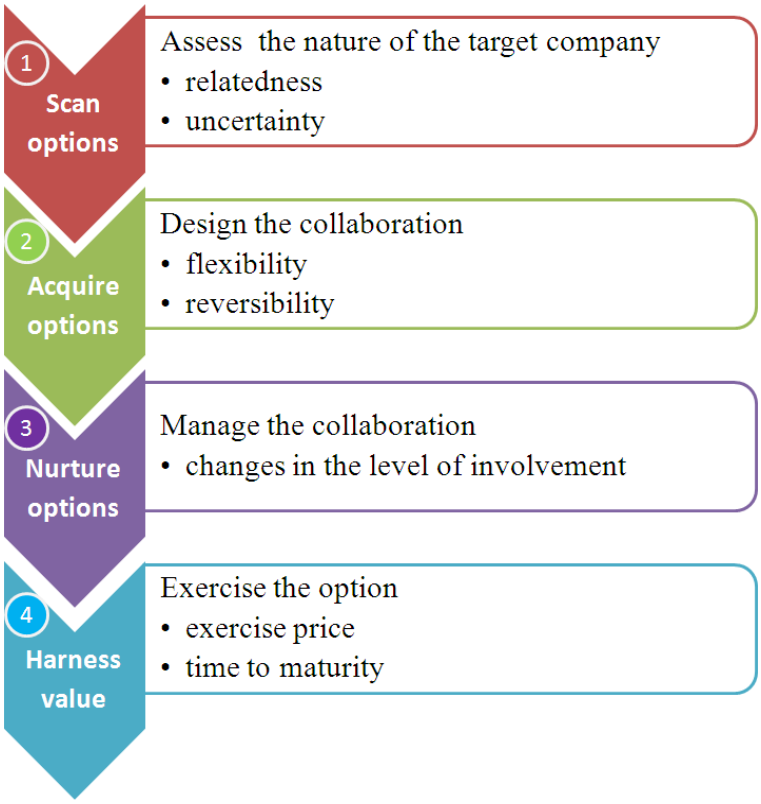

Figure 2.3 The multi-stage process for external corporate venturing activities (Source: adapted by Kulatilaka and Venkatraman, 2001).

Scan opportunities

The first step of the ECV process is the *scan* of the external environment to search for growth opportunities which give the firm the possibility to support existing businesses, improve internal processes, open a window on new markets and technologies, develop new products or seek new technological directions (Ahuja and Katila, 2001, Kogut, 1991; Chesbrough and Tucci, 2004; Dushnitsky and Lenox, 2006; MacMillan et al., 2007). Finding all the potential investments requires a definition of the right space in which this search has to be deployed. Indeed, external opportunities are not all alike. As

previously pointed out, corporations should define their environment to look for opportunities along two main dimensions: the level of *relatedness* between the target company and the corporation and the degree of *uncertainty* characterizing the target company. Taking into consideration these two features together allows corporations to go over the traditional view which is inclined to sustain local search with high familiarity and low uncertainty in order to exploit path dependency (Nelson and Winter, 1982). Also the exploration of new opportunities which reside in far and unfamiliar domains and where the level of uncertainty is high can be valuable investments. ROT suggests that the benefits deriving from close and stable opportunities could be lower than the value created through far and uncertain opportunities, due to the greater value of the options embedded in the latter type of investment.

Acquire options

The second step of the ECV process corresponds to the *acquisition* of the option, that is how the collaboration is drawn. As ECV mechanisms are heterogeneous in terms of their ability to pursue and manage a specific type of option, alternative governance modes exhibit differences in their effectiveness and when they can be used (Nicholls-Nixon and Woo, 2003). This second step of the ECV process, thus, refers to the design of the collaborative structure. That is, given the nature of the opportunity identified in the previous step, how should firms design the collaboration to acquire the option? Corporations have to figure out which ECV mechanism assures the right level of strategic agility, control and positioning to capture potential future benefits from the opportunities.

As previously explained, ROT suggests that ECV mechanisms can be distinguished not only on the base of the level of integration and commitment, but also on the base of the level of *flexibility* and the degree of *reversibility*. More precisely, flexibility is the possibility to defer critical decisions in the future when more information is available and part of the uncertainty is resolved, while reversibility is the possibility to easily exit from an investment without incurring any costs. Summarizing previous results, the levels of flexibility and reversibility assume the greatest value for CVC investments, decrease for non-equity alliances, further decrease for joint ventures, and finally assume the lowest value for acquisitions (van de Vrande et al., 2006). Based on these features, we identified through the matrix of Figure 2.2 the ECV modes which corporations are more likely to adopt depending on the level of flexibility required to manage the collaboration with a specific type of target company.

Nurture options

While in the case of financial options the acquisition of the option is followed by its exercise in the future if the conditions are favorable, in the case of real options, it is needed to introduce an intermediate step to manage the option before its exercise. This is the so called *nurturing* phase in which the option's holder has an active role to keep the option alive and decide about its involvement in the collaboration over time. The possibility to restructure contracts and business agreements with external partners depends on the level of flexibility and reversibility of the ECV mechanism defined in the previous step. Thus, the initial allocation of resources impacts on the nurturing of the option as it defines the starting conditions of the contractual relationship and the

possibility to dynamically change these initial conditions by adapting the ECV investments to the proposed scenario.

The sequential nature characterizing some ECV mechanisms gives the firms high flexibility and reversibility in the management of the collaboration by allowing to evaluate the convenience to proceed with the relationship, or change the level of involvement, or abandon the collaboration. As previously pointed out, the staging process characterizing CVC investments is an useful tool to monitor the option over time. Sequential investments provide the investor with more information about the likelihood of success of the investment limiting its downside risk (Hsu, 2002). Similarly, a strategic alliance can be extended to an acquisition if the value of the partner becomes so high to induce the corporate firm to integrate it into its organization through an acquisition (Kogut, 1991). The underlying idea is that, if the circumstances are favorable, corporations should increase their involvement into the collaborative relationship and subsequently decrease the flexibility and reversibility of the investment. On the other hand, acquisitions provide corporations with a different scenario. The huge amount of resources committed in the unique initial stage to acquire the target company deprives corporations of those levels of flexibility and reversibility characterizing the previous forms of collaboration. Summarizing, the structure and complexity of the nurturing phase in terms of subsequent investments required to keep the option alive depend on the governance mode depicted in the second phase of the ECV process. CVC generally comprises the greatest number of nested investments (given by the total number of financing rounds toward the target company), followed by strategic alliance and joint venture (where the first of the two investments is undertaken to create the alliance/joint venture and the second to acquire, if useful, the target company); while acquisition generally corresponds to a compression of the nurturing phase into a single

step as it has not subsequent follow-ups. We analyze the evolution of ECV modes over time in the next session.

Harness value

Harness value from the external investment represents the final exercise of the option. After this phase the option expires and the benefits embedded in the investment concretely reaches (or not) the corporation. If the nurture phase highlights the sequential nature of the options, the harness phase is more related to the link between actions and creation of value.

Two elements are particularly relevant to make this phase successful. First, the assessment of the *exercise price*. Second, the choice of the *exercise time*. Indeed, the basic decisional rule for growth options is that the option will be exercised, at a certain time, if the value of the underlying asset is greater than the exercise price. To define the exercise price, we need to look at the previous phases of the ECV process. As previously pointed out, when corporations choose a flexible mode of ECV to periodically evaluate and monitor the company's performance, the nurturing phase is long and requires several intermediate steps before reaching the final step – the "harness" phase. On the opposite side, in case of immediate acquisition of the target company, the nurturing phase tends to be null, due to the absence of the staging nature of the investment. When the nurturing phase is long and articulated, the exercise price is the sum of all the resources invested in the nested phases to keep the option alive; when the nurturing phase is short the amount paid to use the knowledge of the target company is compared to the benefits deriving from such knowledge.

Furthermore, unlike financial options in which the expiration date is decided by specific contracts, in case of real options, acting at the right time is not a matter of luck. Empirical evidence shows that, even if conditions become favorable, several firms are unsuccessful in capturing value from their strategic option. This could occur because of the corporate firm's inability to manage the nurture phase or decide the time to exercise the option. As pointed out by Bowman and Hurry (1993), the option's strike can be influenced by the firm's organizational structure as different organization structures influence the extent to which decision makers are left free to strike options. This suggestion can be translated to the ECV context. That is, the harness phase is strictly related to the type of ECV mechanism designed in the acquiring phase and its structural evolution in the nurturing phase. Contractual structures that provide the investing firm with the optimal conditions to efficiently capture external signals will show greater ability in deciding the exercise time. Moreover, contractual structures that help firms in evaluating whether abandoning certain projects because they might not provide the necessary benefits is also important.

Summarizing, the multi-steps representation of ECV activities highlights the following insights:

1. Corporations need to scan the external environment along different dimensions such as the degrees of relatedness between their activities and those of the target company and the levels of uncertainty surrounding the target company.
2. ECV mechanisms proceed along manage each step of the process in different manners. Thus, each governance mode represents for the corporations a unique tool to use under particular conditions.

3. Under the real options lens, modes of ECV can be described along two dimensions: flexibility and reversibility. When the need of flexibility and reversibility is high, firms should prefer a loosely integrated collaborative contract which is structured as a staging process to progressively allocate resources and change their level of involvement over time. On the other hand, when the control is more important than flexibility and reversibility, corporations should choose ECV mechanisms which immediately capture the value embedded in the external opportunity.
4. The length and complexity of the nurturing phase depend on how the collaboration is drawn. Flexible and reversible relationships such as corporate venture capital or alliances give corporations the possibility to manage the nurturing phase through a nested structure of intermediate steps in which the level of involvement progressively increases. On the other hand, acquisitions skip the nurturing phase by directly connecting the second step of option's creation to the final step in which its value is captured.
5. The assessment of the exercise price and the maturity time of the option in the final step of the strategic option navigator is affected by how the ECV mechanism is chosen and managed in the previous steps.

2.5.2 The evolution of external corporate venturing choices over time

To analyze how ECV modes transit over time, we firstly consider CVC where the level of relatedness is low and the degree of uncertainty is high. The choice to start from this case is driven by two motivations. First, CVC is the focus of this work. Second, it represents the most flexible and reversible ECV mode from which both relatedness and uncertainty can vary, by defining less flexible and reversible forms of collaboration.

Through this form of ECV, corporations are fully equipped to face all the aspects of new and uncertain businesses. Indeed, as previously pointed out, CVC investments are a form of collaboration which aims to learn from the target company about new, unfamiliar and uncertain market and technological domains. CVC can be, thus, considered the most general explorative activity to find out several types of potential partners, as suggested by Pfizer: "*Pfizer Venture Investments (PVI) serves as the venture capital arm of Pfizer, supporting a variety of worldwide business development (WWBD) activities. Using Pfizer capital, we invest in innovative healthcare businesses offering new technology platforms that align with our company's strategic direction.*" (Pfizer website).

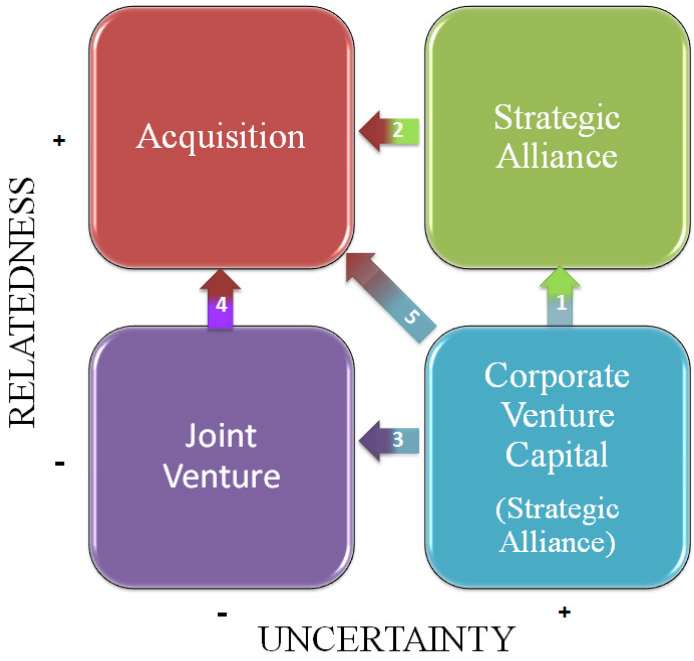

Figure 2.4 The evolution of external corporate venturing mechanisms over time.

From this initial condition, three possible paths can be drawn. The first occurs when the level of relatedness between the corporation and the target company increases, but the level of uncertainty is relatively unchanged. The second corresponds

to the opposite scenario (unchanged relatedness and decrease of uncertainty). Finally, the third possibility shows a simultaneous improvement in the predictability of the environment (decrease of uncertainty) and familiarity with the new knowledge (increase of relatedness). In the following, we consider each case separately.

Arrows 1 and 2. Once a certain level of familiarity with the new knowledge has been built through a constant process of learning, the corporation is in a position to decide whether to allocate more resources to the target company and, thus, select a more appropriate mechanism for scenarios with greater levels of relatedness between the partners' knowledge bases. Folta and Miller (2002) examined equity partnerships suggesting that one of the factor affecting the decision to acquire additional equity in partner firms is the possibility to obtain further learning advantages to investors by internalizing the target and facilitating technology transfer. The corporation can switch from a CVC investment to an alliance where the level of flexibility and reversibility is still high, but lower than in the previous case (arrow 1). This is the case, for instance, of Bedcton, Dickeson and Company (BD), a global medical technology firm, and BD Ventures, its venture capital arm which invests in venture-stage companies that fit well with the BD's business segments (medical, diagnostics and biosciences). Indeed, "*[…] several portfolio companies have entered into development and other strategic relationships with BD subsequent to BD Ventures' investment.*" (Bedcton, Dickeson and Company website). Also Microsoft follows the same evolution in ECV modes: "*A recent example of a company that we've been working with is Tutor.com — an on-demand tutoring and homework help service that students can use when they're stuck with a homework problem, need to study for a test or want to improve their confidence and grades. […] Like most startups, they had limited resources, so being able to use our*

technology and resources was a great help to them. [After an initial set of financing rounds], this summer we took it to another level when we announced a strategic alliance with Tutor.com […]." (Microsoft website).

Subsequently, when also a huge part of the exogenous uncertainty is resolved, the strategic alliance can be converted in an acquisition to exploit a full control on the development of the new knowledge (arrow 2). Eisenhardt and Schoonhoven (1996) suggest that alliances may be formed to reduce market uncertainty and enhance industry coordination by sharing costs and risks. Thus, once uncertainty has been resolved, corporations may decide to engage in a more hierarchical governance mode to obtain strategic control on the partner. "*Pfizer Inc. now owns more than 10% of Australian nanocap pSivida Ltd., but the pharmaceutical giant has no plans to acquire the drug delivery products developer.*". Indeed "*[i]t was a contingent commitment by Pfizer at the time it entered into the strategic alliance with pSivida […] that it would purchase additional shares if [it was] able to go out and raise a certain amount of additional capital […]. Pfizer [typically] enters into these strategic alliances and as part of the agreement will commit to purchase some equity. In some cases, it's an initial purchase followed by a follow-up purchase.*" (Cohen, 2007). Although this is an example in which a corporation decides to not acquire its partner, it shows that after preliminary collaborations in the form of strategic alliances, an acquisition could be the natural expansion of the relationship to increase control on the partner.

Arrows 3 and 4. A second possibility occurs when only the level of exogenous uncertainty decreases making the investment in an external company less risky. Here, the level of relatedness is unchanged but the higher stability in the market demand and in the technological trend allows corporations to become more involved in the

collaboration. CVC investments (or strategic alliances) can, thus, become a joint venture where the firms engaged in the collaboration share resources to jointly develop new knowledge. Joint venture is appropriate in scenarios with low uncertainty and low relatedness, as the two firms commit relatively huge amount of their specific and often complementary resources to pursue a common goal (arrow 3). For instance, Pfizer's philosophy to collaborate is to "[*p]rovide genuine value to Pfizer, patients and partners. [The] partner [will] be part of a team determining the best path for bringing programs forward. From the beginning, we're interested in exploring ways to work together that advance the goals of each of our organizations. This can be achieve with initial commitments in equity followed by more aggressive strategies like the creation of joint ventures with the most valuable partners or other forms of strategic alliances*" (Interview with the Head of Pfizer's Venture Investment Division and Pfizer website).

Once a certain level of familiarity with the new knowledge has been achieved, the joint venture can expand in an acquisition (arrow 4). Indeed, as suggested by Kogut (1991), joint ventures provide firms real options to expand sequentially into new markets by acquiring the target company. Indeed, firms tend to exercise the option by buying out its partners when the joint venture experiences positive results, while it continues to hold onto its investments in the joint venture when negative signals materialize (Kogut, 1991). For instance, PepsiCo and General Mills established in the year 1992 a joint venture - Snack Ventures Europe (SVE). In the year 2004 PepsiCo acquired General Mills' 40.5 percent ownership interest in SVE determining the end of the joint venture. Now, the operations of the joint venture are wholly owned by PepsiCo. Similarly, Fujitsu Limited announced the acquisitions of Siemens's 50% share in their joint venture - Fujitsu Siemens Computers (FSC) because "[*f]ully integrating Fujitsu*

Siemens Computers into the Fujitsu Group fits perfectly into our global growth strategy […]" (Kuniaki Nozoe, president of Fujitsu).

Arrow 5. Finally, if both the conditions simultaneously occur, leading to a decrease of uncertainty and an increase of familiarity with the new knowledge, CVC investments can immediately be converted in an acquisition. Intel Corporation, through its wholly owned subsidiary Intel Capital, invested through the year 2008 in Imagination Technologies Group with increasing equity stakes over time. After these investments, Intel claimed that *"Intel Corp. reserves the right to announce an offer or a possible offer to acquire the shares in Imagination Technologies Group which it does not already own […] if there is a material change in circumstances or in [certain events]*" (London Stock Exchange website). Similarly, Siemens Venture Capital, the venture capital arm of Siemens, started its collaboration with Chantry Networks in 2003 - the leading provider of secure integrated mobility management solutions for wireless networks – through venture capital investments. In October 2005, Siemens announced its intent to acquire the venture "*to offer an integrated enterprise network management platform capable of handling the convergence of wired, wireless and voice systems.*" (Siemens website).

2.6 Conclusions

In addition to attractive financial returns External Corporate Venturing (ECV) provides strategic benefits which result from establishing strategic collaborations between small entrepreneurial companies and large mature corporations. There are several approaches to make ECV. Each approach requires a different level of commitment with respect to corporate resources and yields specific strategic benefits. In this paper, we

address the following research question: *how should firms invest in external opportunities?*

Figure out which ECV mechanism is more adapt under specific circumstances is a challenge for big corporations. To help firms addressing this issue, we propose a theoretical model in which the characteristics of the target is a key-element to choose the correct ECV mechanisms. By combining the Resource Based View and Real Option Theory, we identify two dimensions - the level of relatedness between the corporation and the target venture and the uncertainty surrounding the target company – to detail the nature of outside opportunities and define the ECV mechanism which better manages a specific type of collaborative relationship.

The bi-dimensional matrix proposed in this paper aims to be a tool for corporations to evaluate investments in outside opportunities and determine when to use external corporate mechanisms in an appropriate manner as an instrument of strategic growth. However, the four ECV modes shown in the matrix are not to intend as exhaustive. Much room is left for refinement through further research. This framework only defines a preliminary conceptual foundation for a number of practices which arise in today's business environment. Future research could enrich this representation by integrating other dimensions such as the distinction between market and technological uncertainty, on one hand, and relatedness versus complementarity, on the other hand. First, previous studies on real options pointed out that uncertainty over outside investment returns can be attributed to different sources - unexpected market and technological developments in the industry (Abernathy and Clark, 1985; Folta and O'Brien, 2004; Li and Mahoney, 2006; Oriani and Sobrero, 2008). This distinction is important to take into consideration whether and how different sources of uncertainty change the value of the real options created through external collaborations, and thus

impact on the choice among ECV mechanisms. Second, the concept of relatedness does not recognize that synergies among activities can arise not only from similar resources, but also from complementary resources (Tanriverdi and Venkatraman, 2005). Thus, relatedness can be defined as the extent to which the collaboration uses common knowledge resources between the corporate and the target firms, while complementarity represents the extent to which the collaboration uses a complementary set of common knowledge resources between the corporate and the target firms.

Future research could also empirically test our framework with data from different databases to investigate how CVC investments, alliances, joint ventures, acquisitions and licensing agreements are different to each other depending on a set of variable like relatedness and uncertainty. Empirical investigations about the decisional choice among different mechanisms of external venturing miss in the literature. Finally, theoretical works in which different theories are integrated in a systematic way are scarce. In this paper we have combined the RBV with ROT, but also other frameworks such as organizational learning, transaction costs economic or dynamic capabilities can be jointly applied to explain this phenomenon.

This paper has important managerial implications. In the last years, the most common strategy pursued by firms is to create successful opportunities to identify, develop and commercialize products that bring value to their customers and to the firm itself. To achieve this goal, firms have to build a nimble infrastructure that allows to respond to opportunities with speed and flexibility. All too frequently large corporations lack the flexibility to respond quickly to transform a new idea into a successful product that provides a corporation with new growth and financial returns. The creation of different organizational units inside the same firm dedicated to the search and

management of new opportunities is the starting point of this renewal. The importance to find differences between several forms of ECV is pointed out by the organizational structure of corporations in today's business activities. Indeed, managers typically view acquisitions, alliances and CVC investments as distinct entities, and thus they manage them through separate corporate units. Pfizer, for example, has a dedicated group to ensure that all the capabilities and resources necessary to evaluate and secure licensing, alliance and acquisition opportunities, as well as venture investments and investments in innovative, adjacent or synergistic businesses are in one place with a clear strategy and accountability for results. However, inside the group there are different and distinct areas with specific competencies: "Venture Investments" to recognize strategic equity investments in biotech, specialty pharma, drug delivery, diagnostic and other technology; "Alliance Management" has the task to build trust and relationships between partners; "Licensing" is dedicated to identify portfolio assets as licensing candidates. From this description, it is evident how a clear definition of competencies and resource among units and an efficient coordination among different areas are critical elements to obtain value from new external opportunities. This is possible only if the characteristics of the target company in terms of relatedness and uncertainty are analyzed. With our framework, we intend to help firms in designing their organizations in order to create and harness potential value from different external sources.

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CHAPTER 3 - THE SEARCH OF COMPLEMENTARITY IN EXPLORATIVE STRATEGIES: THE RELATIONSHIP BETWEEN CORPORATE VENTURE CAPITAL INVESTMENTS AND CORPORATE DIVERSIFICATION[6]

ABSTRACT

This paper uses data on 221 Corporate Venture Capital (CVC) funds created by 186 U.S. public firms during the period 1996–2006 to examine the presence of complementarity/substitution between corporate diversification and CVC fund diversification as different forms of exploration. Our results suggest that corporations undertake CVC investments to substitute corporate diversification if the focus is to explore new markets, and complement corporate diversification in the search of new technological domains. We also find that these relationships are sensitive to industry-specific factors: in high-tech sectors the substitution effect for the market side vanishes and the technological complementary effect is amplified.

Key-words:

Exploration, Corporate Venture Capital, Complementarity, Diversification, Portfolio Choices

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3.1 Introduction

The evidence that firms have to face increasing competition in their markets led researchers to investigate how corporations can grow improving their set of competencies. The behavioral theory of the firm, developed by Cyert and March (1963), suggests that firms have the possibility to control their environment through learning processes. More precisely, in the seminal work by March (1991), the author argues that firms can leverage on two different types of learning: exploration, defined as a process of experimentation and discovery, and exploitation, representing the research of solutions which build closely on the existing knowledge (Schildt et al., 2005). In this paper, we mainly focus on the use of different explorative mechanisms.

Moreover, the literature on economics and management of innovation has historically analyzed the role played by endogenous R&D investments as the main source of new knowledge. However, scholars increasingly recognized the partial contribution of this approach to the firm's growth and the strategic benefits deriving by external knowledge (Ahuja and Katila, 2001; Cassiman and Veugelers, 2006). Under this perspective, the inputs which reside outside the firm's boundaries can be a powerful alternative to achieve innovative inputs and create competitive advantages. Researchers have, thus, begun to study the potential for various external sources to provide benefits to firms: alliances, joint ventures, acquisitions, collaborations, M&As and equity investments (Roberts and Berry, 1985; Keil, 2000; Schildt et al., 2005; Ahuja and Katila, 2001; Kogut, 1991; Dushnitsky and Lenox, 2005a, 2005b and 2006). In this research, the firms' decision to commit resources towards innovative inputs which reside outside the firm is analyzed focusing on one strategy, commonly referred to as *Corporate Venture Capital* (CVC). CVC can be defined as equity investments from non-financial corporations

in entrepreneurial companies. We chose to focus on CVC as it represents the second most prevalent group of investors in the market for entrepreneurial financing, after independent venture capitalists, and it is a central mechanism for the renewal of established corporations (Schildt et. al, 2005; Dushnitsky and Lenox, 2006). However, few studies so far have systematically analyzed CVC as a mechanism for exploration.

The goal of our work is to merge the above mentioned two streams of literature to shed new light on the role of CVC investments as a mode of exploration strategy and figure out how firms use CVC investments as a part of their overall corporate strategy. We posit that firms tend to have a more explorative behavior depending on the level of their internal diversification. More precisely, we investigate the relationship between *external* and *internal* exploration by analyzing whether diversification pursued through CVC investments *complement* or *substitute* a more traditional form of exploration such as the internal search for *corporate diversification*. Most of the literature has dealt with these mechanisms as isolated issues, without taking into account possible interactions between different types of investment strategies. Furthermore, internal and external forms of exploration have been traded as independent constructs in the literature (Taylor and Greve, 2006; Child, 2001; Grant and Baden-Fuller, 2004). Prior research has been generally focused on a single explorative domain located either inside (Taylor and Greve, 2006) or outside (Child, 2001; Grant and Baden-Fuller, 2004; Lavie and Rosenkopf, 2006) organizational boundaries, disregarding the possible interactions between search processes defined within the firm and beyond its boundaries. We argue that the interaction between these factors is, instead, an important issue.

Our aim is, thus, to fulfill these gaps by providing a strong theoretical basis and original empirical evidence for addressing the following research question: *how do corporations integrate different forms of explorative search?* Furthermore, we refer to

previous studies that have decomposed corporate diversification into *market* and *technological* domains (Patel and Pavitt, 1994 and 1997; Gambardella and Torrisi, 1998). The importance to introduce such distinction is driven by the evidence that a firm's technological base tends to be wider than the firm's product mix (Patel and Pavitt, 1997). As a consequence, the relationship between corporate and CVC fund diversification under a market perspective could be different from the case of diversification based on technology.

Finally, we also examine whether specific conditions related to the core business of the corporation impacts on the strategic use of CVC investments and, thus, on the relationship between corporate and CVC fund diversification. For this purpose, we analyze whether the relationship between the two forms of exploration strategies differs in high-tech versus low-tech sectors. We propose that high-tech environments, with high degrees of uncertainty and a broad set of opportunities, influence the use of different explorative modes. Firms operating in a rapidly changing environment will achieve competitive advantage through the simultaneous use of different explorative modes.

We study such topics on a sample including all corporations engaged in CVC investments in the United States over the period 1996-2006, as identified by the commercial database *VentureXpert*. Our sample corresponds to 186 firms and 221 CVC funds. Results from our regression analyses predict the existence of a substitutive relationship between corporate and CVC fund diversification, if analyzed under a market-based perspective. Conversely, when the aim is to seek out new technologies, our results suggest a complementary relationship between these two strategies. We also find that the core industry in which corporations operate moderates the abovementioned relationships: in high-tech industries, the complementary effect between corporate technological diversification and CVC fund technological

diversification is stronger, while the substitutive effect in terms of market diversification becomes weaker.

This work provides significant contributions to the existing literature on explorative search. First, we conceptualize CVC investments as a tool available by firms to pursue explorative search. Second, we simultaneously analyze different forms of exploration by integrating the effect of corporate diversification and CVC fund diversification stressing the need to simultaneously study mechanisms of exploration based on the use of internal and external resources. Finally, we try to better understand whether and how industry-specific factors have moderating effect on the combined use of different modes of exploration. The focus is to highlight under which conditions corporations tend to use their set of CVC investments as complement or substitute in respect to their internal activities. These aspects have important managerial implications as they point out that the likelihood to conduct explorative research through CVC is affected, on one hand, by firm's market and technological diversification and, on the other hand, by external conditions such as the level of technological intensity of the core industry of the firm.

We also provide a new contribution to the literature on corporate venture capital. Indeed, we investigate how the structure of CVC funds, in terms of diversification among portfolio companies, is affected by factors which are specific to corporate investors. In the venture capital literature, the determinants of fund's composition have been widely analyzed considering specific characteristics of the fund, entrepreneurial company, transaction and external environment. However, equity investments by corporate (non financial) investors introduce a further element. We show that empirical analyses on CVC fund composition need to include also factors related to the "mother firm" which creates the CVC fund. In this sense, this papers highlights that the level of corporate

diversification is a key characteristic that impacts on the CVC fund composition in terms of its level of diversification.

The rest of the paper is organized as follows. We first briefly summarize the previous literature on CVC and we discuss how different forms of exploration can be related. In session 3.3, we formulate two sets of hypotheses: the first formalizes our expected relation between corporate diversification and CVC fund diversification. The second analyzes the moderating effect of industry-specific factors on the main relationship. We then describe the data sources and the sample, in session 3.4, and the variables used in the empirical analysis, in session 3.5. We present the results of the different regressions in session 3.6. Finally, we outline the main conclusions to be drawn from the theoretical and empirical analysis, and discuss the implications for future research.

3.2 Theoretical background

3.2.1 The different forms of exploration strategies

Previous works on the organizational literature suggest that firms have the possibility to affect their environment through learning processes (Cyert and March, 1963). According with this stream of research, firms have two possible directions for investing in new opportunities: they can search in the neighborhood of current knowledge, or they can search for investments in distant domains. March (1991) conceptualized this distinction introducing the terms *exploitation* and *exploration*, respectively. Exploitation is the search of solutions which build closely on the existing knowledge (Schildt et al., 2005) in order to pursue refinement and efficiency of current activities. Exploration, instead, is

defined as a process of experimentation and discovery (March, 1991), and it is closely aligned with generation of unfamiliar knowledge (Nelson and Winter, 1982).

In highly competitive industries, the speed and complexity of changes create many uncertainties for organizations and force them to continuously search for new growth opportunities. Established organizations are, thus, under pressure to increase their ability of experimentation and exploration to avoid falling into "learning traps" (Levinthal and March, 1993). As a consequence, firms try to create competitive advantage by investing not only in close domains to exploit previous knowledge, but especially in new opportunities which are distant from the firm's core activities. A rich literature suggests that in presence of environmental changes, persisting in current behavior and strategies negatively impacts on the firm's performance and innovation (Smith and Grimm, 1987; Haveman, 1992; Audia et al., 2000). The search for exploration is, thus, an important topic.

Firms, can choose among different modes of exploration. The traditional way to renew capabilities is to enter into new lines of activity by processes of internal business development. This practice is commonly known as *corporate diversification* (Ramanujam and Varadarajan, 1989). The underlying logic is that high levels of exploration imply variance-seeking (McGrath, 2001). Thus, variety (i.e. diversification), involving the discovery of new technologies, businesses, processes or products, is associated with exploration. In exploration, the focus is on gathering new information on many different alternatives rather than fully specializing in one domain and refining an existing knowledge-base. In this sense, corporate diversification implies diversity among distinct businesses, and, thus, it is a form of explorative search.

In addition to allocate internal resources to renew the current set of capabilities, firms can also decide to explore by committing external sources towards new ventures

which reside outside the firm's boundaries. To help firms in the exploration of new opportunities, Roberts and Berry (1985) proposed a matrix embracing different investment mechanisms which firms can choose, depending on the type of relation between the new business and the firm's current markets and technologies: alliances, joint ventures, equity investments, acquisitions. In this paper, we focus on *Corporate Venture Capital* (CVC) as mode to explore new opportunities relying on external ventures. Summarizing, we employ the exploration literature to discuss the relationship between corporate diversification and CVC investments as different exploratory processes through which firms attempt to acquire new capabilities.

3.2.2 Corporate venture capital as a form of exploration

Investments in entrepreneurial ventures have increasingly gained appreciation as a means for corporations to learn about new technologies and markets. In other words, referring to the terminology proposed by March (1991), investments in external companies are considered a form of *explorative* search (Wadhwa and Kotha, 2006).

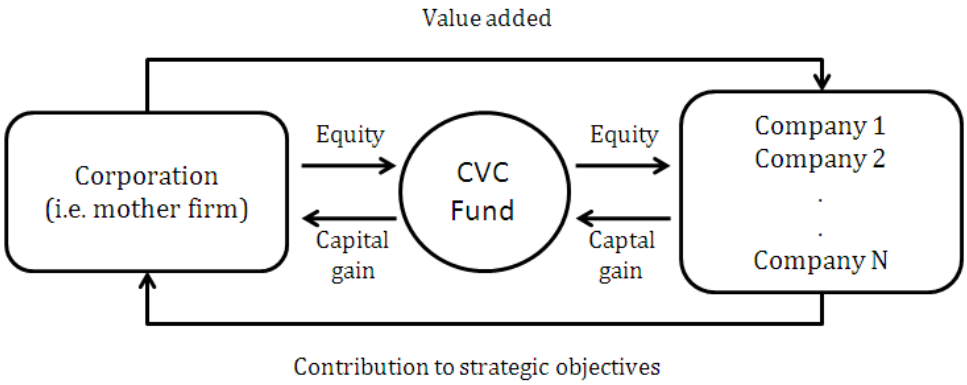

Figure 3.1 Typical structure of corporate venture capital (adapted by Ernst et al., 2005).

CVC is defined as equity investments in small, young and privately held entrepreneurial companies by established corporations, usually motivated not only by financial goals, but mainly by strategic interests (Chesbrough and Tucci, 2004, Dushnitsky and Lenox, 2005a and 2005b). CVC is often labeled as a type of "external corporate venturing", distinct from (a) "internal corporate venturing", which instead refers to the creation of entrepreneurial ventures within the firm; (b) investments by independent venture capital firms or financial corporations, primarily interested in financial returns; and (c) equity investments in publicly held companies or joint ventures. The typical structure of CVC investments is depicted in Figure 3.1, where the *mother firm* (i.e. *corporation*) creates a *CVC fund* beyond its boundaries and directly supplies it with a certain stock of capital to finance a portfolio of *companies* (i.e. *new ventures*), which in turn contributes to the corporation's strategic goals (Ernst et al., 2005).

Big corporations such as Xerox, Lucent, Nokia, Novartis, Pfizer and Intel have explicitly formalized their CVC activities by setting up investment programs motivated by the search for strategic benefits, such as learning and new-knowledge creation. Accordingly, in a recent survey by Ernst and Young (2008), among the respondents (37 CVC units in North America, Europe and Asia), 80% indicates that their programs aim at a pool of strategic and financial goals, 17% merely looks for strategic benefits and only 3% pursues exclusively financial returns. This is confirmed also by managers of some of the largest corporations engaged in CVC activities:

> *"Today, we intend to continue operating as a corporate life science investor which offers sustain to companies with the potential to create strategic benefits for*

> *Novartis […] by exploring new business areas that are critical to the healthcare industry."* (Interview with the Managing Director, Novartis Venture Fund).

> *"At Pfizer, we are implementing an aggressive goal to […] grow our core medicines business, moving into attractive businesses and collaborating with academics, entrepreneurs, and innovators to enrich our portfolio and to expand our capabilities."* (Interview with the Head of Pfizer's Venture Investment Division).

Also, the stream of academic research investigating the CVC phenomenon suggests that the motives pushing corporations to be engaged in CVC investments are not only financial, but especially strategic and mainly related to the creation of new businesses, growth and diversification through new ventures, development of new competencies and technologies and possibility to learn through exploration (Brody and Ehrlich, 1998; Keil, 2004; Ernst et al., 2005; Dushnitsky and Lenox, 2006). Gompers and Lerner (1998), comparing the performance of corporate and independent venture capital investments, found that corporate programs without a strong strategic focus appear to be much less stable than independent venture organizations. In line with this research, Dushnitsky and Lenox (2006) found a positive relationship between CVC and firm value creation, with a greater impact when firms explicitly pursue CVC to harness entrepreneurial inventions, instead of merely search for financial returns. This focus on strategic benefits suggests that CVC can be considered a form of explorative search which provides firms with a tool to monitor the developments of markets and technologies and renew their set of capabilities (Maula, 2007).

Maula et al. (2003) showed that corporations engaged in CVC programs enhance their ability to recognize potentially disruptive technological changes faster than their

peers who do not commit resources to make such investments. Finally, Schildt et al. (2005) comparing different forms of external corporate venturing (CVC investments, non equity alliances, joint ventures and acquisitions) suggested that the less integrated the venture governance mode, the more explorative the learning. Although the authors found only weakly significant results for the hypothesis that CVC is the most explorative mechanism, this work points out the explorative power embedded in all these forms of external corporate venturing. Thus, previous studies assert that "*start-up firms represent an important opportunity for corporate investors to explore new ideas and knowledge*" that would not otherwise be available (Wadhwa and Kotha, 2006: 2).

3.2.3 A missing link: the relationship between CVC fund diversification and corporate diversification

The research reviewed above asserts that corporate diversification, on one hand, and investments in new ventures (CVC), on the other hand, represent two important modes for corporations to explore new ideas and diversify into new market and technological domains (Wadhwa and Kotha, 2006). However, no earlier studies have investigated how CVC programs are integrated inside the firm and assessed the potential synergies of these investments with the more traditional form of explorative search represented by corporate diversification. Specifically, the previous literature has not investigated whether and when diversification pursued through CVC investments *complements* or *substitutes* corporate diversification through internal activities (Chesbrough and Tucci, 2004).

More precisely, we do not have knowledge about studies analyzing the relationship between forms of exploration based on different types of investment sources – within and beyond the firm's boundaries. On one hand, Taylor and Greve

(2006) focused on the internal composition of innovative teams to understand which factors sustain an explorative strategy and which factors favor an exploitative strategy. Their results suggest that teams with multiple knowledge domains produce innovations that increase the variance of product performance (i.e. exploration), while team with extensive experience produces outputs with high average performance (i.e. exploitation). On the other hand, Child (2001), Grant and Baden-Fuller (2004) and Lavie and Rosenkopf (2006) went beyond the firm's organizational boundaries to analyze how strategic alliances can contribute to the firm's explorative and exploitative search of knowledge. However, these studies do not link both the sides – internal and external dimensions – to analyze the interactions between these two forms of research.

This topic is particularly relevant not only for the literature on explorative learning, but also for a complementary stream of research. Investments decisions of VCs have long been of interest in the entrepreneurship and financial literature. Gupta and Sapienza (1992) and Norton and Tenenbaum (1993) investigated the determinants of VC firms' preferences regarding the industry diversity and geographic scope of their investments. Kanniainen and Keuschnigg (2003) presented a model to determine the optimal number of portfolio companies. Fulghieri and Sevilir (2005) investigated the optimal size and focus of venture capital's portfolio. Finally, Cumming (2006) analyzed how the characteristics of new ventures, industry and fund influence the VC portfolio size. While all these studies have made important contributions to advance our knowledge on how VC firms decide about their portfolios, to our knowledge, there is not any study investigating the same issue in the CVC field. The main reason explaining the need to analyze CVC as a different and autonomous form of financing is the presence of the mother firm (i.e. the corporation creating the fund) in the financing process, in addition to the portfolio companies and the fund's managers. In this study, we thus

contribute to the literature on CVC portfolio choices by introducing corporate-level features within the pool of factors affecting the fund composition. In particular, we focus on the analysis of whether the degree of corporate diversification explains variance in the portfolio strategies in terms of CVC fund diversification.

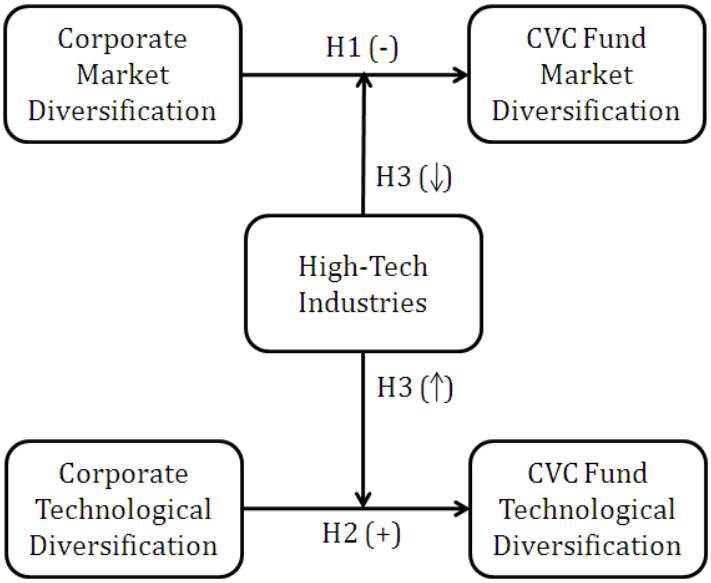

Figure 3.2 Proposed theoretical model.

3.3 Research hypotheses

In addition to develop internal capabilities to diversify their activities, firms typically uses knowledge sources external to the firm. The evidence that firms conduct such internal and external explorative activities simultaneously suggests that they could be related to each other. However, it is not clear which kind of link exists. Two explorative modes could be *complementary* when a firm uses both to create "super-additive" relationships, as the marginal benefit of one activity increases when the benefit of the other increases. On the other hand, the use of two modes of exploration can generate a *substitution* effect when they are alternative and an increase in the benefit deriving from

one mode decreases the benefit of the other, creating "sub-additive" relationships (Vassolo et al., 2004).

To exhaustively fulfill the abovementioned gaps in the literature by understanding the nature of the relationship (complementary versus substitutive) between corporate and CVC fund diversification, we refer to previous studies that have decomposed diversification into market and technological domains (Patel and Pavitt, 1994 and 1997; Gambardella and Torrisi, 1998). Highlighting this distinction allows us to test the hypothesis that different types of diversification, and thus different types of exploration, will manifest themselves in different ways. *Market diversification* implies greater weight on commercialization or production, *technological diversification* refers to the development of new capabilities in technological assets.

A set of managerial studies highlighted the existence of forces affecting both technological and business diversification and factors that separately impact on each of them (Candwell et al., 2004). An empirical research by Gambardella and Torrisi (1998) underscored the opposite effects of these two dimensions on firm's performance: the relationship results positive for greater focus in business operations and negative for greater focus in technological operations. This is confirmed by the empirical evidence that firms within one industry need to develop technologies in various domains for the development of more complex products and production processes (Granstrand and Sjolander, 1990 and 1992; Kodama, 1992 and 1995; Granstrand et al., 1992).

Starting from these important results, we suggest that CVC investments, as a way to obtain diversification, could play a different role, when jointly analyzed with corporate diversification, depending on the nature (market or technological-based) of search considered. Furthermore, we also suggest that such relationships are affected by

external variables such as the level of technological intensity in the core industry of the corporation.

Figure 3.2 presents our theoretical framework, summarizing our four hypotheses. In the next sessions, we analyze each hypothesis separately.

3.3.1 Market perspective

Gambardella and Torrisi (1998: 446), using data on the largest 32 US and European electronics firms during 1984–1992, found that "*the best performing companies were those that focused on their core business […]*". The explanation behind this evidence is provided by Chandler (1990: 30) who asserts that "*the cost advantages of joint distribution or scope were reduced when products required specialized facilities and skills in their marketing and their distribution*". As assets and capabilities needed to succeed in different markets are distinct among sectors, the boundaries across industries are high and, thus, they limit the possibility for firms to enter new markets. Similarly, Rumelt (1991), extending the work by Schmalensee (1985) to estimate the variance components of profit rates in the FTC Line of Business data, found that corporations exhibit little or no differential ability to affect business-unit returns. Put differently, there is no evidence of synergies among business units (which represent different industries) because " *[…] the dispersion among corporate returns is fully explained by the dispersions of industry and business-unit effects. […] If one business-unit within a corporation is very profitable, there is little reason to expect that any of the corporation's other business-units will be performing at other than the norms set by industry, year, and industry-year effects"* (Rumelt, 1991: 182).

Furthermore, the vast literature that originated with the seminal work by Teece (1986) regards collaborations as an effective mechanism providing corporations with

the benefit to combine their competencies with complementary resources offered by external partners. Koza and Lewin (1998) proposed a distinction between exploitative and explorative alliances. The intent of the former is to intensely use partners' assets and capabilities that are difficult to build autonomously, in order to exploit positive synergies. On the other hand, explorative alliances are motivated by the possibility to learn, discover new opportunities and build new capabilities. Rothaermel (2001: 690) asserted that "*organizational learning motivates exploration alliances, while access to complementarities motivates exploitation alliances*". In line with this reasoning, Colombo et al. (2006) suggested that commercial alliances are clearly driven by exploitative reasons, while technological alliances have a more explorative nature because firms have the possibility of developing new technological capabilities through the integration of their own knowledge with that of the partner (Colombo, 2003). Thus, collaborations represent a viable alternative to internal investments for moving into unfamiliar markets by exploiting complementary assets. CVC investments, being an equity-based form of collaboration, provides the firms with the same benefits.

Joining these two streams of literature, we suggest that diversification through CVC funds acts as a substitute in respect to corporate diversification if the focus is on the market dimension. Indeed, the propensity to specialize into a limited number of core market activities (as suggested by the diversification theory) and the weak explorative nature of commercial collaborations (as pointed out by the resource-based view) support the hypothesis that, under a market perspective, firms tend to limit their efforts in explorative research by choosing between modes to obtain diversification.

Hp 1a: There is a negative relationship (i.e. substitution) between corporate market diversification and CVC fund market diversification.

3.3.2 Technological perspective

From the technological perspective, Arora and Gambardella (1990) investigated whether different kinds of linkages created by large corporations with universities and research-intensive companies are complementary to one another. Four types of linkages are identified: agreements with other firms, research agreements with universities, investments in the capital stock of New Biotechnology Firms (NBFs), and acquisitions of NBFs. Based on a sample of large US, European, and Japanese chemical and pharmaceutical producers, the authors found that the relationships identified are positively correlated and, thus, complementary. As the authors pointed out (1990: 362): "*[t]he increasing complexity and multi-disciplinarity of resources required for innovation, and of the stock of knowledge itself, tend to make technological innovations the outcome of interactions and cooperation among fundamentally autonomous organizations […]*". As a result, large corporations tend to sum the efforts made in different forms of explorative search (that in our setting correspond to internal and external searches) to obtain a vast set of growth opportunities. In line with this reasoning, researches on diversification appear to confirm an overall trend towards increasing technological diversification to face the greater complexity characterizing products. Patel and Pavitt, (1997), analyzing data on more than 400 of the world's largest firms, showed that these corporations tend to "*spread their technological resources over a wider spectrum than their products, and particularly into fields where they do not have a distinctive advantage*" (Patel and Pavitt, 1997: 148).

Furthermore, Mowery and Rosenberg (1989) argued that internal technological activities and inter-organizational relationships are necessary complements, rather than substitutes. The hypothesis of complementarity suggests that, on one hand, the presence of internal research is likely to endow a firm with technical expertise to assess the

potential of outside research. On the other hand, external collaborations provide the firm with access to news technological resources that cannot be generated internally. In line with this reasoning, Laursen et al. (2008), considering licensing-in as a mechanism to undertake explorative research in technological domains, compared this form of exploration with the level of technological diversification of the in-licensing firm. Their results suggested that firms with a larger level of absorptive capacities (measured in terms of technological diversification) tend to search more distantly from their existing technological portfolio (i.e. perform an explorative rather than exploitative research) as compared to less technological diversified firms. The idea is that exploration of new technologies require strong absorptive capacities as explorative search faces important cognitive obstacles such as existing shared knowledge and routines, communication channels and information filters that make difficult for a firm recognizing and assimilating technological knowledge developed outside of the firm's boundaries (Nelson and Winter, 1982; Tushman and Anderson, 1986; Cohen and Levinthal, 1990). Thus, this finding suggests a complementary relationship between these two forms of investments where the former – internal technological diversification - supports the latter – licensing-in.

From these findings, we suggest that corporations will tend to use different forms of exploration in order to obtain high levels of variety among their technologies and face the increasing complexity of products. In our setting, this means a combined use of internal and external explorative resources. Thus, CVC investments can be considered a complementary mode to corporate diversification for the search of new opportunities.

Hp 1b: There is a positive relationship (i.e. complementarity) between corporate technological diversification and CVC fund technological diversification.

3.3.3 The effect of the environmental context

Rather than merely searching for complementarity or substitution between different forms of exploration, we also aim to identify contextual variables that affect these relationships. As our analyses are based on a sample of corporations operating in different sectors, we identify the distinction between high-tech and low-tech sectors as an important factor influencing the extent to which corporate and CVC fund diversification are complementary or substitute. High-tech industries are generally characterized by two aspects: on one hand, high levels of uncertainty and, on the other hand, a wide set of opportunities. As far as the latter, Dushnitsky and Lenox (2006) suggested that firms are more likely to invest when there are rich technological opportunities within an industry. Indeed, in the presence of a large pool of opportunities, corporations are more likely to use different mechanisms to capture value from them and, thus, complement internal investments with CVC investments.

Furthermore, diversifying activities allow a firm to address uncertainty and limit the risk of each investments. Exogenous uncertainty influences the degree to which firms can survive by mainly refining current technologies rather than seeking out new opportunities. In unstable environments (with rapid technological change and obsolescence) firms should commit more resources to explore in a broad spaces of opportunities when compared to more stable environments characterized by less uncertainty (Rowely et al., 2000; Beckman et al., 2004). Thus, firms operating in a turbulent environment should maintain a high level of flexibility by not investing in a small set of opportunities which are highly related to their current technological knowledge-bases. Indeed, a technological shock could radically limit their competitive advantages in these domains. Instead, firms should allocate resources in a broader set of opportunities to create options for dealing with environmental shocks.

If the presence of higher uncertainty and valuable opportunities pushes firms in exploring new opportunities, we would notice an impact on our main hypotheses. More precisely, we expect the substitutive relationship between corporate market diversification and CVC fund diversification to be mitigated in high-tech industries. Similarly, the complementary link in case of technological exploration is estimated to be stronger than in low-tech sectors.

Hp 2a: In high-tech industries the negative relationship (i.e. substitution) between corporate market diversification and CVC fund market diversification is lower than in low-tech industries.

Hp 2b: In high-tech industries the positive relationship (i.e. complementarity) between corporate technological diversification and CVC fund technological diversification is greater than in low-tech industries.

3.4 Sample and data sources

We tested our hypotheses on a sample of CVC funds originated by U.S. corporations in the period 1996-2006. To ensure consistency across data, we decided to limit our analyses to U.S. public firms. We decided to refer to the United States since it is the largest and most developed industry in the world (NVCA, 2008), "*representing 74% of global investments in the five quarters up to April 2008. Europe forms a second tier, and Israel and China are minor players.*" (Ernst & Young, 2008). Venture capital under management by corporations in the United States increased from 3,100 $ millions in the 1996 to 18,107 $ millions in the 2006, corresponding to the 6.5% and 7.8% of the total

capital in the venture capital sector, respectively. In 2006, CVC investments dedicated their resources to new ventures in the areas of information technology (52.65%), healthcare (26.36%) and non-high technology sectors (20.99%).

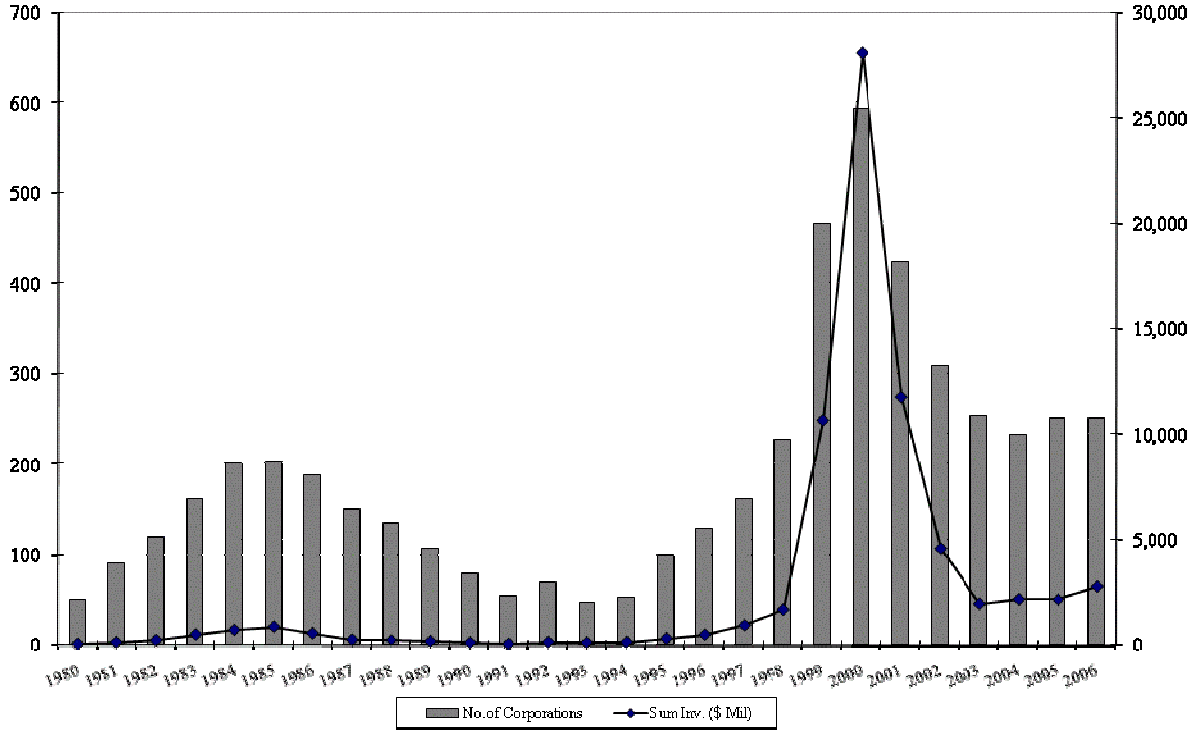

Figure 3.3 Number of corporate investors and CVC investments in 1980-2006 (source: *VentureXpert*).

We decided to focus on the period 1996-2006 as it represents the last and biggest wave characterizing the CVC cycle. Indeed, the level of CVC investing has been extremely variable over time and has mirrored the cyclical nature of the venture capital industry in a significant manner (see Figure 3.3). Investments in CVC generally show periods of rapid growth and decline. The first CVC funds began in the mid-1960. This date signed the beginning of the first wave, covering the period from the late 1960 to the early 1970, with the beginning of the decrease around 1973. The second wave occurred in the late 1970 and the early of 1980 (Gompers and Lerner, 1998 and 2001). Finally, the biggest wave occurred in the late 1990, with a peak in 2000, where corporations participated in

approximately 20 percent of venture investments in the United States, to take advantage of the technological shock caused by Internet (source: *VentureXpert* database).

To construct our sample of U.S. corporations active in CVC investments[7], we operated in the following way. We first identified through the *VentureXpert*[8] database all the CVC funds created in the U.S. over the period of analysis. This corresponds to a total number of 281 CVC funds created by 239 corporations. Then, we refined this initial sample. First, we dropped CVC funds labeled as "Unspecified funds" or "Undisclosed funds" which contain no information, reducing our sample to 239 funds and 202 corporations. Second, we excluded CVC funds with only one portfolio company for the following reason. Portfolio companies are in general small and young entities characterized by only one industry code. In these cases, the Herfindhal index for the market diversification assumes a value equal to zero corresponding to perfect specialization. However, this type of interpretation could be misleading as it is evident that a portfolio with only one company is specialized in the industry associated with that company. After this step, the sample included 231 CVC funds created by 192 corporations. Finally, as we focused only on public firms, we dropped from the sample also private corporations which do not have a matching code on financial databases like *Worldscope*. Our final sample consists of 221 CVC funds originated by 186 U.S. public

[7] Among the several types of investors included in *VentureXpert*, we selected only corporate firms defined as "Corporate Venturing Group" and "Corporations".

[8] The database is offered by *Venture Economics*, a division of *Thomson Financial*. The data are collected through industry associations (European Venture Capital Association, the National Venture Capital Association, and other key associations in Asia and Australia) and the investment banking community. *VentureXpert* contains a comprehensive coverage of investments, exit, performance activity in the private equity industry and it provides a broad set of information on venture funds, venture capital firms and their portfolio companies; the status of the investments (IPO, M&A, active, dissolved, failed), the identification of the limited partner, the number of rounds with their amount of financing and the total amount invested. Other available data are a brief description of the firms' businesses, the sector in which firms operate and information on the team. Previous academic studies on the VC industry have widely used this data source (Gompers, 1995; Kortum and Lerner, 2000; Maula, 2001; Dushnitsky, 2004; Dushnitsky and Lenox, 2005).

firms in the period 1996-2006. The total number of funded companies is 1,616 and the total number of rounds is 2,382.

Our data gathering process is structured into three steps. For each investor, we collected from *VentureXpert* information on the capital under management, the number of funds managed, the ventures belonging to their investments portfolio, the amount invested in each company and in each round and the number of co-investors. For each fund, we gathered the following additional data: fund name, vintage year, managing firm, stage focus, geographical location, number of portfolio companies and fund size. Finally, for each CVC-backed company, we extracted data about the main industry in which it operates, founded year, technology application, stage of development, country, public status (private, public, subsidiary, defunct, government owned) and investment status (active, LBO, defunct, acquisition), total amount of financing obtained by CVC firms, CVC firms involved, corresponding funds, number of financing rounds received and date of each financing round. Based on these data we built the variables of analysis, which we detail in the following paragraph. Our database is, thus, a cross sectional sample of CVC funds, constructed in order to allow for each variable one observation for the whole period 1996-2006.

Second, a hand-checking procedure was used to link the *VentureXpert* sample of corporate investors with the *Worldscope* dataset to obtain the corresponding identification code and gather data on the corporate total sales and the corporate R&D expenses. Finally, we gathered patent data to construct our technological measures. We used two data sources in order to identify the set of patents assigned by the U.S. Patents and Trademarks Office (USPTO) to both the investor firms and the companies included in our sample. The first is the *NBER database* (see Hall et al. (2001) for a detailed description of the database) which "*comprises detail information on almost 3 million U.S.*

patents granted between January 1963 and December 1999, all citations made to these patents between 1975 and 1999 (over 16 million), and a reasonably broad match of patents to Compustat (the data set of all firms traded in the U.S. stock market)" (Hall et al., 2001: 2). In particular we referred to the second version of this dataset which has been extended till the 2002, so that the final time period covered through this source is from the 1996 to the 2002. To collect patents for the remaining period 2003-2006 we referred to a second source: the *Delphion* database which offers full-text documents on patents granted by the USPTO since 1975[9]. To maintain consistency, reliability, and comparability of patents, we used patents granted in the United States. We collected a total number of 135,525 granted patents for the corporations and 29,413 granted patents assigned to the portfolio companies. The granted patents for both corporations and portfolio companies are gathered considering the date of their original application (i.e. priority date) as suggested by previous studies (Ahuja and Katila, 2001; Dushnitsky and Lenox, 2005a).

3.5 Variables

3.5.1 Dependent variables

To test our hypotheses we defined two different dependent variables to describe the degree of diversification of the CVC portfolio structure. Indeed, the aim of this study is

[9] A strength of both these databases is the possibility to appropriately identify the patents that were granted to subsidiaries of our sample of corporate investors and aggregate the patents assigned to these subsidiaries in that year to the parent firm: *NBER database* aggregates the patents assigned to these subsidiaries in a given year to the parent firm level, while *Delphion* offers the "corporate tree" tool which allows to construct the corporate family trees and create the same patent aggregation offered by the previous database. *Delphion* has also been used to collect data about the patents requested by the investee companies of our sample.

the investigation, from two different perspectives, of the relationship between external diversification obtained through CVC investments and direct diversification performed inside the corporation, market and technology-based. To address this goal, we adopt *CVC Fund Market Diversification* and CVC *Fund Technological Diversification* as our dependent variables.

To calculate our dependent variable, we referred to the literature on firm's diversification and we translated this concept to the case of fund diversification. Measures developed for the analysis of firm's diversification abound in the literature, stemming from several research areas on strategy, economics, and finance. Researchers have developed two main methods to measure diversification: a classification scheme which categorizes firms into particular groups (Rumelt, 1974) or a product count system (Jacquemin and Berry, 1979) which develops a percentage or ratio (market share, sales, expenditures into different businesses) to measure the level of diversification. Regarding the latter group, there are several possible product count measures to choose from. The simplest method is counting the number of industries in which the firm does business, or using the percent of the firm's largest business. However, these proxies may give a distorted picture of firm diversification. To solve this problem, several studies adopted a weighted method which gives the largest contributors to firm's businesses with greater percentage of sales (Palepu, 1985; Robins and Wiersema, 1995 and 2003; Ahuja and Katila, 2001). In particular, these studies refer to the *Herfindahl Index*, which is widely diffused as measure of economic concentration in the industrial organization literature. In our setting, we use the complement of the *Herfindahl Index* and we define the following index of fund diversification:

$$Herfindhal_j = \left[1 - \sum_{j=1}^{J} \left(P_{ij}\right)^2\right] = \left[1 - \sum_{j=1}^{J} \left(\frac{N_{ij}}{N_i}\right)^2\right]$$

P_{ij} is the proportion of investee companies belonging to a specific class i in the fund j. If we refer to the *Market Diversification*, *Nij* denotes the number of companies of the CVC fund *i* operating in industry *j* (with *j* = 1,…, J) and N*i* refers to the total number of portfolio companies. If we refer to a measure of *Technological Diversification*, *Nij* denotes the number of patents granted by the companies belonging to the CVC fund *i* in the technological domain *j* (with *j* = 1,…, J) and N*i* refers to the total number of patents of all the companies belonging to the CVC fund *i*. These indexes take value 0 for a CVC portfolio which is not diversified at all (all portfolio companies operate in a single industry or all innovations are filed in the same patent class) and increases for higher level of diversification, its upper limit being 1 (the investee companies operate in different business segments or their patents are spread across a very large number of different patent classes). We use the 4-digit Standard Industrial Classification (SIC) and the 4-digit International Patent Classification (IPC) systems as market and technological domains to construct these two measures. A detailed description of the procedure followed using these classification schemes is presented in Appendix A. Finally, as the previous literature provides different measures for the level of diversification, we also performed a robustness check considering the *Entropy Index*, instead of the *Herfindhal Index* (see Appendix B).

3.5.2 Independent variables

To test our first set of hypotheses we defined *Corporate Market* and *Technological Diversification* as our main independent variables, computed at the level of the

corporation. To measure this variable, we followed the same procedure previously presented for the proxy of CVC fund diversification. However, in this case, the term P_{ij} refers to the proportion of firm's sales in a specific industry class *j* (for the market diversification) or the number of patents granted by the corporation *i* in a specific technology domain *j* over its total number of granted patents.

In order to test our second set of hypotheses, we also introduced a dummy variable which takes into account the distinction between high-tech and low-tech industries (*High-Tech*) in the core business of our corporations (identified by the primary SIC code). We categorized as high-tech (dummy taking value 1) the following industries: technology, telecommunication and health care. Basic materials, consumer goods, industrials, oil & gas, and utilities belong to the low-tech group (Hall and Vopel, 1997).

3.5.3 Control variables

Following previous research, we included a set of control variables which could have important impacts on CVC portfolio composition. Analyzing a sample of 214 Canadian VC funds, Cumming (2006) suggested that portfolio size could be affected by four categories of factors: the VC funds' characteristics (type of fund, duration, fund rising, number of fund managers), the entrepreneurial firms' characteristics (stage of development, technology and geographic location), market conditions and the nature of the financing transaction (staging, syndication and capital structure). In our analyses, we include the first three groups. However, as previously explained, the presence of the corporate firm as additional player in the CVC process (when compared to the VC structure) suggests to consider also corporation-level factors. We know proceed with a description of these variables.

The first set of variables regards the corporate firm. We control for corporate size, using the logarithm of corporate sales in the same year in which the fund has been created (*Log(Corporate Size)*), since "*larger firms possess greater resources for investing in research and, thus, are more likely to pursue more internal R&D as well as external CVC*" (Dushnitsky and Lenox, 2005: 957). To take into account the variance in inputs for innovation activity which impact on a firm's propensity to innovate (Wodhwa and Kotha, 2006) and, thus, to invest in diversified CVC programs, we also controlled for R&D expenses, which represent all direct and indirect costs related to the creation and development of new processes, techniques, applications and products with commercial. Since our measure of R&D expenditure can be highly correlated with firm size, we use *R&D Intensity* (instead of only R&D expenses), measured as the ratio of R&D expenditure to corporate investors' sales in the fund vintage year. We gather these data on firm's sales and R&D expenditures from *Worldscope*.

The first control variable of the second group is the CVC fund size, measured as the log transformation of the total amount of money (Mil $) invested in the CVC fund (*Log(CVC Fund Size)*). The dummy variable *Early Stage*, takes the value 1 for funds investing in early-stage and 0 for later-stage companies. This distinction has been widely applied by the previous literature (Gupta and Sapienza, 1992; Norton and Tenenbaum, 1993). To create these two macro categories we aggregated the more detailed classification provided by *VentureXpert*. In *VentureXpert*, a fund can be classified as seed stage/startup, development, early stage, balanced/diversified, expansion, later stage, mezzanine stage, buyouts, recap, turnaround/restructuring/special situations, distressed debt, generalist, other private equity/special situation, fund of funds, secondary funds, energy, real estate, or timber. Not all these categories are represented in our sample. However, we considered as belonging to the first group funds investing in

seed stage/startup, development or early stage companies and to the second group those investing in later stage or expansion companies. *California* is a dummy variable taking value 1 when the fund's geographical location is California, 0 otherwise. This variable aims to capture differences between corporations operating in the U.S. West coast and investors located in the East coast. Indeed, corporations based in California result being the most active in terms of resources committed towards new ventures, followed by Massachusetts, New York and Pennsylvania (NVCA, 2008).

The last group of control variable is represented by a set of environmental conditions in which corporate investors operate. As suggested by the CVC cycle, the year 2000 registered the highest peak in terms of number of corporations engaged in CVC activities and largest amount committed to CVC investments. This trend has been explained as a firm's strategy to take advantage of the technological shock caused by Internet. To capture differences in the portfolio decisions of corporate investors, we created a dummy variable which splits the sample of CVC funds between pre-2000 and post-2000, on the base of their vintage year (*Year2000*).

Finally, Lerner's empirical work (2002: 25) suggests that "*during boom periods, the prevalence of overfunding of particular sectors can lead to a sharp decline in terms of venture funds' effectiveness.*". This difference could have important impact on the level of involvement of VC investors and thus on portfolio composition. Indeed, higher expected returns push investors to supply more venture capital funding than during period with lower expected returns. To control for these market conditions, we used the yearly *Datastream Index* of real returns per industry to test if CVC funds formed over period in which the market is "bullish" have higher/lower fund diversification than period characterized by a "bearish" market. Referring to our period of analysis, the measure of *Annual Returns* is assessed as follows:

$$Annual\ \mathrm{Re}turns_j = \left(\frac{P_{j2006} - P_{j1996}}{P_{j1996}} \right)$$

where P_j is the yearly *Datastream Index* for the sector *j* in which the corporate firm operates. As our sample is composed by several diversified firms, it was not always unambiguous defining the industry *j* to which our measure has to be referred. To resolve this problem, we adopted the following proxy: in presence of more than one SIC code describing the corporate activities, we used the primary SIC code to define the industry on which the index is assessed.

3.6 Analyses and results

3.6.1 Method

In this session, we discuss some important methodological issues: the first is related to the specification of our regression model, while the second regards the test of complementarity.

Our dependent variables, *CVC Fund Market* and *Technological Diversification* (FD), are bounded between zero and one and, thus, are a fractional response form. This feature makes an OLS specification not adapted to test our hypotheses. Indeed, two main econometric problems are encountered: the first is the heteroskedasticity problem and the second is that some of the OLS fitted values are not bounded between zero and one. For these reasons, most research with the same type of data used a logistic transformation to estimate the linear model by OLS. (Sampat, 2005; Dermine and Neto

de Carvalho, 2006; Keswani and Stolin, 2006). In our case, this transformation assumes the following expression: ln(FD/(1−FD)).

However, OLS with logistic transformation also has some problems. First, if the FD variable assumes value zero or one, then the logistic transformation is not defined, creating missing values for the dependent variable. Second, it is not straightforward interpreting the coefficient estimates of the explanatory variables as they refer not to the original dependent variable, FD, but on the new dependent variable, ln(FD/ (1−FD)). To address these issues, we implement the method proposed by Papke and Wooldridge (1996), known as "Fractional Logit Regression Model" using Quasi-Maximum Likelihood Estimation (QMLE). The authors suggested this technique to manage dependent variables that are bounded between 0 and 1, as in our case. More precisely, the model ensures that the predicted values of FD lie in the interval [0, 1], thus resolving the inadequacy of OLS estimations.

In this paper, in order to investigate Hypotheses 1a and 1b we refer to a test of complementarity which looks at the sign and level of significance of the coefficient of the *Corporate Market Diversification* and *Corporate Technological Diversification* variables. If the level of the coefficient is positive and significant, then the hypothesis of complementarity is supported. Conversely, when the coefficient is negative and significant, the hypothesis of substitution is confirmed. However, we are aware that several previous works typically use two different approaches for testing the hypothesis of complementarity, known as "productivity" and "adoption" approach (Athey and Stern, 1998). The "adoption approach" relies on reduced-form estimations of the use of one of the complements conditional upon the adoption of other complements, controlling for other observable characteristics of the adopter. In this approach, complementarity implies a positive correlation between the levels of adoption of the hypothesized

complements (Arora and Gambardella, 1990; Holmstrom and Milgrom, 1994; Arora, 1996). An alternative method for testing complementarity is the "production function approach" based on the t-test of the pair-wise interactions between the potential complements (Ichniowski et al., 1997; Caroli and Van Reenen, 2001; Bresnahan et al., 2002). Finally, Cassiman and Veugelers (2006: 71) proposed a procedure where the two methods are combined: "*[t]he two-step procedure constructs predicted values for the innovation strategy from the adoption approach. It uses the predicted values of these nonlinear regressions as instruments for the firm's innovation strategy in the productivity regression.*".

3.6.2 Descriptive statistics

We first present some descriptive statistics for the variables in our model referred to the whole sample (see Table 3.1).

Variable	*Obs*	*Mean*	*Std. Dev.*	*Min*	*Max*
Corporate Market Diversification	221	.5524936	.2294947	0	.87500
CVC Fund Market Diversification	221	.5666188	.2220041	0	.90625
Corporate Technological Diversification	221	.7206795	.1995867	0	.98284
CVC Fund Technological Diversification	221	.6419919	.2211802	0	.96153
Log (Corporate Size) - (Mil $)	221	3.408397	1.012067	.2565347	5.21409
R&D Intensity	221	10.21658	36.97978	0	540.180
Log (CVC Fund Size) - (Mil $)	221	.7944579	.4158202	0	2.33650
Early Stage	221	.6063348	.4896712	0	1
California	221	.3891403	.4886621	0	1
Year2000	221	.2624434	.4409611	0	1
Annual Returns	221	1.153159	.4858741	-.0818757	2.04046
High-Tech	221	.6651584	.4730064	0	1

Table 3.1 Descriptive statistics for our sample.

We observe that the average CVC fund size is 0.08 billions $ and the average number of investee companies for CVC fund is 9.3. Of the 221 funds analyzed, 39% is located in California (the remaining 61% includes funds in other parts of the United States, especially in the East coast). The majority of them is focused on early-stage ventures (61%) and their vintage year is before the Internet bubble of the 2000 (74%). Finally, Table 3.1 allows to compare the levels of fund's diversification by industry and technology: the average level of diversification of the 221 CVC funds is 0.56 and 0.46 for the market and technological domains respectively.

Table 3.1 also provides information about the 186 U.S. corporate investors managing the 221 CVC funds. Corporations engaged in CVC activities are generally big firms with an average size of 17.14 billions $ and an average rate of R&D expenditures over their size of 10.2. These corporations are also active in terms of patenting with, on average, 830.5 patents presented to the USPTO. The majority (67%) operates in high-tech industries and the level of direct diversification pursued through internal investments is about 0.55 and 0.72 for the market and technological sides.

Table 3.2 presents the correlation matrix for the variables of interest on the whole sample. We test for multi-collinearity by calculating the *Variance Inflation Factors* (VIF). None of the scores approached the commonly accepted threshold of 10 to indicate potential multi-collinearity problems. The mean VIF was 1.43 with a maximum value of 2.48. These results suggest that multi-collinearity is not a problem.

3.6.3 Regressions

The aim of our paper is to test the presence of complementarity/substitution between different modes of exploration, as different ways to pursue diversification.

#	*Variable*	1	2	3	4	5	6	7	8	9	10	11	12
1	*Year2000*	1											
2	*Early Stage*	0.3994*	1										
3	*California*	0.2063*	0.1152	1									
4	*Log (CVC Fund Size)- (Mil $)*	-0.0808	-0.0197	-0.0891	1								
5	*Log (Corporate Size) - (Mil $)*	-0.0054	-0.0805	-0.2180*	-0.0049	1							
6	*R&D Intensity*	-0.0434	-0.0365	0.1366*	0.0608	-0.5170*	1						
7	*Corporate Market Diversification*	0.0496	0.0008	-0.0748	0.0448	0.3879*	-0.2184*	1					
8	*CVC Fund Market Diversification*	-0.0291	0.0140	-0.0235	0.0779	0.0905	-0.0241	-0.0837	1				
9	*Corporate Technological Diversification*	0.1153	0.1389*	0.0245	0.0026	0.1830*	-0.1547*	0.1310	0.1018	1			
10	*CVC Fund Technological Diversification*	0.0934	0.0544	0.0399	0.0755	0.0518	0.0192	-0.0134	0.3465*	0.1693*	1		
11	*High-Tech*	0.0417	-0.0467	0.2808*	0.0307	-0.2248*	0.0901	-0.3443*	0.1054	-0.0749	0.0767	1	
12	*Annual Returns*	0.0784	0.1164	0.2344*	-0.0629	-0.1427*	0.0155	-0.1411*	-0.0007	0.0082	-0.0429	0.0639	1

Table 3.2 Correlation matrix - * Correlation coefficient significantly different from zero at the 5% level.

Dependent Variable	CVC Fund Market Diversification			CVC Fund Technological Diversification		
Model	(1)	(2)	(3)	(4)	(5)	(6)
Corporate Market Diversification		-.455* (.2605)	-.482* (.2601)			
Corporate Technological Diversification					.663** (.2837)	.080 (.4837)
Log (Corporate Size) - (Mil $)	.141* (.0741)	.175** (.0762)	.152** (.0767)	.177 (.1280)	.139 (.1320)	.112 (.1316)
R&D Intensity	.002 (.0058)	.002 (.0056)	.002 (.0055)	.005 (.0063)	.005 (.0066)	.004 (.0061)
Log(CVC Fund Size) - (Mil $)	.145 (.1216)	.161 (.1224)	.151 (.1235)	.262 (.2337)	.251 (.2342)	.236 (.2354)
Early Stage	.114 (.1240)	.113 (.1240)	.094 (.1235)	.145 (.2181)	.088 (.2174)	.090 (.2164)
California	-.063 (.1529)	-.042 (.1550)	-.052 (.1529)	.082 (.2213)	.055 (.2229)	.053 (.2216)
Year2000	-.098 (.1634)	-.085 (.1619)	-.110 (.1616)	.259 (.2420)	.230 (.2468)	.198 (.2498)
Annual Returns	.038 (.1420)	.016 (.1423)	-.017 (.1480)	-.141 (.2052)	-.147 (.2061)	-.227 (.2132)
High-Tech	.281* (.1459)	.217 (.1526)	.003 (.1848)	.277 (.2315)	.305 (.2341)	-.252 (.4360)
*Corporate Market Diversification * High-Tech*			.388* (.2130)			
*Corporate Technological Diversification * High-Tech*						.965* (.6224)
Constant	-631* (.3810)	-.448 (.4007)	-.276 (.4192)	-1.257* (.6900)	-1.454** (.7233)	-.833 (.8123)
Pseudo R^2	.2005	.2020	.2044	.2068	.2161	.2208
N. of observations	221	221	221	221	221	221

Table 3.3 Fractional Logit Regression using Quasi-Maximum Likelihood Estimation (Robust standard errors are in parentheses. *p < 0.1; **p < 0.05).

We referred to the following line of reasoning. If an increase of the variety of in-house competencies (i.e. corporate diversification) raises the level of diversification of CVC funds, we would expect to observe complementarity between corporate and CVC fund

diversification. In other words, if these two strategies are complementary, then they will be positively related. In case of substitution, the opposite output occurs.

Table 3.3 reports the results of our QLME analyses. Robust standard errors are in parentheses, in order to control for heteroskedasticity. Models 1 and 4 (for the market and technological perspective respectively) omit the corporate diversification variables. The only significant predictors (at the 10% level) in Model 1 are the logarithm of corporate size and the distinction between high- and low-tech industries, as might be expected from theory. Larger firms and firms operating in high-tech sectors tend to create more market diversified CVC funds than smaller firms or firms active in low-tech sectors. Beckman and her coauthors (2004), for instance, showed that firm size contributes to exploration, while Rowley et al. (2000) suggested that firms operating in rapidly changing environments (i.e. high-tech industries) tend to allocate more resources towards exploration than in more stable environments (i.e. low-tech industries). Surprisingly, the same variables are not significant when their effect on the CVC fund technological diversification is analyzed, thus, suggesting that corporate size does not affect portfolio decisions focused on the search of new technologies.

In Model 2 and Model 5 our main independent variables on corporate diversification are introduced. Model 2 tests the Hypothesis 1a which predicts a substitutive relationship between corporate and CVC fund diversification for market domains. The negative (-0.455) and significant (at the 10% level) coefficient for our main independent variable supports this hypothesis. Conversely, Hypothesis 1b suggests a complementary relationship between corporate and CVC fund diversification for technological domains. The coefficient of *Corporate Technological Diversification* in Model 5 is equal to 0.663 and significant at the 5% level, thus, sustaining also this second hypothesis. The data of these models also confirm the positive impact of

Log(Corporate Size) on *CVC Fund Market Diversification* and the absence of significant effect on *CVC Fund Technological Diversification*, as in the previous models.

Finally, Models 3 and 6 are a test for interaction effects. The moderating effect suggested by our second set of hypotheses is significant. More precisely, introducing the interactive term between our main independent variables (*Corporate Market* and *Technological Diversification*) and the dummy *High-Tech* to the previous regressions, we find that the effect of substitution between corporate and CVC fund diversification for the market side vanishes (Hp. 2a confirmed at the 10% level), while for the technological perspective, the complementary effect is amplified (Hp. 2b confirmed at the 10% level). Because of the more competitive environment characterizing high-tech industries, corporations operating in these sectors tend to be more explore-oriented. Dushnitsky and Lenox (2005b), analyzing the conditions under which firms are likely to pursue equity investment in new ventures as a way to source innovative ideas, suggest that corporations tend to prefer industries with high technological ferment. Beckman et al. (2000) argue that firms operating in turbulent environments with high uncertainty have to monitor vast spaces of opportunities, exploring new applications of their technologies.

Our analysis, therefore, provides evidence of significant differences in the use of CVC investments as explorative tools for seeking out new opportunities. In particular, the distinction between market and technology domains matters. This is in line with the diversification literature suggesting that the technological competencies of large firms are spread over a large number of fields, while market capabilities tend to be more focused.

3.7 Discussion

In this paper, we started from the observation that firms often simultaneously invest in multiple exploration projects. We identify two sources of exploration (corporate diversification and CVC investments) and two types of relationships (complementarity and substitution). More precisely, our goal is to shed new light on the role of CVC investments inside large corporations, in sustaining the search for diversification, as a form of explorative learning. In particular, we test the presence of complementarity or substitution between corporate diversification (pursued through internal investments) and CVC fund diversification (by investing in external new ventures). The second, and related, objective is to examine how some key industry characteristics can differentially affect firms' propensity to use CVC investments as a complement (or substitute) to internal corporate investments.

Our results on a sample of 221 CVC funds created by 186 U.S. public corporations suggest that external ventures are attractive because they can help the firm overcome "local search" and reach out for new and distant capabilities. Interestingly, our evidence indicates that the use of explorative processes by large corporations varies depending on the context and the nature of explorative search. When the corporate goal is to sustain a technology-based strategy or when the main industry of the mother firm is a high-tech sector, firms tend to create complementary relationships between explorative modes thus exploiting super-additive effects. In case of search for market opportunities, the scenario is the opposite: an exploration performed through external resources (i.e. CVC investments) substitutes efforts based on internal development, thus, creating sub-additive effects (Vassolo et al., 2004).

The contributions of this paper are multiple. First, we conceptualize corporate diversification and CVC investments as different ways to sustain explorative learning.

Both these mechanisms help firms in the creation of knowledge platforms, permitting to leverage a wide array of distant market and technological opportunities. This is an interesting aspect as previous works analyzed different mechanisms of exploration in isolation or by considering only substitutive effects (Dushnitsky and Lenox, 2005b), without considering possible complementary relationships. Second, we compare in an integrated framework two modes to create diversity among activities which are based on different types of resources: the former refers to the use of *internal* development processes, while the latter is oriented towards investments in *external* ventures. The third contribution is more related to the literature on portfolio choices. While several studies on venture capital have investigated how managers tend to create their portfolios in terms of preferences for particular stages of development, industries or technologies of the supported deal, level of diversification and size of the fund (Norton and Tenenbaum 1993, Cressy et al., 2007), in the CVC field, little attention has been paid on how corporate investors cope with the composition of their portfolios. CVC, if compared to traditional VC investments, is characterized by the presence of the corporate firm which creates the fund (i.e. the "mother firm"), in addition to the fund's managers and the investee companies. Thus, studies on portfolio choices made by corporate investors need to introduce also this aspect. In this study, we address this issue by analyzing how firm-specific characteristics, as the level of corporate diversification, the size and the R&D intensity of the mother firm, impact on the choices of portfolio's design. Forth, following the literature which decomposes diversification into market and technological domains, we increase our knowledge on the importance to conduct analyzes based on the distinction between these dimensions.

To conclude, some limitations and directions for future research. The most critical limit of this work is about the test of complementarity. In this paper, we simply

analyze if the sign and level of significance of the coefficient of our main independent variables (*Corporate Market* and *Technological Diversification*) are positive and significant (reflecting the presence of complementarity) or negative and significant (supporting the existence of substitution). As pointed out in the methodological session, other approaches can be implemented to more systematically investigate the presence of complementarity. Thus, future works could extend our analyses by testing the hypothesis of complementarity through the "productivity" or the "adoption" approach (Athey and Stern, 1998), or a combination of the two (Cassiman and Veugelers, 2006).

Second, our analysis relied on data from a single country. This kind of specificity raise problems about the generalizability of our results to other contexts. Future research could extend these analyses in different countries. Third, in the introduction of corporation-level factor influencing portfolio choices we introduced only the degree of diversification of the mother firm. However, in the literature on CVC a further interesting driver to consider is the industry and technological overlap (or relatedness) between the portfolio companies and the corporation (Schildt et al., 2005). Further works could include these dimensions in the analysis to improve our understanding on how firms direct their investments. Forth, we focused on CVC as a form of external corporate venturing. It could be interesting to analyze how other forms of exploration through external resources (alliances, acquisitions, joint ventures) are integrated within the firm and how firms decide about different modes to invest in new ventures. Fifth, we assumed, on the basis of academic surveys (MacMillan et al., 2008; Ernst and Yung, 2008), that the primary motives for corporate investors are strategic and based on the search for exploration. We were unable to get more detailed data on corporate investors' objectives by distinguishing between exploratory versus exploitative motives. Future studies could extend our framework by capturing this different nature of goals

and analyzing not only the relationships between internal and external forms of exploration, but also of exploitation. Finally, we also investigate the effect of inter-industries differences on the use of CVC as explorative tool through the macro-distinction between high versus low-tech sectors as suggested by Hall and Vopel (1997). However, we are aware that a dummy variable that roughly captures the intensity of technological research within an industry has some limits. Indeed, within these broad categories there is high heterogeneity that is not explained and that could be captured, for example, referring to the technology and market characteristics that determine the regime of appropriability within which the firm operates (Teece, 1986). Future studies could include this variable by using the Yale Survey (Levin et al., 1987) or the survey used in the work by Cohen et al. (2000) that gathered data to construct measures of appropriability at the industry level widely used by several applications (Levin et al., 1985; Cohen et al., 1987; Cassiman and Veugelers, 2002).

3.8 Appendices

3.8.1 Appendix A. Use of standardized classification systems (SIC and IPC)

Among the several attempts made by the previous literature to measure the degree of diversification, we refer to those approaches deploying indexes based on standardized classification systems like SIC (Standard Industry Classification) and IPC (International Patent Classification). The assumption is that if two businesses (technologies) share the same SIC (IPC) code, they must have common input requirements and similar production (and technology) functions. A fund investing in similar companies and a firm operating in similar industries or technological areas can, thus, be considered weakly

diversified. Generating the abovementioned measures of diversification (for both funds and corporations) based on the classification schemes involved a number of steps and problems, especially for the market-based perspective. For *Corporate* and *CVC Fund Market Diversification*, we started from gathering data about industries where corporations and investee companies operate. Specifically, *VentureXpert* provides a classification based on a proprietary scheme, called Venture Economics Industry Classification (VEIC). For the portfolio companies, *VentureXpert* also offers the match between the VEIC and the SIC codes. However, to be sure of the perfect comparability in terms of classification systems, we manually control each VEIC-SIC pair assigned to each venture using a manual process and making some hand adjustments to obtain a homogeneous classification based on the SIC codes. A second concern related to the construction of these measures for the corporations arose. Detailed VEIC codes (4-digit number) were available only for the funded firms, while the investing corporation's industry were identified with a more aggregate code (1-digit number). This created a problem for the assessment of corporate market diversification based on the same degree of accuracy for industries of both corporations and ventures. Thus, we complemented the data gathered from *VentureXpert* with *Worldscope*, which provides a list of maximum eight SIC codes at the 4-digit level for each of our corporations on the base of the distribution of sales.

The measurement of *Corporate* and *CVC Fund Technological Diversification* posed minor problems as patent classification (IPC) is unique and the detail level is the same for both corporate and CVC funds. To examine the extent of diversification, we needed to determine the technological portfolio of each firm (corporations and investee companies), measuring the distribution across IPCs of its granted patents. For this

purpose, we collected granted patents by the USPTO and *Delphion* as described in the data sources section.

3.8.2 Appendix B. Robustness check

As a robustness check, we also estimated our statistical model using the *Entropy Index* as our dependent variable, defined as suggested by Robin and Wiersema (2003 and 2005). Unlike the *Herfindahl index*, this second measure accounts for possible integration or relatedness among businesses or technological domains. Using the same notation for the specification of the *Herfindahl index*, we define:

$$Entropy_j = -\left[\sum_{j=1}^{J}\left[\left(P_{ij}\right) * \ln\left(P_{ij}\right)\right]\right] = -\left[\sum_{j=1}^{J}\left[\left(\frac{N_{ij}}{N_i}\right) * \ln\left(\frac{N_{ij}}{N_i}\right)\right]\right]$$

A number of studies have been carried in order to analyze which of the two indexes is the most reliable for measuring diversification (Woerheide and Persson, 1993; Acar and Sankaran, 1999; Robin and Wiersema, 2003). From these studies emerge that these two indexes tend to measure different aspects of diversification. This means that their validity is strictly dependent on the theoretical concerns at the base of the research. In particular, Robin and Wiersema (2003) suggest that *Entropy Index* should be preferred whenever the focus of the research is on the relatedness of portfolio assets, while the *Herfindahl Index* should be preferred to test the presence of "pure" diversity of assets in portfolio. Although, in our case, the estimates from both the models were similar and since the purpose of this paper is to study the relationship between corporate and CVC portfolio diversification in terms of diversity (and not relatedness), in the following, we refer to the *Herfidhal* measure of diversification to present our analyses and results.

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CHAPTER 4 - HOW GOOD ARE VCS AT VALUING TECHNOLOGY? AN ANALYSIS OF PATENTING AND VENTURE CAPITAL INVESTMENTS IN NANOTECHNOLOGY[10]

ABSTRACT

This paper analyzes how VC firms evaluate the patent portfolios of start-up companies in their financing decisions. On one hand, we determine whether the amount of VC financing is associated with three elements related to technological portfolios: patent counts, patent scope and the number of core technology patents. On the other hand, we examine whether the valuation of patents in the financing decisions varies across different types of VC firms, depending on their degree of industry specialization and affiliation. We provide empirical evidence from a sample of 332 VC-backed companies in the nanotechnology sector.

Keywords:

Venture Capital, Patent Portfolios, Specialization, Nanotechnology.

[10] This paper is co-authored with Federico Munari and it has been presented at the 2008 Academy of Management Annual Conference (Technology Innovation Management Division), Anaheim, August 8-13, where it received the Best Paper Finalist Award for the Technology Innovation Management Division.

4.1 Introduction

The economic literature points to the superior ability of Venture Capital firms (VCs) in accurately assessing the value of early-stage companies' technological capabilities and patent portfolios. For instance, previous studies have shown a positive association between patenting rates and total amount of VC financing (Baum and Silverman, 2004; Mann and Sager, 2007) and between the breadth of patent protection and VCs' valuation of new companies (Lerner, 1994). Moreover, previous works have examined the effects of VC on patented innovations at an industry level (Kortum and Lerner, 2000) or at a company level (Bertoni et al., 2006), showing a positive association between VC and patent productivity.

In general, however, there is only a limited understanding of the determinants of patent value that are more directly taken into consideration by VC firms in their investment decisions. Indeed, it is likely that such decisions are influenced by other factors in addition to mere patent counts and patent scope. In particular, no attempt has been made to assess whether and how VCs take the patent content into consideration. To address this issue, we introduce the distinction between patents directly related to the core technological capabilities of the company, which we label as *core technology patents*, and those belonging to other technological domains not directly related to the core technological capabilities of the company.

In addition to that, it should be noted that there is also a high heterogeneity in the characteristics of VC firms, in terms of age, affiliation, managerial style, reputation, experience, stage and industry focus. It is thus likely that the ability to evaluate technology and intellectual property might not be the same for all VCs, but it might be a function of two critical elements, their degree of specialization in the industry and their

type of affiliation. First, several scholars have acknowledged the importance of maintaining a high degree of specialization in order to control uncertainty and risk, and to gain access to networks and information, or to possess a deeper knowledge of the ventures' environment (Gupta and Sapienza, 1992; Norton and Tanenbaum, 1992; Cressy et al., 2007). Second, the affiliation of the VC firms, separating Independent Venture Capitalists from Corporate Venture Capitalists, is likely to impact on their selection criteria and valuation skills, due to differences in objectives and capabilities (Bertoni et al., 2006; Gompers, 2002). However, to our knowledge no attempt has been made in the literature to assess whether VCs differ in their valuation ability.

Thus, the purpose of our paper is twofold: on one hand, we determine whether the amount of VCs' financing obtained by the company is associated with the number of *core technology patents* of the start-ups' technological portfolios. We argue that, ceteris paribus, companies with a higher number of patents related to their core technological capabilities tend to receive a higher amount of VC funding. On the other hand, we examine whether the valuation of patent portfolios varies across VCs, depending on their affiliation and degree of industry specialization. We argue that VCs that are specialized in the same industry as the investee company tend to place more importance in their financing decisions on the number of patents held in new core technologies, compared to generalist VC firms. Similarly, we argue that corporate VC firms tend to place a higher value on patents related to new core technologies in their financing decisions, compared to independent VC firms.

We analyze such topics with a sample of 332 VC-backed companies in the nanotechnology sector in the period 1985-2006, selected through the commercial database Venture Expert. Our results show that the mere number of patents applied by the company before the first investment round does not have a significant impact on the

amount of financing received. On the contrary, the stock of patents belonging to the nanotechnology class (which represents the core technological domains of the companies in our sample) has a positive and significant effect on VC financing. Moreover, VCs specialized in the field of nanotechnology tend to place more value on nanotech patents in their financing decisions, compared to unspecialized VCs. However, we did not find significant differences between Corporate VCs and Independent VCs in the assessment of the technological contents of patent portfolios in their financing decisions.

The rest of the paper is organized as follows. We first briefly summarize previous literature which has addressed the relationship between patenting and VC investments. Moreover, we discuss the association between the degree of specialization of the VC firm and its type of affiliation and its ability to evaluate the patent portfolios of the investee company. We then describe the nanotech sector, the sample and the variables used in the empirical analysis. We then present the results of different regression analyses. In the final section we outline the main conclusions to be drawn from the theoretical and empirical analysis, and discuss the implications for future research.

4.2 Background

Venture Capitalists (VCs), i.e. financial intermediaries investing equity in young companies, are a distinct type of investors for entrepreneurial companies operating in dynamic and uncertain industries. One of the major peculiarities of VC investments is the difficult and uncertain valuation on which their selection process is based. Indeed, the lack of a clear performance history for early-stage companies does not allow the application of conventional financial evaluation methods. Thus, venture capitalists have

to rely on a subjective assessment procedure driven by a multidimensional list of characteristics.

Several studies have tried to highlight the most important features considered by VCs in the selection of new ventures. The results highlight a comprehensive list of the evaluation criteria considered relevant by VCs: financial aspects, product-market attractiveness, technological characteristics, strategic-competitive impact, management team features and deal criteria (Tyebjee and Bruno, 1984; Muzyka et al., 1996). A deeper understanding of the criteria employed by successful VCs in evaluating new ventures, in particular for what concerns the role played by patent portfolios, is important for two main reasons: from the VCs' point of view, it would provide a useful framework for evaluating entrepreneurial ventures and reduce the failure rates of new ventures. From the entrepreneurs' point of view, it could clarify the factors leading to a higher likelihood of obtaining VC financing.

For the purpose of our work, we will focus on the set of technological capabilities developed by the new venture (and in particular on those protected by patents) as a potential driver of the investment decision by VCs.

4.2.1 The relationship between patenting and VC investments

The economic literature points to the superior ability of VCs in accurately assessing the value of new ventures' technologies and patent portfolios. The majority of the studies confirm that patents are an important signal of a start-up's innovative capabilities, increasing the likelihood of obtaining VC financing.

At an industry level, Kortum and Lerner (2000) examine the relationship between the total number of patents issued at the USPTO and the amount of VC financing across 20 manufacturing industries between 1965 and 1992 in the United

States. They observe that increases in VC activities in an industry are associated with higher patenting rates. At a company level, in a study of 204 biotech start-ups, founded in Canada between 1991 and 2000, Baum and Silverman (2004) found that start-ups with more patent applications and grants obtained significantly more VC financing. Finally, a recent study by Mann and Sager (2007) in the software and biotechnology industries found similar results: patenting increases the likelihood of start-up firms receiving VC financing, even though the relationship seems to be present in later financing rounds, but weak, if not absent, in initial ones. It also shows that the relationship between patenting rates and VC financing depends less on the size of the patent portfolio than on the firm's receipt of at least one patent. However, the study does not address the causation issue, related to the possibility that funding might facilitate patenting.

Besides presenting some controversial results, the literature on the relationship between patenting and VC investments provides a limited understanding of the determinants of patent value that are more directly taken into consideration by VC firms in their investment decisions. In fact, it is likely that such decisions are influenced by other factors in addition to mere patent counts. One exception is represented in a work by Lerner (1994), predicting that the breadth of patent protection is significantly associated with higher valuations by VCs. His analyses, based on a sample of 535 financing rounds at 173 VC-backed biotechnology companies, show that patent scope (operationalized as the count of different IPC classes to which the patent is assigned) positively affects the valuation of new biotech companies by VCs.

We take these works as our foundation and we extend and integrate them by introducing a third element referred to patents which VC firms could include among their selection criteria. This factor is the technological content of the start-up's patent

portfolio. The logic that underpins our hypotheses is that patents differ not only in their potential economic value, but also in terms of fit with specific types of technological capability. The Resource-based View (RbV) highlights the critical role played by capabilities, considering a firm's resources as the primary determinant of competitive advantage (Barney, 1991). Among the firm's resources and capabilities, Prahalad and Hamel (1990) mainly pointed out the critical benefits embedded in the *distinctive* (or *core*) competencies. The authors suggested that a core technological competency is a source of long-run competitive advantage for the firm because it provides potential access to a wide variety of markets, makes a significant contribution to the perceived customer benefits of the end product and is difficult for competitors to imitate. However, the evidence that firms are becoming more technologically diversified over time challenges the conventional wisdom that for every company there exists only a narrow set of technological competencies on which the company should focus (Patel and Pavitt, 1994 and 1997; Gambardella and Torrisi, 1998). In line with this thinking, Granstrand et al. (1997) suggested a classification of technological competencies, along two dimensions: the patent share, reflecting the relative importance of each field in the firm's total technological portfolio, and the firm's revealed technological advantage in each of the technical fields. The most relevant evidence deriving from this representation is that, in addition to *distinctive* competencies, characterized by high levels in the two dimensions, management needs to sustain a broader set of technological competencies (*background*, *marginal* and *niche*), in order to co-ordinate continuous improvement and innovation in the corporate production system. Thus, firms typically become multi-technology, with a set of competencies distributed across several technical fields, and tend to construct diversified technological portfolios, where each patent refers to a different type of technical competency, distinctive or not.

In this paper, we thus investigate whether technological heterogeneity, in terms of technological competence underlying the patents of the start-ups' portfolio, is considered by VC firms and influences their financing process. Thus, we do not analyze all patents as a whole, but we focus on those patents protecting a specific core technology. In this line, we introduce the concept of *core technology patents* to isolate the importance of that technology strongly linked to the core competencies of the firm (Patel and Pavitt, 1994; Granstrand, 1997). When deciding to invest, for instance, in a nanotech start-up, it is likely that VCs put more emphasis and importance on the assessment of those patents that are more directly related to the core technological competencies of the company, represented in this case by the nanotech patents. Indeed, core technology patents which refer to the resources the company can use to create unique levels of competitive advantage, could be considered by VCs as the most valuable because they are the most critical and distinctive resources a company possesses (Prahalad and Hamel, 1990). Thus, as a first contribution of the paper, we test the following hypothesis:

Hp 1: The number of core technology patents held by a company has a positive impact on the amount of funding received by a VC firm.

4.2.2 The heterogeneity of VC firms and its impact on the valuation of a start-up's patent portfolio

The role of specialization: specialist versus generalist VCs

Most of the financial and strategic literature on venture capital tends to consider VC firms as a homogeneous group, ignoring their significant differences in objectives,

investment decisions and managerial styles. On the contrary, more recent works have shown that VC characteristics - and in particular their degree of specialization in an industry - can make a difference in terms of the outcome of their investments (Cressy et al., 2007; Gompers et al., 2005).

VCs adopt different strategies regarding the composition of their investment portfolios (Gupta and Sapienza, 1992; Norton and Tenenbaum, 1993). Some VC firms tend to specialize in specific industries and development stages, in order to acquire expertise and gain greater value, whereas others follow a more generalist approach, diversifying their investments across a wide variety of industries and technologies. For instance, the empirical study by Gupta and Sapienza (1992) shows that VCs focusing on early stage ventures prefer less industry diversity and narrower geographic scope when compared to other VCs. Furthermore, larger VCs prefer greater industry diversity and broader geographic scope than smaller VCs.

Following the predictions of the resource-based theories of the firm (Barney, 1991), previous experience cumulated in a given industry, thanks to specialization, might allow VC managers to gain a better understanding and deeper knowledge of the technological, market and competitive specificities of the investee companies' context. This, in turn, might facilitate not only the correct assessment of new investment opportunities, but also allow them to effectively add value to the investee companies, through more competent monitoring and advice. Busenitz et al. (2004) point out that VCs' learning should result in long-term positive performance implications, given that a VC investor with a significant experience of both successes and failures in an industry could gain a deeper insight into how to select potential "winners" and improve their performance over time. Norton and Tanenbaum (2002) acknowledge the importance of maintaining a high degree of specialization in order to control risk and gain access to

networks and information. Similar results are found also by Cressy et al. (2007), who argue that possessing a deeper knowledge of the ventures' environment confers competitive advantages in terms of reduced information asymmetries and uncertainty in the valuation and selection process.

The critical role played by specialization has been also highlighted by Gompers et al. (2005), who point out that, when there are complementarities and a direct relationship between the investments embedded within the portfolio, the VC firm more quickly liquidates its investments through IPOs and with higher valuations. Building on such results, the authors thus recognize "*[…] the importance of industry-specific human capital and the network of industry contacts to identify good investment opportunities, as well as the know-how to manage these investments*" (Gompers et al., 2005, p.5).

Thus, the ability to evaluate technology might not be the same for all the VCs, but it might be a function of their degree of specialization in an industry. More precisely, we expect that, ceteris paribus, VCs specialized in the same industry as the investee company give more importance to patents related to the core technological capabilities of the company, compared to unspecialized VCs. We therefore suggest the following hypotheses:

Hp 2a: The number of core technology patents held by a company has a positive impact on the amount of funding received by an Industry-specialized VC firm.

Hp 2b: The number of core technology patents held by a company has no significant impact on the amount of funding received by a generalist VC firm.

The role of affiliation: independent versus corporate VCs

Concerning the heterogeneity of VC firms, a further distinction can be drawn in terms of affiliation. A particularly important distinction in the venture capital community is the one between Independent Venture Capitalists (VCs), where the capital is provided by professional financial intermediaries, and Corporate Venture Capitalists (CVCs), where the investor is not a financial entity but a corporation (Hellmann, 2002).

These two types of investors widely differ in several ways: structure of incentives, monitoring behaviour, time horizon, scale of capital invested and set of objectives pursued (Chesbrough, 2000). As far as the latter is concerned, the main financial aim of VCs is to liquidate their investments through IPO or to sell the company to a larger firm in the shortest possible time. In contrast, CVCs generally aim to capture the value from strategic assets, open up a window on new promising technologies, respond more competitively in dynamic industries and accelerate market entry (Brody and Ehrlich, 1998, Dushnitsky and Lenox, 2006). The existence of these critical differences explains the need to analyze VCs and CVCs as autonomous forms of financing new ventures.

In the previous literature, such evidence led to the analysis of the distinct contributions of VC and CVC to the investee ventures. Jain and Kini (1995) compared the growth of VC and CVC-backed firms, finding that the former outperformed the latter; Bertoni et al. (2006) suggested that, even though both VC and CVC positively affect venture growth, the benefits of the former considerably exceed those of the latter. These results can be explained considering the active role of VCs in the businesses they finance, not only through monitoring, but also by providing valuable support and governance. Previous studies have shown the significant role played by VCs in terms of their ability to obtain additional financing for the investee companies by cultivating a

broad network of commercial partners and allies in the financial markets (Macmillan et al., 1989; Sapienza et al., 1996), professionalization of start-up firms by recruiting valuable managers to complement or replace the existing members of the entrepreneurial team (Hellmann and Puri, 2002) and improvement of ventures' performance at the IPO (Brav and Gompers, 1997). To summarize, VC firms can primarily be characterized by their commercial ability and financial knowledge.

On the other hand, VCs do not possess the same influence in areas that are closely related to the core business of the investee companies and, as "outsider" investors, it is likely that they are less able to support the technological and commercial quality of the venture (Stuart et al., 1999). CVCs, on the other hand, are affiliated to corporations with well-defined businesses and competencies, internal expertise and specific technological knowledge. Furthermore, corporations engaged in CVC are generally active in high-tech industries and often operate in the same area as the investee company. Thus, CVCs have the reputation needed to help companies in their growth by easily providing them with business partners and the ability to evaluate technological resources in their due diligence processes. As a consequence, it is likely that CVCs will develop more expertise (if compared to VCs) in the evaluation of specific technological capabilities. Thus, we expect VCs and CVCs to differ not only in terms of objectives but also in their decision-making process by choosing different criteria to select potential financing ventures. More precisely, we suggest that while VCs may be influenced by mere patent counts in their investment decisions, CVCs may pay more attention to other measures which, instead, reflect the technological content of patents.

Hp 3a: The number of core technology patents held by a company has a positive impact on the amount of funding received by a Corporate VC firm.

Hp 3b: The number of core technology patents held by a company has no significant impact on the amount of funding received by an Independent VC firm.

4.3 Methods

4.3.1 The context

Nanotechnology can be defined as the study and use of the unique characteristics of materials at the nanometre scale, between the classical large-molecule level to which traditional physics and chemistry apply and the atomic level in which the rules of quantum mechanics take effect (Lemeley, 2005). Although the scientific interest in the "nano" world can be traced backed as far as the 1950s, a key date for the industrial development of nanotechnology is 1981, with the design of the Scanning Tunnelling Microscope by IBM scientists. The STM allowed researchers to "see" atoms and molecules at the nanometre scale, a precondition for finding novel proprieties at the nanoscale and making use of this knowledge to develop new materials and products. Indeed, the wide interest in nanotechnology stems from the fact that the ability to operate with atomic precision allows scientists to produce materials with improved or new optical, magnetic, thermal or electric proprieties, opening up a broad range of commercial applications.

An important characteristic of patents in nanotechnology is their inter-disciplinarity: nanotechnology is sometimes referred to as a general-purpose technology, because in its advanced form it will have a significant impact on almost all industries and all areas of society. It attracts scientists from many areas of science (e.g., physics, chemistry, biology, computer science, etc.), and in the wide spectrum of

potential market applications, which can involve very different businesses (such as computers, flat-panel displays, diagnostic products sensors, lighting devices and many others).

The field of nanotechnology is an optimal setting to study how VC firms evaluate patent portfolios in their investment decisions for various reasons. First, several new ventures have been created in nanotechnology in the United States and other countries in the world, which are mainly spin offs from universities and government laboratories. The creation and growth of new companies has been favoured by the wide availability of funding from governments, established companies and venture capitalists. In particular, VC investments in the nanotech field have steadily increased over the last decade, reminiscent of the earlier development of the biotech industry. Second, patents represent an important and effective mechanism to protect the returns stemming from nanotech investments, as witnessed by a real "boom" in the number of nanotechnology patents registered all over the world during the last 10 years. According to the Wall Street Journal, "Patents awarded annually for nanotechnology inventions have tripled since 1996, with 10-fold or greater increases in some areas during the past years". For many nanotech start-ups, the intellectual-property portfolio represents the main asset, to be exploited through business models based on the commercialization of new products (vertical integration) or on licensing revenues.

In addition, defining a nanotechnology patent is not an easy task, given the newness of the field and the many different scientific and technical areas involved. Such characteristics make it extremely difficult to adopt conventional IPC classes to tag nanotech patents, inducing high levels of uncertainty for patent examiners, inventors and prospective investors, including VCs.

In order to facilitate interdisciplinary searches and monitor trends in nanotechnology, the EPO has recently developed a new code (the Y01N) in order to tag all nanotech patents[11]. All European patent applications have been classified ex-post by a group of patent experts in order to tag them, if applicable, with the new code. The new classification has been publicly disclosed by the EPO since January 2006. Since that date, with a simple query on the search engines of the EPO website, it has been possible to collect information on all the patents granted in the nanotech field.

4.3.2 The sample

We created a sample of companies operating in nanotechnology and financed by VC funds over the period 1985-2006. Our data on VC investments in nanotechnology are taken from Thomson Venture Economics (*Venture Expert*), which can be considered the most comprehensive commercial data source on the global VC industry. All VC-backed companies operating worldwide in the field of nanotechnology over the period 1985-2006 were identified[12], amounting to 361 companies. For each company, we collected the following information from Venture Expert: country, main industries (according to the 4-digit Venture Expert Industry Classification), VC firms investing in the company (including the leading investor in syndicated deals), founding year, year of the first and subsequent stages of investment, amount raised (in US $) in each financing round.

[11] In the Y01N subclass the term 'nanotechnology' "[...] covers all things with a controlled geometrical size of at least one functional component below 100 nanometres (nm) in one or more dimensions susceptible to make physical, chemical or biological effects available which cannot be achieved above that size without a loss of performance (Scheu, 2005)".

[12] Venture Economics classifies all venture capital and private equity deals in 6 main categories (and several other sub-categories), according to the stage of development of the investee company: seed, early-stage, expansion, later-stage, buyout/acquisition, and other. Since our interest resides in new ventures, we focused exclusively on deals belonging to the first 4 categories, and excluded from the analysis "buyout/acquisition" deals. In order to identify companies operating in nanotechnology, we adopted the classification of Venture Expert, which assigns each company to specific technological areas, including nanotechnology.

Information on the initial amount of funding received by VC was available for only 332 companies, which therefore represent our final sample.

For each VC-backed company, we identified the leading investor as either (a) the PE firm that at the moment of the buyout was explicitly mentioned as the leading investor or (b) the firm that held the largest equity stake in the buyout. We then complemented such information by gathering the following data on all the VC firms investing in nanotechnology: firm name, affiliation (i.e. independent, corporate, financial, public), number of companies in the current portfolio, breakdown of portfolio companies by industry.

In order to construct the patent portfolios of our sample companies, we referred to patent applications at the European Patent Office. We first identified all patent applications at the European Patent Office in the field of nanotechnology over the period 1980-2006. Nanotech patents were identified as showing the code Y01N in the ECLA classification scheme. As of June 2007, the date of data extraction, the European Patent Office register contained 9813 nanotech patent applications.

4.3.3 Variables

Dependent variable

VC Financing Amount measures the log transformation of the total amount of VC financing (in million US dollars) obtained by the company at the first investment round[13]. Limiting the study to the initial financing round eliminates the problems related

[13] While Venture Economics identifies the date and number of investors for each financing round, and in most cases the amount invested by each investor, it does not systematically track the price paid per share. Given that data on the so called pre-money valuation - the product of the price paid per share in the financing round and the shares outstanding before the financing round - were largely unavailable, we

to the causality link between patenting and VC financing. Indeed, previous work has shown that the receipt of VC funding might significantly enhance patent productivity (Kortum and Lerner, 2000; Bertoni et al., 2006). By considering only the initial financing rounds, we could directly assess the impact of the characteristics of patent portfolios on VC investment decisions, our research question, and rule out the "chicken-egg" problem related to the positive impact of VC investments on patenting activity.

Independent variables

The *Patents* variable measures, for each company, the stock of patent applications at the European Patent Office at the date of the first financing round. The searches were conducted in June 2007 using the April 2007 version of the Patstat database, created by the European Patent Office.

For each company, *Nanotech Patents* measures the stock of patent applications at the EPO in the nanotechnology class. This variable represents the previously labelled *core technology patents* in the specific case of nanotechnology-based companies. Nanotech patents were identified through the "Y01N" code of the ECLA classification, specifically introduced by the EPO to tag this kind of patent.

Patent scope captures the average breadth of patents included in the portfolio of the VC-backed company at the year of the first financing round. Ideally patent scope should be measured, for each patent, through the subjective assessment of experts in the nanotechnology field (e.g. researchers, patent attorneys) in order to value the breadth of the claims. However, this is practically impossible for large groups of patents. We thus decided to apply the measure identified and validated by Lerner (1994) in his study of

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were unable to assess the impact of patent portfolio size, focus and scope on firm value, as in Lerner (1994).

the biotechnology industry. Therefore, for each patent, we measured patent scope by counting the number of IPC classes to which patent examiners assigned each nanotech patent, using the first four IPC digits only. We then computed the average value of this measure for all the patent applications included in the company's portfolio during the year of the first financing round. If the company had no patents, we coded the average patent scope as zero, as in Lerner (1994).

In order to identify different types of VC firms investing in nanotechnology we used the following dummy variables, which were used to perform "split sample" regression analyses.

Specialized VC is a dummy with the value 1 if the company was financed by a leading VC firm specialized in nanotechnology, and 0 in all other cases[14].

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[14] The measure of specialization of the leading VC firm in nanotechnology is adapted from Cressy et al. (2007). For each VC firm included in Venture Expert, we first defined an index, *RIA*, or Revealed Industrial Advantage in nanotechnology, computed as:

$$RIA_{iN} = (C_{iN} / C_{.N}) / (C_{i.} / C_{..})$$

where:
C_{iN} is the number of portfolio companies of VC firm *i* in the field of nanotechnology,
$C_{.N}$ is the total number of companies invested in the nanotechnology field by all VC firms
$C_{i.}$ is the total number of portfolio companies of VC firm *i* and
$C_{..}$ is the total number of companies invested by all VC firms (i.e. across all sectors).

The numerator in this measure ($C_{iN}/C_{.N}$) represents the VC firm *i*'s share of all investments in the field of nanotechnology and the denominator ($C_{i.}/C_{..}$) the VC firm *i*'s share in all investments (i.e. across all sectors). RIA_{ij} therefore measures the VC firm *i*'s *investment focus* in nanotechnology *relative to that of its VC competitors.*

Note that:

$$RIA_{iN} \begin{cases} = 0 \Leftrightarrow C_{iN} = 0 \\ < 1 \Leftrightarrow C_{iN} / C_{.N} < C_{i.} / C_{..} \\ \geq 1 \Leftrightarrow C_{iN} / C_{.N} \geq C_{i.} / C_{..} \end{cases}$$

so that a value of RIA_{iN} less (greater) than one indicates that the VC firm *i* is relatively unspecialised (specialised) in nanotechnology.
We used Venture Economics in order to identify, for each VC firm, the share of its portfolio companies in nanotechnology, as well as the total number of portfolio companies included in each industrial sector over the period 1990-2006. We computed the *RIA* index over the period 1990-2006, consistently with the time period under study.
We then used the *RIA* index to create the dummy variable *Specialized VC*. For each company in the sample, *Specialized VC* takes the value 1 when the company was acquired by a leading VC firm specialized in nanotechnology (i.e. with a *RIA* greater than 1), and 0 in all other cases.

Corporate VC is a dummy with the value 1 if the company was financed at least by one Corporate VC firm, and 0 otherwise, based on the classification provided by Venture Expert.

Control variables

We also included a set of control variables in our analyses which might affect the total amount of financing obtained by the investee company in the initial round.

Company Age measures the age of the company at the date of the initial financing round, computed as the difference between the investment year and the foundation year of the company[15].

Market scope captures the degree of market diversification of the investee company. Previous research has shown that the size and attractiveness of the product markets in which the target companies operate represent important determinants of the investment decision by VC firms (Tyebee and Bruno, 1984; MacMillan et al, 1985). It is thus likely that companies operating in different markets are characterized by a higher growth potential, thus obtaining higher valuations and financing by VC firms. We measured the market scope of the investee company with the count of different industries to which the company is assigned by Venture Economics.

Dummy US is a dummy with the value 1 for companies located in the United States, and 0 in all other cases. Since the VC industry in the US is by far the most developed in the world in terms of overall amount of funds available, number and

[15] The information on the foundation year of the companies included in the sample was obtained from Venture Expert. In cases where such information was missing, we performed searches on the Internet to gather the relevant data. However, we were not able to find this kind of information for 19 companies out of 332 included in our sample. For such companies, we computed Company Age as the average age at the first financing round of the nanotech companies backed by VC firms in the same stage of development.

experience of VC firms, it is possible that US nanotech ventures benefit from higher investment opportunities than their foreign counterparts.

Dummy Early VC takes the value 1 for investment in the "seed" or "start-up" stages of development. Indeed, Gompers (1995) has shown that the amount of financing received from VC firms tends to be higher, on average, in later rounds compared to earlier rounds, as a consequence of reduced uncertainty and information asymmetries.

4.4 Analyses and results

4.4.1 Descriptive statistics and correlation analysis

Table 4.1 presents descriptive statistics from the sample of VC-backed companies.

Variable	*Obs*	*Mean*	*Std. Dev.*	*Min*	*Max*
Log VC financing (mil US $)	332	0.75019	1.47175	-3.21888	4.71456
Patents	332	0.84335	1.97557	0	15
Nanotech Patents	332	0.20783	0.80155	0	7
Patent Scope	332	0.45976	1.08355	0	7.66
Company Age	332	2.03012	2.70822	0	18
Dummy US	332	0.86145	0.34600	0	1
Market Scope	332	1.64759	0.70768	1	4
Dummy Early VC	332	0.33133	0.47140	0	1

Table 4.1 Descriptive statistics for VC-backed companies.

On average, the companies included in our sample received 5.01 million US $ in the first financing round from VC firms. At time of first VC investment, they had a mean of 0.84 patents and 0.28 nanotech patents in their portfolio, with a maximum of 15 and 7 patents respectively. Such low figures are due to the fact that only a limited number of

companies had obtained a patent before their first financing. More precisely, only 28% (95/332) of the companies had a patent at initial VC financing, whereas this number lowers to 10% (35/332) for nanotech patents. However, it should be noted that such figures are higher than those reported by Mann and Sager (2007) in their study of the software and biotechnology industries. They found that the number of firms with at least one patent before the first financing was just 9% (75/877) in their sample of VC-backed software companies, and 23% (49/212) in their sample of VC-backed biotech companies. Therefore, such results confirm the importance of patenting in the nanotech business. Concerning the breadth of patent protection, the average number of four-digit IPC classes into which a sample patent is classified is 0.46. On average, sample companies operate in 1.7 different industrial sectors, according to the classification of Venture Economics, with a maximum number of 4 different sectors. The mean age of the company at the date of the initial VC investment is around 2 years. The large majority of our sample companies are located in the United States (around 86%), followed by Europe (7%), Canada (3%) and Israel.

Table 4.2 reports the correlation matrix for our variables. We note that whilst most correlations are moderate there is a rather high correlation (0.54) between *Patents* and *Patent scope,* which might pose problems of multicollinearity. As a robustness check, we therefore replicated our regression analyses including and excluding *Patent Scope* in the specification model. The results substantially remain the same in all the models estimated concerning the effects of patent portfolio characteristics on VC financing. For the sake of simplicity, in this paper we report only the tables of the full models with both independent variables. A further useful tool in determining when too much collinearity exists to make proper inference about model parameters is the Variance Inflation Factors (VIF). We calculated this index for all our regressions. None of the scores

approached the commonly accepted threshold of 10 to indicate potential problems (Chatterjee and Price, 1977; Freund and Wilson, 1998).

		1	2	3	4	5	6	7	8
1	Log VC financing	1							
2	Patents	0.1046	1						
3	Nanotech Patents	0.0981	0.1179*	1					
4	Patent Scope	0.1244*	0.5495*	0.0157	1				
5	Company Age	0.1467*	0.3261*	-0.0307	0.2909*	1			
6	Dummy US	0.034	-0.0628	0.0061	-0.0874	-0.0439	1		
7	Market Scope	0.0086	0.0857	-0.0729	0.0281	-0.0339	0.0221	1	
8	Dummy Early VC	-0.4029*	-0.0771	-0.0389	-0.1194*	-0.1995*	-0.0696	0.0341	1

Table 4.2 Correlation matrix (Correlation coefficient significantly different from zero at the 5% level).

4.4.2 Regression analyses and results

We analyzed the relationship between start-up companies' patent portfolio characteristics and the total amount of VC financing in a regression framework, in order to control for the potential influence of other factors. We first adopted an OLS estimator on the full sample including all 332 VC-backed companies. Table 4.3 (Column 1) shows the results of this first model. The coefficient of the variable *Patents* is positive (0.013), although not statistically significant. The mere number of patents, therefore, does not have a significant impact on the amount of funding obtained by VC firms. This evidence

is in line with results obtained by Mann and Sager (2007) in the software industry, showing the limited significance of having a patent before the first round of financing on the progress of companies through the VC cycle. It is also consistent with the results of Hsu (2004), who finds no relation between pre-funding patents and various measures of firm performance in his study of a dataset of VC-backed and SBIC start-ups.

A possible explanation for this evidence resides in the fact that VCs do not simply consider the existence of patents in the process of screening and due diligence of prospective investments, but evaluate in more depth the nature of the underlying inventions being patented, in terms of relatedness with the core technological activities of the start-up. Indeed, our regression shows that the coefficient of the variable *Nanotech Patents* is positive (0.154) and statistically significant at the 1% level. This suggests that VCs are sophisticated investors with an ability to evaluate the technological focus of patent portfolios, by placing greater relevance on those patents more directly related to the core technological competencies of the company, in this specific case related to nanotechnology. This evidence is even more significant if we consider that the EPO publicly reported the new Y01N code for nanotech patents in its databases only in January 2006. Before that date the identification of nanotech patents was an ambiguous and uncertain task, given the inter-disciplinarity and the newness of the field.

On the other hand, we do not find a support in our data for the positive impact of patent breadth on VC financing. Although positive in sign, in fact, the variable *Patent Scope* is not statistically significant in our estimates. This evidence, in conflict with the results obtained by Lerner (2004) showing the positive effects of patent scope, might be due to the newness and uncertainty of patenting in the nanotechnology sector, still characterized by a real rush towards strategic patenting. On one hand, first inventors

have strong incentives to stake broad claims in the early days of a technology, in order to safeguard their inventions from infringements and thus increase their innovation's rents (Merges and Nelson, 1990). Early in the history of a technology, there is a higher possibility of obtaining broad patents, due to the absence of competing inventions, the high uncertainty about the market applications and the limited understanding of the prior art landscape by patent examiners. At the same time, however, in the specific case of nanotechnology "[…] the intensifying race to file patent applications has sparked concern that a proliferation of patents, especially broadly defined ones, could hobble innovation and produce a thicket of conflicting legal claims that could eventually drive up costs for consumers" (WSJ, 18/6/04). Therefore, it is not immediately possible to ascertain the value of large patent scope in this uncertain environment.

Turning to the control variables, only the dummy *Early VC* is statistically significant at the 1% level, and negative in sign. As expected, companies in earlier stages of development (i.e. seed, start-up) tend to receive a lower amount of financing in the initial rounds, also as a way of reducing uncertainty and opportunistic behaviour by entrepreneurs (Gompers, 1995).

We then turn to analyze whether the relationship between the patent portfolios of start-up firms and the amount of VC financing depends on the characteristics of the VC investor. We first look at the effects of the degree of specialization in nanotechnology of the leading VC firm investing in the company. In order to do that, we split our observations into two sub-samples depending on whether the leading VC firm is specialized (*Dummy Specialized VC* =1) or not (*Dummy Specialized VC* =0) in nanotechnology. In particular, we have a first sub-sample including all the companies financed by leading VC firms specialized in nanotechnology (253 observations), and a

second sub-sample including all the observations by leading VC firms which are not specialized in this field (77 observations)[16].

	(1) Full sample	(2) Specialized VC firms	(3) Unspecialized VC firms	(4) Corporate VC firms	(5) Independent VC firms
Variable	*Log (VC financing)*	*Log (VC financing)*	*Log (VC financing)*	*Log (VC financing)*	*Log (VC financing)*
Patents	.012	.035	-.450***	-.041	.031
	(.044)	(.048)	(.145)	(.064)	(.068)
Nanotech Patents	.153***	.149***	.096	.180**	.139**
	(.046)	(.044)	(.223)	(.084)	(.062)
Patent Scope	.071	.047	1.347***	.067	.070
	(.064)	(.065)	(.373)	(.110)	(.080)
Company Age	.029	.003	.119**	.099**	.003
	(.032)	(.034)	(.054)	(.039)	(.036)
Dummy US	.061	-.012	.037	.399	-.169
	(.185)	(.185)	(.547)	(.311)	(.238)
Market Scope	.054	.079	-.162	.036	.055
	(.115)	(.135)	(.258)	(.185)	(.144)
Dummy Early VC	-1.189***	-1.475***	.372	-1.244***	-1.134***
	(.170)	(.189)	(.350)	(.255)	(.227)
Constant	.866***	.966***	1.010	.736*	.921**
	(.280)	(.304)	(.661)	(.436)	(.359)
R^2	.178	.239	.178	.223	.161
F ratio	11.63***	11.98***	4.91***	7.46***	5.98***
N. obs.	332	253	77	142	190

Table 4.3 Regressions for patent portfolio characteristics and VC financing: full and split samples (Robust standard errors are in parentheses. ***, **, * significant at the 1%, 5% and 10% levels respectively).

Table 4.3 reports in columns 2 and 3 the results of the split sample analysis, showing interesting differences. In fact, the coefficient of *Patents* is positive (0.035) and

[16] We were not able to compute the index of specialization in nanotechnology for two companies in our sample, due to missing data.

not significant in the sub-sample of companies backed by VCs specialized in nanotechnology, whereas it is negative (-0.450) and significant at 1% level in the sub-sample of unspecialized VC firms. On the contrary, the coefficient of *Nanotech Patents* is positive (0.149) and statistically significant at the 1% level in the former sub-sample, whereas it becomes insignificant at conventional levels in the latter sub-sample. In addition, in the sub-sample of companies backed by unspecialized VC firms, the coefficient of Patent Scope is positive (1.347) and statistically significant[17].

Such results confirm that VCs which have a stronger focus in the nanotech sector tend to accumulate a specific knowledge allowing them to evaluate more effectively those patents that are closely related to nanotechnology, i.e. the core technology of the start-ups in our sample. On the contrary, generalist VC firms do not put more emphasis on the number of core technology patents (in terms of the mere size of the technological portfolio) in their financing decisions.

Finally, Columns 4 and 5 of Table 4.3 report the findings of the split sample analysis related to the type of affiliation of VC firms. Column 4 refers to the sub-sample including all the companies financed by at least one Corporate Venture Capitalist (142 observations), whereas Column 5 refers to companies backed only by Independent VC firms (190 observations). In contrast to the previous split analysis in which the distinction between *Specialized* versus *Generalist* VCs is driven by the presence (absence) of a specialized (unspecialized) leading investor, in this second case we define a company financed by *at least one* CVC firm as a CVC-backed start-up, independently of

[17] However, the analysis of the correlation matrix for the subsample of companies financed by VC firms which are *not* specialized in nanotechnology shows the presence of a high correlation (0.81) between *Patents* and *Patent Scope*. We therefore ran further estimates dropping the latter variable from the model. In this case, the coefficient of *Patents* results positive but not statistically significant, whereas *Nano Patents* remains positive and not statistically significant. This analysis provides a more robust confirmation than VC firm specialized in nanotechnology tend to value more nanotech patents in their investment decisions than unspecialized VC firms.

the presence of a corporate leading investor. Indeed, the few observations in which the leading investor is a CVC firm (17 observations) do not permit the application of the same proxy used in the previous analysis. Independently of the VC's affiliation, the coefficients of *Nano Patents* are positive and statistically significant at the 5% level, whereas mere *Patent* counts and *Patent Scope* are not statistically significant. Our analysis therefore does not provide evidence of significant differences in the evaluation of patent portfolios by CVCs and Independent VCs in the course of the selection and financing process.

4.4.3 Robustness check

To test the robustness of our results we also performed a set of OLS regressions including additional control variables regarding the characteristics of the entrepreneurial team. As previously pointed out, one of the most important criteria taken into consideration by VC firms in their screening process is related to the management team of the company. It is relatively uncontroversial that the high quality of human capital of a new start-up (both in terms of education and experience) is positively associated with superior ability to attract VC financing (Tyebjee and Bruno 1984; MacMillan et al., 1985; Baum and Silverman, 2004; Beckman et al., 2007).

MacMillan et al. (1985), in a study based on a questionnaire to a group of 14 VCs in the US, highlight that the most important criteria determining whether or not a VC will finance a start-up is the quality of the entrepreneur in terms of his experience and personality. Bates (1990) finds that educational skills are positively correlated with the received financial resources in entrepreneurial ventures. A study by Kaplan and Stromberg (2004) suggests that the experience of start-up management teams is important in guiding the investment decisions by VCs. Also, a recent study by Hsu

(2007) suggests that prior founding experience, founders' social networks and founding teams with a doctoral degree holder are positively related to the likelihood of being funded with higher valuations.

	(1) Full sample	(2) Specialized VC firms	(3) Unspecialized VC firms	(4) Corporate VC firms	(5) Independent VC firms
Variable	*Log (VC financing)*	*Log (VC financing)*	*Log (VC financing)*	*Log (VC financing)*	*Log (VC financing)*
Patents	.029	.046	-.596	-.086	.170
	(.074)	(.080)	(.355)	(.116)	(.113)
Nanotech Patents	.127**	.138**	.109	.175*	.070
	(.062)	(.064)	(.409)	(.100)	(.091)
Patent Scope	.016	.012	1.790**	.165	-.057
	(.093)	(.093)	(.696)	(.255)	(.103)
Company Age	.045	.025	.259*	.092	.002
	(.051)	(.049)	(.148)	(.0744)	(.062)
Dummy US	-.501*	-.370	-1.599	-.315	-.919**
	(.300)	(.284)	(.941)	(.457)	(.446)
Market Scope	.079	.061	.137	.198	-.005
	(.160)	(.189)	(.346)	(.216)	(.251)
Dummy Early VC	-1.169***	-1.454***	-.293	-1.143***	-1.315***
	(.234)	(.258)	(.500)	(.307)	(.407)
PhD	-.138	-.102	-.334	-.198	.041
	(.291)	(.294)	(.618)	(.416)	(.440)
MBA	.123	.013	.705	-.040	.259
	(.238)	(.259)	(.534)	(.320)	(.361)
Founding Experience	.514**	.561**	.441	.553*	.534
	(.219)	(.244)	(.441)	(.296)	(.337)
Constant	1.133**	1.104**	1.400	.969	1.332*
	(.461)	(.482)	(.989)	(.674)	(.687)
R^2	.193	.251	.374	.241	.199
F ratio	4.23***	4.96***	2.48**	2.72***	1.98**
N. obs.	168	135	33	82	86

Table 4.4 Regressions with team-level variables: full and split samples (Robust standard errors are in parentheses. ***, **, * significant at the 1%, 5% and 10% levels respectively).

In line with these works, we include additional control variables related to the start-up's ''human capital'' in our regression models. By collecting information through the Venture Expert database and the websites of our sample of new ventures, we were able to gather data on the top-management teams of 168 companies included in our sample (out of 332)[18]. For such sub-sample of companies, we were therefore able to construct three dummy variables characterizing the start-up's top management team, in order to control for important antecedents of VC financing decisions, as highlighted by previous literature. *PhD* takes value 1 if at least one member of the team has a doctoral degree, *MBA* takes value 1 if at least one member of the team holds an MBA degree, and *Founding Experience* takes value 1 if at least one member of the team has previously founded a new firm (Beckman et al., 2007).

The results obtained in the previous analyses are in large part confirmed. Even controlling for top-management team's characteristics, the number of nanotech patents is positively associated to the amount of VC financing received by the company (Table 4.4, Column 1). Specialized VCs tend to give more emphasis to the evaluation of the core technology patents (the coefficient of the variable Nanotech Patents is positive, 0.138, and statistically significant at the 5% level) than generalist VCs (Table 4.4, Columns 2 and 3). Furthermore, while in the previous models (Columns 3 and 4 in Table 4.3) we did not find significant differences between Corporate and Independent VCs in the assessment of patent portfolios as both positively evaluate nanotech patents, in Models 3 and 4 of Table 4.4 we now find a clearer distinction. Controlling for top-management teams' characteristics, it now seems that corporate investors are more likely to finance a

[18] Since data on top-management teams were available only for a limited number of companies included in our sample (168 out of 332), we decided to present the results of the regression models including such variables in a distinct "Robustness check section" of the paper, in order not to lose too many observations in our study. In any case, the results of our analyses run on the full sample or on the partial sample (controlling for top-management teams' characteristics) are very similar, thus providing strong support for our hypotheses.

start-up with a number of core technology patents than traditional VC investors. Indeed, the coefficient of *Nanotech Patents* in the sub-sample of CVC firms is positive (0.175) and significant at the 10% level, whereas it is not significant for the sub-sample of Independent VCs.

Turning to variables capturing top-management teams' characteristics, the dummies *PhD* and *MBA* are both not statistically significant in all the models. On the other hand, the entrepreneurs' previous experience in the creation of new firms is positively evaluated by VCs (the coefficient is 0.514, statistically significant at the 5% level in Column 1, Table 4.4).

4.5 Conclusions

This paper analyzed the impact of the characteristics of patent portfolios by start-ups - in terms of size, scope and number of core technology patents - on the amount of financing obtained by VC firms. It provides two main contributions to the existing literature on the relationship between patenting and VC investments. First, it moves beyond the simple analysis of patent counts, by claiming that VC firms consider the technological focus on core technological competencies of the IPRs possessed by target companies in their selection process. Second, it recognizes that VC firms are not all alike when it comes to the capabilities required to effectively assess the value of start-ups' technology and intellectual property. In particular, we argued that their degree of specialization in the specific industry of the company under scrutiny and their type of affiliation might influence their evaluation criteria and skills.

We tested our expectations on a sample of 332 VC-backed companies in the nanotechnology sector. Our results show that the mere number of patents applied by the

company before the first investment round does not have a significant impact on the amount of financing obtained, after controlling for the age, the stage of development, the degree of market diversification and the location of the start-up. On the contrary, the start-up's stock of patents belonging to the nanotechnology class, representing its core technological competencies, has a positive and significant effect on VC financing. Such findings help to interpret previous evidence by Mann and Sager (2007) showing no impact of patents obtained before financing and the amount invested by VCs. We show that it is the *type* of patents owned by the start-up that matters in the financing decision, in particular in terms of their technological content, rather than their quantity. Overall, our results support the view of VCs as competent investors, with the ability to identify and evaluate the technological capabilities of target companies.

Moreover, it also suggests that these kinds of selection skills are not evenly distributed amongst VC firms. In fact, we showed that VCs which are relatively more specialized in nanotechnology in their investment strategies tend to place a higher value on nanotech patents in their financing decisions than unspecialized VCs. Specialization therefore seems to provide a better understanding and deeper knowledge of the technological specificities of the investee companies' context. This, in turn, might facilitate the correct assessment of new investment opportunities.

On the contrary, we did not find significant differences between Corporate and Independent VCs in the assessment of patent portfolios in the financing decisions. It might be that CVCs retain an evaluation advantage compared to their independent counterparts only if they possess a sufficient absorptive capacity, in terms of previous technological knowledge stock. Dushnistsky and Lenox (2005) demonstrated that the marginal contribution of CVC investments in patenting is higher for incumbent firms with higher absorptive capacity. This suggests that the ability of an investing incumbent

firm to appropriately identify and transfer knowledge through interaction with a new venture requires the former to have sufficient technical understanding. In this paper we were not able to discriminate CVCs in terms of levels of absorptive capacity, in particular regarding the nanotechnology field, although this is an issue which could be directly addressed by future research.

These findings also highlight threefold managerial implications. Although the benefits deriving from a high degree of specialization are well known in the literature (Gupta and Sapienza, 1992; Norton and Tanenbaum, 1993; Busenitz et al., 2004), this work suggests how the kind of VC experience plays an important role in investment decisions. More precisely, VCs with a previous knowledge of technological areas which fit with those of the core competencies developed by the investee company could better recognize and leverage these distinctive resources, thus limiting the risk of failure and creating more successful portfolios. At the same time, this result also suggests that high degrees of specialization for start-ups are considered a positive signal by VCs. Indeed, our findings highlight the fact that patents which are more directly related to the core business of the company are considered more valuable by the VCs. Thus, companies focusing their efforts on activities which better characterize their core business could obtain a greater amount of financing. Finally, investors may prefer funds managed by specialized venture capitalists, as they have a specific knowledge which allows them to evaluate more effectively patents. Also, investors may have a further guarantee of success if this knowledge is closely related to the core competencies of the funded companies, as they represent those technological areas in which the start-ups have more experience.

To conclude, there are some qualifications and suggestions for future research. To begin with, our analysis relied on data from a single sector, nanotechnology,

characterized by a high degree of newness, uncertainty and inter-disciplinarity. As we have already mentioned, such specificities raise concerns about the extent to which our results can be applied to other contexts, in particular to more mature and established businesses.

Second, it is likely that investment decisions by VCs are also influenced by other characteristics of patent portfolios that we did not consider in our analysis, for instance patent lifetime (as a proxy of the remaining economic usefulness of the patent), family size (as a proxy of the market size of the underlying invention) or patent legal status (i.e. existence of renewal or opposition). There are therefore opportunities to analyze other determinants of patent value that are more directly taken into consideration by VC firms in their investment choices.

Third, the effect of affiliation on the VCs' ability to value technological portfolios needs to be investigated in other fields as well, other than nanotechnology. Indeed, due to the few observations of our sample in which the investee company was financed by a corporate leading investor, the distinction in terms of affiliation is not extremely strict. To construct our split sample, we adopted a proxy, such as a Corporate Venture Capital backed company, the start-up of which contained at least one corporate firm in their group of investors. Gathering information, for instance, on biotech firms, would enable the collection of more comprehensive information, contributing to addressing this issue through a more accurate procedure. The presence of a corporate firm as the leading investor, rather than simply belonging to the group of investors, could provide different results when compared to those highlighted in this work.

Finally, we limited our analysis to the initial financing rounds of the VC cycle, as a way of circumventing the causality problems which limited previous research on patenting and VC investments. Mann and Sager (2007) suggest that patents have their

greatest value for companies at the later stage of the investment cycle, whereas in earlier stages other determinants, such as the characteristics of the entrepreneurial team, play a dominant role. However, they do not provide a direct empirical test for such claims. Further research should investigate in more depth the relative importance of the different criteria adopted by VC firms in the evaluation of start-up companies and how they change during the VC cycle.

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CHAPTER 5 - DISCUSSION AND CONCLUSIONS

5.1 Summary of the Dissertation

This Doctoral Dissertation was triggered by an emergent trend in corporate strategy: firms are increasingly referring to investments in corporate venture capital (CVC) as means to create new competencies and foster the search for competitive advantage through the use of external resources. The motivation underlying this evidence is that new entrepreneurial companies generally have superior skills and abilities to compete in emergent and/or technology-driven environments. Thus, large corporations try to benefit from these promising ventures by providing them with financial resources and exploiting their competencies to renew their own set of competencies.

In line with this consideration, I directed my attention to three topics of particular relevance for better understanding how CVC may contribute to the firm's growth. In Chapter 2, I adopted an external perspective to analyze how CVC investments interact with other forms of external corporate venturing (ECV). In Chapter 3, I moved toward an internal perspective to figure out the relationship between corporate venture capital investments (exploiting external resources) and a more traditional strategy to create competitive advantage, that is, corporate diversification (based on internal resources). Finally, in Chapter 4, I focused on the more general field of venture capital (VC) to investigate (i) the determinants of patent value that are more directly taken into consideration by VC firms in their investment decisions and (ii) whether the ability to evaluate technology and intellectual property varies depending on the type of investors considered (specialized vs. generalist, and independent vs. corporate VCs).

5.2 Theoretical contributions

The present study makes several theoretical and empirical contributions to the literature on CVC and more generally to the previous studies on both ECV and VC. In the following, I briefly discuss the main contributions along these three macro-areas.

5.2.1 Literature on Corporate venture capital (CVC)

One of the key contributions of this Dissertation is related to the observation that CVC is only one of the several modes adopted by corporations to invest in valuable resources in response to performance and competitive problems. Thus, CVC needs to be analyzed in conjunction with other mechanisms to create new knowledge.

Relationship between CVC and other mechanisms of external venturing

CVC has been deeply analyzed in isolation (Chesbrough, 2000 and 2002; Dushnitsky and Lenox, 2005a and 2005b). Generally, it has been compared to traditional VC because they represent two distinct forms of equity financing toward new, innovative and potential companies (Gupta and Sapienza, 1992; Jain and Kini, 1995; Brav and Gompers, 1997; Maula et al., 2004; Bertoni et al., 2006;).

However, CVC activities can be also described as belonging to the pool of mechanisms used by established corporations to pursue strategic objectives through external resources, such as entering new businesses, developing new technologies and, more generally, creating new knowledge (Roberts and Berry, 1985). In this sense, systematic works where CVC is compared to other forms of ECV miss. I tried to fill this gaps in Chapter 2.

Relationship between CVC and investments in internal projects

As previously pointed out, the growing corporate use of CVC has stimulated research to analyze this phenomenon (Chesbrough, 2000 and 2002; Dushnitsky and Lenox, 2005a, 2005b and 2006; Ernst et al., 2005; Keil, 2004). The majority of these studies has used the lens of organizational learning to depict why established firms commit resources to this form of investment (Dushnitsky and Lenox, 2005a, 2005b; Schildt et al., 2005) and how CVC may influence a company's ability to learn and gain new knowledge and skills that might lead to the creation of strategic advantage (Keil, 2004). However, although researchers have recognized the importance of CVC activities for capability building (Keil, 2004; Dushnitsky and Lenox, 2005a and 2005b), they have not systematically or empirically documented this role, especially when it is positioned within the broad context of corporate strategy and corporate entrepreneurship (Sharma and Chrisman, 1999).

This study addressed this important issue, (i) by clarifying the role that CVC programs play in building capabilities that could enhance the firm's performance and (ii) by analyzing how CVC interacts with corporate diversification that has been traditionally associated to the role of capability building. In particular, I started from that literature describing CVC as a mode used by established corporations to perform explorative search and gain access to different types of ideas with the aim to revitalize their innovation activities (Dushnitsky and Lenox, 2005a; Schildt et al., 2005). Similarly, I also referred to those studies which define corporate diversification as a strategy pursued by established firms to create competitive advantage by investing not only in close domains to exploit previous knowledge, but especially in new opportunities which are distant from the firm’s core activities (Ramanujam and Varadarajan, 1989). Thus, both CVC and corporate diversification can be described as explorative tools. Taken

these two streams of literature together, I provided original empirical evidence on the extent to which CVC complements or substitutes corporate diversification as two distinct forms of exploration.

The determinants of CVC fund composition

Investments decisions of VCs have long been of interest in the entrepreneurship and financial literature (MacMillan et al., 1985; Fried and Hisrich, 1994). Several studies on VC have deeply investigated how VC managers decide about the composition of their funds in terms of preferences for particular stages of development, industries or technologies of the supported company, level of diversification and size of the fund (Gupta and Sapienza, 1992; Norton and Tenenbaum, 1993; Cressy et al., 2007). In particular, previous studies have investigated the determinants of VC fund composition focusing on characteristics of the VC fund, features of the investee company, nature of the financing transaction and market conditions (Kanniainen and Keuschnigg, 2003; Fulghieri and Sevilir, 2005; Cumming, 2006). However, when investors are distinguished on the base of their affiliation - *independent* versus *corporate* venture capital investors, it is also critical introducing the effect of characteristics related to the nature of the investor on the VC fund composition. While all the previous studies have made important contributions to advance our knowledge on how VC firms decide about their portfolios, to our knowledge, there is not any study investigating the same issue when the VC investor is a corporation.

This Dissertation intended to fill this gap and set out to analyze how corporations active in VC investments cope with the composition of their portfolios. The importance to analyze this topic is driven by the consideration that CVC, if compared to traditional VC

investments, is characterized by three players: the portfolio companies, the VC fund's team and the corporation sponsoring the VC fund (generally labeled as the "mother" firm). If the first two agents are common to traditional VC activities, the last player is distinctive of CVC. Thus, studies on VC portfolio choices made by corporate investors need to introduce also this last aspect. In this study, I analyzed, in particular, how the level of corporate diversification explains variance in the portfolio strategies in terms of CVC fund diversification.

5.2.2 Literature on external corporate venturing (ECV)

In addition to the specific contributions to the literature on corporate venture capital, the present study also makes several contributions to the broad literature on corporate entrepreneurship.

Multi-theoretical approach to study inter-organizational relationships

This Dissertation contributed to the research on inter-organizational relationships by developing a framework in which two different theoretical approaches are combined to explain the use of different governance modes to create collaborations with external partners.

Collaborative relationships have been studied using different perspectives, such as transaction cost economics (Williamson, 1991; Hennart and Reddy, 1997 and 2000; Young-Ybarra and Wiersema 1999; Vanhaverbeke et al., 2002), the resource based view (Burgelman, 1984; Lane and Lubatkin, 1998; Ahuja and Katila, 2001; Keil et al., 2008), agency theory (Dushnitsky, 2004; Katila et al., 2008), real options theory (Bowman and Hurry, 1993; Kogut, 1991; Folta and Miller, 2002). While focusing only on one theory

can help in understanding how that theory contributes to explain a specific phenomenon in isolation, a multi-theoretical approach may be more appropriate to provide a richer description of complex phenomena as the choice among different forms of collaborations. In this research, I moved toward this direction by integrating the resource based view and real options theory in a comprehensive framework to investigate how and when corporations use CVC, strategic alliance, joint venture and acquisition as mechanisms to create new knowledge and reinforce their competitive positioning. This study, thus, explained the factors influencing the choice among different mechanisms of collaboration. On one hand, the resource based view predicts that in inter-organizational relationships it is critical taking into consideration how the resources owned by the partners are related in terms of degree of similarity and overlap (Schildt et al., 2005; Keil et al., 2008). On the other hand, real options theory highlights that investments in new ventures can be surrounded by different levels of uncertainty (Folta, 1998; Chi, 2000; Huchzermeier and Loch, 2001; Folta and Miller, 2002; van de Vrande et al., 2006). Furthermore, real options theory allows to describe governance modes in terms of level of flexibility and reversibility provided to corporations to cope with the collaboration. As different levels of uncertainty and relatedness require different degrees of flexibility, analyzing potential partner along these two dimensions simultaneously allows firms to figure out which level of flexibility, and thus which form of collaboration is more appropriate to manage the relationship with that partner.

A dynamic perspectives to study inter-organizational relationships

In addition to the critical role played by uncertainty, a real option theory of governance mode choices also provides the important contribution to analyze mechanisms for ECV

adopting a dynamic perspective. Conversely to the majority of the previous studies that analyzed the determinants influencing the choice among different forms of governance modes in a static manner (Hagedoorn and Duysters, 1999; Vanhaverbeke, et al., 2002; Dushnitsky and Lenox, 2005; van de Vrande, 2006), corporations which refer to a real options reasoning can figure out how actively manage their collaborations by adapting the design of the initial governance mode in response to changes in a set of conditions.

In Chapter 2, I discussed how in response to variations of the intensity of relatedness and uncertainty characterizing the target company, firms can address the issue of how upgrade the relationship into a different mode of collaboration. Indeed, real options reasoning recognizes that many investments create valuable follow-on opportunities. Thus, ECV activities can be described as sequential investments which give the firms the flexibility to make an up-front investment and acquire the possibility to both capitalize on favorable opportunities and mitigate negative scenarios by proactively confronting uncertainty over time in a flexible manner (Kogut, 1991; Kogut and Kulatilaka 2001). This study suggested that by monitoring the evolution of the level of both relatedness and uncertainty, corporations can exploit high degrees of flexible to change their inter-organizational governance mode to better manage the collaboration.

A new framework for studying ECV

Previous study analyzing how firms choose among different forms of inter-organizational relationships generally provide a list of dimensions which could impact on the design of the governance mode. These studies generally suggested a positioning of different ECV modes along a continuum in which a specific variable assumes increasing intensity. An exception is the work by Roberts and Berry (1985) in which the

authors analyze the effect of newness and familiarity along both a market and a technology dimension simultaneously. I contributed to this reasoning providing a new taxonomy in which two factors derived by two different theoretical perspective (the resource-based vie and real options theory) are orthogonally combined to figure out a governance mode for each combination of the two dimensions (relatedness and uncertainty).

5.2.3 Literature on venture capital (VC)

The third line of research to which this study contributes is related to the general field of VC. In particular, two aspects are broadened: the determinants of VC fund composition and the role of patents in VC financing decisions.

The role of patents in VC financing

The previous literature on VC highlighted the superior ability of VC firms in accurately assessing the value of early-stage companies' technological capabilities (Lerner, 1994; Kortum and Lerner, 2000; Baum and Silverman, 2004; Mann and Sager, 2007). However, these studies generally focused on two characteristics related to technological capabilities: the number of patents and the scope of patents. If these measures can be considered as proxies for assessing the ability of entrepreneurial companies to innovate, they do not capture a more precise feature of patents, that is their content. Distinguishing patents in terms of the technological domain which intend to protect may considerably improve our understanding on how VC firms decide about their potential investments.

This study analyzed technological portfolios by introducing the distinction between patents directly related to the core technological capabilities of the company, labelled as core technology patents, and those belonging to other technological domains not directly related to the core technological capabilities of the company. Based on this distinction, the underlying idea was that technological portfolios with the same number of patents may not be all alike for VC investors. Indeed, during the process of screening, VC firms may give particular emphasis to the content of the patents in addition to the mere patent count and patent scope.

Differences between CVC and VC activities

Several studies highlighted the needs to analyze CVC and VC as different forms of financing (Jain and Kini, 1995; Norton and Tanenbaum, 2002; Busenitz et al., 2004; Bertoni et al., 2006; Cressy et al., 2007). These two types of investors widely differ in several ways: structure of incentives, monitoring behaviour, time horizon, scale of capital invested and set of objectives pursued (Chesbrough, 2000).

Chapter 4 of this Dissertation contributed to this stream of literature suggesting that potential differences between corporate and independent VCs can also be highlighted in their ability to assess patent portfolios of potential investee companies. In particular, such consideration may led to distinct contributions of VC and CVC to the investee ventures depending on the nature of the investor's technological expertise. This contribution goes beyond the traditional concept of specialization (Gupta and Sapienza, 1992; Norton and Tenenbaum, 1993) because it defines the nature of such specialization distinguishing between VC expertise in the core technological competencies of the investee companies versus general expertise in several technological domains.

5.3 Managerial implications

The findings of this Dissertation have several managerial implications for all the actors engaged in ECV, CVC and VC activities - entrepreneurs, independent VC investors and corporations – as discussed in the following.

5.3.1 Implications for entrepreneurs

VC selection criteria

The empirical study of Chapter 4 refined the importance to define a comprehensive list of the evaluation criteria considered relevant by VCs (Tyebjee and Bruno, 1984; MacMillan et al., 1985; Muzyka et al., 1996). In particular, I focused on technological capabilities of the new venture by highlighting their signaling role of quality. A deeper understanding of the criteria employed by successful VCs in evaluating new ventures, in particular for what concerns the role played by patent portfolios, is important for entrepreneurs seeking funds as it clarifies the critical factors leading to a higher likelihood of obtaining VC financing.

As VCs receive a large number of proposal, broad screening criteria are used to reduce this set to a more manageable number for a more in-depth evaluation. The main result deriving from Chapter 4 of this study is that VCs do not merely consider the patent count in their screening process, but they refer to their knowledge developed in a specific technological domain to assess the importance of those patents protecting the core competencies of the investee companies. In this sense, a high degree of specialization in start-ups' competencies is considered a positive signal by VC investors. Thus, entrepreneurs should take into consideration that although in the initial screening VCs roughly analyze their technology in terms of number of patents owned by the

entrepreneurial team, the final decision about the amount of financing to commit is based on a detailed evaluation of the content of the patents. Thus, new ventures should focus their efforts on activities which better characterize their core business to obtain a greater amount of financing.

Type of collaboration

An entrepreneur seeking for additional resources to develop its project can refer not only to CVC or VC investments but also to other types of collaborations such as alliances, joint ventures, acquisitions or licensing agreements. In this complex environment, entrepreneurs could be in trouble in the decision of what form of collaboration is appropriate for their strategic goals.

Although I did not explicitly consider the perspective of the entrepreneurs, in Chapter 2, I suggested how corporations tend to decide about potential collaborations depending on two attributes that describe the potential entrepreneurial partner (relatedness and uncertainty). In this sense, starting from a corporate perspective, this study indirectly suggested under which conditions entrepreneurs have more likelihood to obtain resources from a partner with a specific form of collaboration rather than another.

5.3.2 Implications for independent venture capital investors

VC selection criteria

The above-mentioned contribution related to the evaluation of technological capabilities of new ventures is also important from the VCs' point of view because it provides an

useful framework for evaluating entrepreneurial ventures and reduce the failure rates of the investee companies.

Although the benefits deriving from a high degree of specialization are well known in the previous literature (Gupta and Sapienza, 1992; Norton and Tanenbaum, 1993; Busenitz et al., 2004), Chapter 4 suggested how the nature of VC experience plays an important role in investment decisions. VCs with a previous knowledge in technological areas which fit with those of the core competencies developed by the investee company better recognize distinctive technological resources and, thus, limit the risk of failure by creating more successful portfolios.

5.3.3 Implications for corporations investing in external venturing

Organizational structure

In the broad context of inter-organizational relationships, the need to help firms in designing an "optimal" organizational separation among units which reflects managers' view of external corporate venturing modes as distinct activities is strong.

Chapter 2 provided firms with some guidelines about how to build a nimble infrastructure that allows to respond to opportunities with speed and flexibility. The ability to handle different types of opportunities through an appropriate form of collaboration is a prerequisite to succeed in uncertain environments and obtain value from the collaboration. An organizational structure with separate units dedicated to the management of different external investments (alliances, venture capital investments, joint ventures, licensing agreements and acquisitions) is functional to help firms in deciding which organizational unit is more suitable to identify, manage and create value from the collaboration with a potential partner. This is the first requirement.

The second step is to develop an efficient communicative system in order to sustain interactions and facilitate the dialogue among the units in order to manage the evolution of collaborative relationships without losses of efficacy. This allows corporations to change the governance mode of the collaboration in response to changes in the external conditions which could be impossible to achieve if organizational units do not interact.

Furthermore, Chapter 2 of this study also highlighted the explorative nature of CVC activities in respect to other forms of external corporate venturing. Firms could initially approach a new venture with this type of governance mode and, in a second moment, move toward a less flexible solutions when certain conditions are satisfied. Thus, organizations should be designed in order to give the CVC unit the greatest visibility toward new opportunities and, thus, play that role to initially identify potential partners whose activities are uncertain and new for the corporation and to assign that partner to a different unit over time depending on the evolution of external conditions.

Importance of technological expertise in undertaking CVC investments

Corporations active in VC investments could have an advantage in respect to traditional VC investors in selecting innovative companies. This advantage could be exploit to sustain their strategic corporate objectives and foster their growth.

Indeed, CVCs are affiliated to corporations with well-defined businesses, competencies, internal expertise, specific technological knowledge and are generally active in the same high-tech industry of the investee company. Thus, CVCs have the reputation needed to attract innovative companies because entrepreneurs are aware that this type of investor has the ability to better evaluate their technologies and can

easily provide them with the right set of financial resources. On the other hand, VCs do not possess the same influence of corporate investors in some technological areas and, as "outsider" investors, it is likely that they are less able to support the technological quality of the venture (Stuart et al., 1999).

5.4 Limitations and future research

5.4.1 Limitations of the Dissertation

Some of the main limitations of the papers presented in this Dissertation are discussed in the following session.

Main variables

In all the three papers, I analyzed a limited set of variables to better understand the role of such factors in the context under analysis. For instance, in Chapter 2, I referred only to two dimensions characterizing a potential partner for collaborations – relatedness and uncertainty. However, it is likely that the choice among different forms of external corporate venturing mechanisms is affected also by other elements such as the presence of strong intellectual property regimes, the level of diversification of the corporation and the target company, the type of uncertainty surrounding the activities of the target company, the speed of resolution of such types of uncertainty and the extent to which corporations have absorptive capacity to learn from the partner and integrate the new skills within their organizations.

Similarly, in Chapter 3 I investigated the relationship between CVC fund diversification and corporate diversification. However, I did not consider a further dimension particularly relevant in VC investments made by corporations, that is the distance or relatedness between the corporate activities and those of the investee company. Indeed, several studies highlighted how this attribute has evident effects on the success of inter-organizational relationships and on the corporate mother's performance, growth and learning (Ahuja and Katila, 2001; Schildt et al., 2005).

Finally, in the topic discussed in Chapter 4, I referred to the core technology patent as key-variable describing the importance of technological competencies in VC financing. However, it is likely that investment decisions by VCs are also influenced by other characteristics of patent portfolios as patent lifetime (as a proxy of the remaining economic usefulness of the patent), family size (as a proxy of the market size of the underlying invention) or patent legal status (i.e. existence of renewal or opposition). There are therefore opportunities to analyze other determinants of patent value that are more directly taken into consideration by VC firms in their investment choices.

Cross sectional data

The empirical papers presented in Chapters 3 and 4 used cross-sectional data to investigate respectively how corporate diversification is related to CVC fund diversification and how core technology patents are related to the amount of VC financing received by investee companies. However, this design of the research limits the possibility to analyze such relationships over time and study the presence of potential causality problems.

A longitudinal research setting could help to create further understanding of the relationships investigated. For instance, examining all the steps of the VC cycle could increase our knowledge about the relative importance of patents and other criteria adopted by VC firms during each step of the financing process (Mann and Sager, 2007). Similarly, longitudinal studies could capture how CVC activities contribute to corporate diversification over time.

Geographical and industry focus

The empirical papers focused on two different countries. Chapter 3 referred to data on US corporations active in CVC investments, while Chapter 4 analyzed data on VC activities in UK. Furthermore, the study presented in Chapter 4 was based on a single sector, nanotechnology, characterized by a high degree of newness, uncertainty and inter-disciplinarity. Such specificities raise concerns about the extent to which our results can be applied to other contexts to highlight potential differences among countries and between new and mature businesses. Further studies could follow this direction to increase the possibility to generalize the findings presented in this Dissertation.

5.4.2 Future research

In addition to the directions for future research highlighted in the previous session, which refer to specific limitations of the papers presented in this work, in the following I discuss some macro-areas for future contributions to the existing literature on CVC, inter-organizational relationships and VC.

Exploration and exploitation in CVC

Although this study analyzed the role of CVC investments as an explorative mode to seek out new opportunities, I disregarded the second dimension suggested by March (1991), that is, the exploitative side. Indeed, several studies have asserted that corporations use CVC not only to create new directions of growth, but also to exploit existing resources to benefit from synergies and complementarities (Chesbrough, 2002; Dushnitsky and Lenox, 2005a and 2005b). Future research could foster this direction by analyzing how firms could use CVC investments to resolve the exploration-exploitation tension overtime.

Furthermore, CVC allows to analyze the trade-off between exploration and exploitation across boundaries and domains. Indeed, CVC investments show for definition, an internal and an external dimension. Regarding the internal side, CVC are affiliated to corporations that operate in well-defined businesses and technological domains. For the external side, instead, CVC is a form of equity-based financing which allow corporations to extend their set of competencies by exploiting external resources developed by new, small and technology-based companies. Internally a corporation may shift from exploitation to exploration or vice versa within and across its domains (i.e. transitioning overtime from prior to new knowledge or technologies, re-positioning in known markets or entering new ones). Externally a corporation can create a CVC fund where the portfolio of companies may also interchange exploitation and exploration overtime. The challenge is to integrate both the dimensions. The blend of exploration-exploitation pursued through CVC investments could complement or reinforce a more traditional form of exploration-exploitation such as internal R&D expenditures or corporate diversification. In summary, corporations could encounter challenges in

balancing exploration and exploitation, but could use CVC investments to reconcile these conflicting pressures.

Theoretical inter-disciplinarity for inter-organizational relationships

In this Dissertation I fostered that line of research that aims to integrate different theoretical perspectives in a single framework. However, the combination between the resource based view and real options theory is only one of the possible combinations. Future research could also try to integrate transaction cost economics to the previous two perspectives or investigate inter-organizational relationships with others pairs of theories. The same multi-theoretical approach can also be applied to investigate several phenomena, not only the choice among governance modes.

Patent's quality in VC investments

The paper focused on VC introduced a new dimension in addition to patent count and patent scope to describe technological portfolios. More precisely, I analyzed the role played by the content of the patent in the VC selection process. However, other dimensions characterizing patents could be taken into consideration by future research. In particular, no investigation has been yet provided about how VC firms evaluate the quality of patents in terms of number of citations received. This dimension could have important implications not only for the VC community, but also for the entrepreneurial community. Indeed, more attention dedicated to the citations received by the start-up's patents in the VC process, could foster entrepreneurs to search for qualitative innovations, instead of only create innovations, not more precisely defined.

Innovative benefits from CVC investments

This Dissertation also fosters that stream of literature investigating whether and how CVC investments provide corporations with innovative benefits. This is in line with the work by Dushnitsky and Lenox (2005a). The authors proposed that CVC programs "*may be instrumental in harvesting innovations from entrepreneurial ventures and thus an important part of a firm's overall innovation strategy*" especially in weak intellectual property regimes and when the firm has sufficient absorptive capacity. However, the authors used as proxies of absorptive capacity the past expenditure in R&D and the patent stock of the corporations.

The measure presented in Chapter 4 of *core technology patents* of the investee companies could be applied to investigate whether and how corporate investors, in addition to their absorptive capacities, can exploit their ability to evaluate the content of patent portfolios to access knowledge from entrepreneurial ventures and sustain the search for innovation.

5.5 References

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