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THREE ESSAYS IN CONTROL, ENTREPRENEURSHIP AND INNOVATION

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UNIL | Université de Lausanne

FACULTÉ DES HAUTES ÉTUDES COMMERCIALES

DÉPARTEMENT COMPTABILITE ET CONTRÔLE

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THÈSE DE DOCTORAT

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pour l'obtention du grade de
Docteur en Sciences Économiques, « mention Management »

par

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Jury

Prof. Michael Rockinger, Président
Prof. Raul Barroso, expert externe
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Contents

Introduction and Summary

Innovation is the use of new knowledge to offer a new product or service that customers want (Afuah, 2003). Earlier, Schumpeter (1934) defined innovation as ideas applied successfully in practice. My favorite definition for innovation comes from Freeman and Soete (1997):

Innovation = Invention + Commercialization

This dissertation is a combination of three independent chapters on the subjects of management control systems (MCS[1]), entrepreneurship, and innovation. This dissertation has a special focus on radical innovation, therefore it is important to make the distinction between incremental and radical innovation. Incremental innovation is represented by minor changes or adjustments to existing technology (Munson & Pelz, 1979). In contrast radical innovation depicts revolutionary changes in technology and markets, contributing considerable improvements to existing practices and products (Duchesneau, Cohn, & Dutton, 1979; Ettlie, 1983). Furthermore, radical innovation introduces major new value propositions that disrupt existing consumer habits and behaviors (Markides & Geroski, 2005). But why is this important? Does it matter? The answer to this last question is yes. It does matter! Day (2007) reported that incremental innovation represents 85% to 90% of companies' new product development (NPD) portfolios. However it rarely generates the growth companies seek. This concentration on incremental innovation can affect a firm's innovative capacity by delaying all projects, stressing the organization, and failing to achieve high growth revenue goals. Still these incremental innovation projects are necessary for continuous improvement even though

[1] Simons' (1995) definition. MCS are interpreted as 'formal, information-based routines and procedures managers use to maintain or alter patterns in organizational activities'.

they do not provide companies with a competitive edge or contribute much to profitability (Cooper, 2003). On the other hand radical innovations provide firms with new market opportunities that can generate profits. According to a study by Kim and Mauborgne (1999), only 14% of NPDs are radical innovations, but these account for 61% of all profit from innovation. Consequently, radical innovation is important because firms that rely on purely continuous improvement and incremental innovations could aspire to maintain their market position while firms that pursue radical innovation can position themselves advantageously apart from competition and become market leaders.

Porter (1985) described how firms outperform rivals through competitive advantages. In order to understand how competitive advantages are generated by organizations, we need to take strategy from a broad vision to an internal consistent configuration of processes which represent the building blocks of competitive advantage (Ghemawat, Rivkin, & School, 1998). Researchers such as (Davila, Epstein, & Shelton, 2006) have also been interested in the inputs, processes, and outputs of innovation. In the literature innovation inputs have traditionally focused on the role and contribution of internal research and development (R&D) (Griliches, 1979; Hall, 1992; Himmelberg & Petersen, 1994). However, R&D is only one of the innovation inputs (Dushnitsky & Lenox, 2005b). More and more scholars (Chesbrough, 2002a, b; Chesbrough & Rosenbloom, 2002; Chesbrough & Tachau, 2002; Chesbrough, 2002c; Cohen & Levinthal, 1990; Davila, Epstein, & Shelton, 2005; Henderson & Cockburn, 2000; Teece, Pisano, & Shuen, 1997) acknowledge the ability to exploit external knowledge as a fundamental element of innovation strategy. Their research contributes to better understand the innovative inputs beyond the boundaries of the firm on what is commonly known as Open Innovation[2]. In this respect scholars e.g. (Cohen, Nelson, & Walsh, 2002b; Keil, 2002) have studied innovative external inputs contributing to open

[2] Chesbrough's definition of open innovation: "a paradigm that assumes that firms can and should use external ideas as well as internal ideas, and internal and external paths to market, as they look to advance their technology. Open Innovation processes combine internal and external ideas into architectures and systems."

innovation. Some examples of these inputs are the interaction between firms and universities, mergers & acquisitions, and strategic alliances. Research on Corporate Venture Capital[3] (CVC) as a source of open innovation is limited and has recently attracted scholar interest (Dushnitsky & Lenox, 2006).

The aim of this dissertation is to look at different managerial practices to generate radical innovation and to assess its contribution to value creation. More specifically, the purpose of this study is firstly to understand why firms invest billions of dollars in startups. In particular, we aim to understand the internal and external determinants influencing CVC investment activity. Secondly, we extend research by looking at the value creation of CVC and its interaction with R&D. We study the business sectors and regions in which these create value. Finally, we seek to identify what it is that a firm does in terms of processes, MCS, and organizational structure to generate radical innovation.

The main research questions are:

I. What influences CVC?

II. What is the contribution of CVC, and its interaction with R&D to value creation?

III. How is radical innovation organized and managed?

Summary

One of the key emphases of these three essays is to provide practical managerial insight. However, good practical insight, can only be created by grounding it firmly on

[3] Gompers and Lerner (1998) CVC's definition: External equity investments made by established firms in privately-held entrepreneurial start-ups.

theoretical and empirical research. Practical experience-based understanding without theoretical grounding remains tacit and cannot be easily disseminated. Theoretical understanding without links to real life remains sterile. My studies aim to increase the understanding of how radical innovation could be generated at large established firms and how it can have an impact on business performance as most businesses pursue innovation with one prime objective: value creation. My studies focus on large established firms with sales revenue exceeding USD $ 1 billion. Usually large established firms cannot rely on informal ways of management, as these firms tend to be multinational businesses operating with subsidiaries, offices, or production facilities in more than one country.

I. Internal and External Determinants of Corporate Venture Capital Investment

The goal of this chapter is to focus on CVC as one of the mechanisms available for established firms to source new ideas that can be exploited. We explore the internal and external determinants under which established firms engage in CVC to source new knowledge through investment in startups. We attempt to make scholars and managers aware of the forces that influence CVC activity by providing findings and insights to facilitate the strategic management of CVC. There are research opportunities to further understand the CVC phenomenon. Why do companies engage in CVC? What motivates them to continue "playing the game" and keep their active CVC investment status. The study examines CVC investment activity, and the importance of understanding the influential factors that make a firm decide to engage in CVC. The main question is: How do established firms' CVC programs adapt to changing internal conditions and external environments. Adaptation typically involves learning from exploratory endeavors, which enable companies to transform the ways they compete (Guth & Ginsberg, 1990). Our study extends the current stream of research on CVC. It aims to contribute to the literature by providing an extensive comparison of internal and external determinants leading to CVC investment activity. To our knowledge, this is the first study to examine the influence of internal and external determinants on CVC activity throughout specific expansion and contraction periods determined by structural breaks occurring between 1985 to 2008.

Our econometric analysis indicates a strong and significant positive association between CVC activity and R&D, cash flow availability and environmental financial market conditions, as well as a significant negative association between sales growth and the decision to engage into CVC. The analysis of this study reveals that CVC investment is highly volatile, as demonstrated by dramatic fluctuations in CVC investment activity over the past decades. When analyzing the overall cyclical CVC period from 1985 to 2008 the results of our study suggest that CVC activity has a pattern influenced by financial factors such as the level of R&D, free cash flow, lack of sales growth, and external conditions of the economy, with the NASDAQ price index as the most significant variable influencing CVC during this period.

II. Contribution of CVC and its Interaction with R&D to Value Creation

The second essay takes into account the demands of corporate executives and shareholders regarding business performance and value creation justifications for investments in innovation. Billions of dollars are invested in CVC and R&D. However there is little evidence that CVC and its interaction with R&D create value. Firms operating in dynamic business sectors seek to innovate to create the value demanded by changing market conditions, consumer preferences, and competitive offerings. Consequently, firms operating in such business sectors put a premium on finding new, sustainable and competitive value propositions. CVC and R&D can help them in this challenge.

Dushnitsky and Lenox (2006) presented evidence that CVC investment is associated with value creation. However, studies have shown that the most innovative firms do not necessarily benefit from innovation. For instance Oyon (2007) indicated that between 1995 and 2005 the most innovative automotive companies did not obtain adequate rewards for shareholders.

The interaction between CVC and R&D has generated much debate in the CVC literature. Some researchers see them as substitutes suggesting that firms have to choose between CVC and R&D (Hellmann, 2002), while others expect them to be complementary (Chesbrough & Tucci, 2004). This study explores the interaction that CVC and R&D have on value creation. This essay examines the impact of CVC and R&D on value creation over sixteen years across six business sectors and different geographical regions. Our findings suggest that the effect of CVC and its interaction with R&D on value creation is positive and significant.

In dynamic business sectors technologies rapidly relinquish obsolete, consequently firms operating in such business sectors need to continuously develop new sources of value creation (Eisenhardt & Martin, 2000; Qualls, Olshavsky, & Michaels, 1981). We conclude that in order to impact value creation, firms operating in business sectors such as Engineering & Business Services, and Information Communication & Technology ought to consider CVC as a vital element of their innovation strategy. Moreover, regarding the CVC and R&D interaction effect, our findings suggest that R&D and CVC are complementary to value creation hence firms in certain business sectors can be better off supporting both R&D and CVC simultaneously to increase the probability of generating value creation.

III. MCS and Organizational Structures for Radical Innovation

Incremental innovation is necessary for continuous improvement but it does not provide a sustainable permanent source of competitiveness (Cooper, 2003). On the other hand, radical innovation pursuing new technologies and new market frontiers can generate new platforms for growth providing firms with competitive advantages and high economic margin rents (Duchesneau et al., 1979; Markides & Geroski, 2005; O'Connor & DeMartino, 2006; Utterback, 1994). Interestingly, not all companies distinguish between incremental and radical innovation, and more importantly firms that manage innovation through a one-size-fits-all process can almost guarantee a sub-optimization of certain systems and resources (Davila et al., 2006). Moreover, we conducted research on the utilization of MCS along with radical innovation and flexible organizational structures as these have been associated with firm growth (Cooper, 2003; Davila & Foster, 2005, 2007; Markides & Geroski, 2005; O'Connor & DeMartino, 2006).

Davila et al. (2009) identified research opportunities for innovation management and provided a list of pending issues: How do companies manage the process of radical and incremental innovation? What are the performance measures companies use to manage radical ideas and how do they select them? The fundamental objective of this paper is to address the following research question: What are the processes, MCS, and organizational structures for generating radical innovation? Moreover, in recent years, research on innovation management has been conducted mainly at either the firm level (Birkinshaw, Hamel, & Mol, 2008a) or at the project level examining appropriate management techniques associated with high levels of uncertainty (Burgelman & Sayles, 1988; Dougherty & Heller, 1994; Jelinek & Schoonhoven, 1993; Kanter, North, Bernstein, & Williamson, 1990; Leifer et al., 2000). Therefore, we embarked on a novel process-related research framework to observe the process stages, MCS, and organizational structures that can generate radical innovation. This article is based on a case study at Alcan Engineered Products, a division of a multinational company provider of lightweight material solutions.

Our observations suggest that incremental and radical innovation should be managed through different processes, MCS and organizational structures that ought to be activated and adapted contingent to the type of innovation that is being pursued (i.e. incremental or radical innovation). More importantly, we conclude that radical can be generated in a systematic way through enablers such as processes, MCS, and organizational structures. This is in line with the findings of Jelinek and Schoonhoven (1993) and Davila et al. (2006; 2007) who show that innovative firms have institutionalized mechanisms, arguing that radical innovation cannot occur in an organic environment where flexibility and consensus are the main managerial mechanisms. They rather argue that radical innovation requires a clear organizational structure and formal MCS.

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1. Internal and External Determinants of Corporate Venture Capital Activity

1.1. Introduction

Firms innovate to differentiate themselves and advantageously set themselves apart from competition. Consequently, activities that allow them to renew and adapt their innovation strategy to internal and external changing conditions are critical to firm survival (Schumpeter, 1951).

Corporate entrepreneurship (CE) refers to the process of organizational renewal (Phan, Wright, Ucbasaran, & Tan, 2009). According to Guth and Ginsberg (1990) CE encompasses two distinct dimensions. On the one hand corporate venturing (CV) activities focus on the processes related to creating new businesses and integrating these into the parent company (Narayanan, Yang, & Zahra, 2009). According to Sharma and Chrisman (1999), CV can be divided into internal and external CV. Internal CV involves the creation of new businesses within the boundaries of the firm (Phan et al., 2009), while external CV, also referred to as Corporate Venture Capital (CVC), involves an investment in a young high-growth firm defined as a startup (Phan et al., 2009). On the other hand CE takes into account the organizational renewal activities that improve a firm’s ability to compete, which may or may not involve adding new businesses to a parent company. Kuratko and Audretsch (2009) define this CE approach as strategic entrepreneurship, which involves identification and exploitation of new innovative opportunities within firm boundaries and in which the main source of organizational renewal consists of research and development (R&D).

Nowadays even the largest and most technologically advanced firms require knowledge beyond their boundaries seeking to optimally combine internal and external sources of knowledge to benefit from the positive effects that internal and external sources have to offer (Cassiman & Veugelers, 2002).

R&D has been the traditional activity conducted by firms to exploit internal knowledge and generate innovation (Griliches, 1979; Hall, 1992; Himmelberg & Petersen, 1994). Nonetheless firms can alternatively use a large range of activities to implement their innovation strategy (Dushnitsky & Lenox, 2005a), in particular, activities aimed at exploiting external knowledge. These activities have recently caught the attention of scholars (Chesbrough, 2002a; Chesbrough, 2002c; Cohen & Levinthal, 1990; Davila et al., 2006; Henderson & Leleux, 2002; Henderson & Cockburn, 2000; Teece et al., 1997) especially under the lens of innovation activities beyond the boundaries of the firm. For example, Chesbrough's (2003a, b) concept of 'Open Innovation' suggests that firms use external and internal ideas as well as internal and external paths to market as they look to advance their technology. In that respect, partnerships with universities and state-run research facilities (Cohen et al., 2002b), mergers & acquisitions, and strategic alliances (Keil, 2002) are the traditional activities conducted by firms to gain access to and exploit external knowledge.

CVC is also defined as external equity investments made by established firms in privately held entrepreneurial startups (Gompers & Lerner, 1998a; Gompers & Lerner, 1998c). This alternative way to exploit external knowledge has also attracted the attention of scholars (Dushnitsky & Lenox, 2006). CVC investment provides several benefits because it increases financial returns (Allen & Hevert, 2007), provides growth options (Allen & Hevert, 2007; Burgelman & Välikangas, 2005; Hurry, Miller, & Bowman, 1992), increases innovation output and new product development opportunities (Maula, Autio, & Murray, 2005; Maula, Autio, & Murray, 2009; Roberts & Berry, 1985; Wadhwa & Kotha, 2006), and creates market value (Dushnitsky & Lenox, 2006). CVC investment also provides strategic flexibility relative to R&D as it involves an equity investment that can be restructured or exited in case of changing internal or external conditions (Folta, 1998). In addition, it gives firms access to information that reduces market and technology uncertainties. Kogut (1991) considers that this information reduces uncertainty, giving partners (e.g. in the case of a CVC between a large firm and a startup) an advantageous position to scale the CVC activity up or down in response to environmental changes. According to Chesbrough (2002a), firms can justify CVC investment if it creates value for their shareholders in ways they cannot replicate themselves due to lack of exposure to technology and markets, or inferior knowledge of technologies and commercialization. CVC investment also allows firms to extend their core business or improve their next generation of products complementing internal R&D activities (Basu, Phelps, & Kotha, 2011). In some cases, CVC investment helps mitigate the technological and market uncertainty risks related to new product development. Finally, firms benefit from CVC investment by being able to gain access to people working for startups with a particular set of skills beyond the firms' internal capabilities, allowing them to increase their knowledge and better assess new product development opportunities (Dushnitsky & Lenox, 2005b).

These benefits explain why CVC investment by established firms[4] has drastically increased in the last four decades. As reported by the Thomson Reuters Venture Expert database, which compiles CVC investment worldwide, the amount of money invested by publicly-listed firms from 27 countries[5] increased from less than $ 1 billion in 1997 to $4 billion in 2008 with a peak of $16 billion in 2000 (see Figure 1).

[4] CVC investments are typically made by large established firms (Dushnitsky and Lenox, 2006). Consequently we focus our study on such firms.

[5] Available data of publicly listed companies with central offices domiciled in the following countries: Australia, Austria, Belgium, Canada, China, Denmark, Egypt, Finland, France, Germany, Hong Kong, India, Israel, Italy, Japan, Malaysia, Mexico, Netherlands, Norway, Singapore, South Korea, Spain, Sweden, Switzerland, Taiwan, United Kingdom, and Unites States of America.

INSERT FIGURE 1

However, despite all the benefits previously described, CVC activity experiences strong investment activity fluctuations. In the early 1970s, 25% of the Fortune 500 companies had a CVC program (Fast, 1979). During the mid-70s these programs where greatly reduced until 1978 when favorable changes to investment legislation led to an increase in venturing investments by independent venture capitalists as well as CVC (Dushnitsky & Lenox, 2005a). By the early 1980s firms renewed their interest in CVC. However by the mid-80s CVC was again reduced, accentuated by the financial market downturn of 1986 and 1987. Afterwards the “bullish” Internet market period of the 1990s ignited CVC momentum and corporations re-introduced CVC (Yost & Devlin, 1993). After the collapse of the Internet bubble in 2000, corporations once again headed out of CVC (Chesbrough, 2002b). Recently between 2005 and 2008 there was a new CVC expansion cycle. By the year 2000 the CVC activity peaked to more than 450 established firms actively investing in CVC (see Figure 2).

INSERT FIGURE 2

The purpose of this study is to understand why firms such as high-tech companies (e.g., Apple, Intel, and Motorola), automotive giants (e.g., BMW, Ford Motor Company, and Honda), food and beverage leaders (e.g., Nestlé, Starbucks, and, Carlsberg), machinery companies (e.g., Caterpillar and Honeywell), pharmaceuticals (e.g., Johnson & Johnson, Roche, and GlaxoSmithKline) among others invest billions of dollars in startups. In particular, we aim at studying the internal and external determinants influencing CVC investment activity. To do so we build a robust data set and perform tests through a Probit variable reflecting CVC investment activity to explore whether internal and external conditions impact CVC activity. Studying 399 large firms that follow a simultaneous R&D and CVC innovation strategy, we analyzed a panel of publicly listed companies between 1985 and 2008, and found that internal and external conditions are associated with CVC activity.

Our study extends the current stream of research on CVC. The goal is to make scholars and managers aware of the internal and external determinant forces influencing CVC. Our study provides findings and insights to facilitate the strategic management of CVC. To our knowledge, this is the first study that examines the influence of internal and external determinants on CVC investment activity between 1985 and 2008, a period characterized by several expansion and contraction periods of CVC activity.

The paper has the following structure. In Section 2 we look at the literature relevant to our subject and develop hypotheses. We describe our data in section 3 and our methodology and variables in section 4. In section 5 we discuss the results obtained from our quantitative analysis. In section 6 we expand on the discussion and provide conclusions and managerial implications in section 7.

1.2. Literature Review and Hypotheses

We base our study on theories and previous research that have tried to explain why organizations invest in innovative startups. Through institutional theory, Ensley and Carr (2006) analyzed the internal and external drivers that create isomorphic pressures influencing organizational investment in startups. Institutional theory takes into account the institutionalized environments as well as the conformity and legitimacy pressures that lead firms to isomorphism (DiMaggio & Powell, 1983). Mimetic isomorphism applied to CVC investment behavior can be further related to explain conformity and legitimacy seeking because mimetic isomorphism is generally considered a response to uncertainty; the more technological uncertainty and goal ambiguity, the greater the rate of isomorphism (DiMaggio & Powell, 1983). When studying CVC behavior, mimetic pressures could be explained as the need to follow what the rest of firms do. An established firm could feel urged to follow other leading organizations due to reputation consequences in case they do not follow (Scharfstein & Stein, 2000). A more recent theoretical approach that complements the study of corporate practices and diffusion is that of Ansari et al. (2010) in which population-level and organizational-level mechanisms are linked by diffusion and implementation factors influencing the adaptation of practices. These scholars explore the importance of both economic and rationale factors on the diffusion of corporate practices. This theory relates to our paper as they suggest studying the firm's internal factors to explain the adoption and diffusion of management practices. In our case we study the internal factors that influence the adoption of CVC considered as a sophisticated managerial practice to explore external knowledge and generate innovation. According to Burgelman and Valikangas (2005), CVC investment can be influenced by the internal financial conditions of the firm, such as availability of free cash flow and lack of growth. However, Bruton and Ahlstrom (2003) concluded that the process and behavior of a large firm investing in a startup is also influenced by external environmental conditions such as the financial market conditions. Based on this argumentation, we hypothesize that there are some key internal and external determinants linked to CVC activity.

1.2.1. Shortage of Growth Opportunities and CVC Activity

According to Wennekers and Thurik (1999) the economic decline of the 80s caused a renewed interest for entrepreneurial practices that could reinforce and alleviate the lack of growth. More importantly they analyzed the role of startups as a means of growth in times of economic stagnation.

According to Zahra (1991) firms that seek corporate growth can engage in CVC as it provides external knowledge and growth platforms. Tsai and Wang (2008) reported that large firms eagerly seeking growth opportunities utilize external knowledge as a source of new growth opportunities. In addition, McGrath et al. (2006) reported that in 1998 Nokia communicated that their CVC unit Nokia Ventures Organization (NVO) was established to look for growth opportunities beyond the existing business, but within their vision.

CVC activity can also strengthen a firm's ability to create new growing business opportunities. Large firms gain access to proprietary technologies from startups that can then be combined with existing internal R&D technologies to create new products (Gompers & Lerner, 2001a). Chesbrough (2002c) also proposed that firms seeking for a catalyst to boost growth could engage in CVC. In their research, Lin and Lee (2011) found that firms seeking growth can employ CVC to support corporate growth. Contrary to investments for financial reasons, CVC can serve as a mechanism to identify emerging technologies and an innovation enhancer, which in turn assists established firms to acquire future growth opportunities. They found that there was no significant relationship between CVC and growth. However, they concluded that firm growth was not affected by increasing the amount of CVC. Studies on growth and strategic benefits including technology acquisition (Chesbrough, 2003b), knowledge accumulation (Wadhwa & Kotha, 2006), and organizational renewal (Siegel, Siegel, & MacMillan, 1988) indicate that these all contribute to company growth, hence firms with shortages of growth can engage in CVC. Growth opportunities can be exploited internally through R&D or externally through CVC where a startup can be developed and become a direct growth vehicle leading to the development of a new business unit (Campbell, Birkinshaw, Morrison, & van Basten Batenburg, 2003). A large firm can make R&D technological resources available to a startup, as R&D technological resources can be leveraged by the nascent novel external innovation represented by startups' new technology (Hill & Birkinshaw, 2006). These internal resources can be represented by in-house R&D as previous research shows that large firms' innovation intensity is a way to mitigate future low growth opportunities (Garner, Nam, & Ottoo, 2002; Yew Kee, Tjahjapranata, & Chee Meng, 2006).

Furthermore, for firms experiencing a loss in growth, CVC can facilitate the formation and expansion of a firm's "ecosystem" consisting of suppliers, customers and other providers, thus stimulating demand for their core products (Lin & Lee, 2011). An example of this "ecosystem" expansion is developed by Campbell et al. (2003) as Intel Capital invests in startups that in turn increase the demand for Intel microprocessors for the new products being developed by growing startups. Another study focusing on a firm is DuPont's CVC initiative. Bhardwaj et al. (2006) reported that DuPont invested rapidly but selectively in startups to explore growth opportunities to help them mitigate growth stagnation within specific sectors. In other words, DuPont CVC invests in multiple new startups in order to alleviate shortages of organic growth (Vassolo, Ravara, & Connor, 2005; Vassolo, Anand, & Folta, 2004).

Burgelman and Valikangas (2005) explain that CVC activity is often started by large established firms as a form of "insurance" against the possibility of the existing mainstream businesses failing to support corporate growth. In other words, insufficient prospects to meet corporate growth objectives foster CVC investment activity. Hence we present the following hypothesis related to firms' growth:

H1. A firm experiencing shortages of growth is prone to engage in CVC activity.

1.2.2. Resource Availability and CVC Activity

Burgelman and Valikangas (2005) addressed the linkage between free cash flow and CVC investment, stating that the amount of capital to be invested through CVC varies depending on cash flow availability. They propose a quadrant for CVC situations (see Figure 3). Both "CVC orphans" and "CVC drive" rely on availability of financial resources. "CVC orphans" refers to situations in which companies have uncommitted financial resources (e.g. free cash flow availability with no specific project allocation) and growth prospects of core mainstream businesses are sufficient hence there is little motivation to support CVC. "CVC drive" refers to situations in which companies have sufficient free cash flow and growth prospects are expected to be insufficient. Top management is then likely to form and support CVC. The lower quadrants indicate that there are no financial resources available, "CVC irrelevance" refers to situations in which there is no free cash flow, but the growth opportunities look sufficiently promising, and therefore top management is likely to consider CVC irrelevant. Finally "CVC desperate" occurs when there is a lack of financial resources combined with inadequate growth prospects making top management prone to desperately commit to the first reasonable looking startup for which, given the substantial uncertainty associated with CVC, the likelihood of failure would be high.

Previous studies on innovation activities and cash flow have analyzed the relationship between R&D and cash flow (Cohen, 2010; Fazzari, Hubbard, & Petersen, 1988; Szewczyk, Tsetsekos, & Zantout, 1996). These conclude that corporate investment, including R&D, is sensitive to cash flow availability. Moreover, Jensen (1986) indicated that free cash flow induces managers to approve innovation projects. However, there is a different school of thought with contrary predictions. For example, Hall (1992) and Himmelberg and Petersen

(1994) reported low sensitivity of R&D to cash flows because firms want to protect this difficult to replicate intangible asset. Therefore, even if firms could potentially make their R&D expenditures vary with cash flow availability, they tend not to do so to preserve their innovation capabilities.

Dushnitsky and Lenox (2005a) mention that, in contrast to R&D, CVC activity does not face the problem of retaining highly technical R&D staff. Therefore CVC professionals can be prone to terminate their employment should the firm go through financial cash flow difficulties. They also provide evidence that firms with greater cash reserves have the resources that can be invested in CVC without compromising internal operations. More specifically, they find that cash flow has a positive effect on CVC investments. They add as an anecdote that even Intel, investing hundreds of millions in startups, commits no more than 10% of its cash flow to equity investments. In addition, Dushnitsky and Lenox (2005a) argue that the cost of financing via external investor funds (e.g. external venture capitalists) is higher than the cost of financing through internal cash flow due to information asymmetry on technological and market knowledge therefore justifying the financing of startups via CVC internal means i.e. cash flow, instead of external venture capitalists. For these reasons, we expect CVC investment to exhibit a high sensitivity to a firm's cash flow. Therefore we present the following hypothesis:

H2. Financial resource availability positively impacts the CVC activity of the firm.

INSERT FIGURE 3

1.2.3. R&D and CVC Activity

R&D and CVC activities are both important to firms for growth and value creation (Burgelman & Välikangas, 2005). Sahaym et al. (2010) conclude that R&D influences the use of CVC finding that R&D expenditure increases the number of CVC deals in an industry, particularly in those industries which are growing rapidly and changing technologically. CVC also limits the commitment to R&D expenditure in emerging technologies that tend to be uncertain while maintaining the potential to increase large firm involvement as the market and technology potential become clearer (Basu et al., 2011). Essentially, CVC provides the flexibility to use a step-by-step investment commitment mitigating a potential large exposure to R&D expenditure losses, while maintaining the option to further invest should prospects for the novel technology appear to be attractive (McGrath & Nerkar, 2004).

Moreover, Sahaym et al., (2010) found that business sectors with greater absorptive capacity developed by prior R&D expenditure display greater efforts towards pursuing innovations using CVC. In this sense we identified studies on motivations to undertake R&D to create the foundation for organizational absorptive capacity that equips firms with mechanisms toappropriate returns and make R&D worthwhile (Levin, Klevorick, Nelson, & Winter, 1987). Jaffe (1986) also conducted research on R&D and its linkage to profitability and market value, finding that firms with lower R&D activity suffer from lower profits and lower market value than firms with higher R&D activity. R&D expenditures signal firm commitment to technology that in turn generates valuable resources such as patents, laboratory facilities, and specialized technology staff all of which can attract startups that lack such technological resources creating a symbiotic relationship in terms of innovation and knowledge exchange between large established firms and startups. From this interaction established firms gain access to new technologies from startups that can then be combined with internal R&D to create new products (Henderson & Cockburn, 2000; Stuart, Ha, & Hybels, 1999).

Nowadays even the largest and most technologically advanced firms require knowledge beyond their boundaries seeking to optimally combine internal and external sources of knowledge to benefit from the positive effects that both sources have to offer (Cassiman & Veugelers, 2002). Large firms and startups cooperate while aware of the potential hazards of intellectual property leakage (Cassiman & Veugelers, 2006). This notion is particularly problematic because CVC investors are often viewed suspiciously by startups due to the perception that a CVC investor's goal can be to expropriate a startup's technology (Dushnitsky & Shaver, 2009; Katila, Rosenberger, & Eisenhardt, 2008). However despite this hazard, R&D and CVC can in fact be seen as complementary activities with R&D and CVC being respectively focused on internal and external knowledge. Ennen and Richter (2010) suggest that complementarities result from the skillful matching of heterogeneous resources which generate positive returns above and beyond the effect of each resource generated on its own. Chesbrough (2002c) proposes that due to their exposure to technology and markets, large firms can have superior knowledge of technologies and commercialization, and be able to invest in CVC and leverage on existing R&D resources. Such firms with deep technological expertise derived from R&D have more competences to evaluate startups and create value (Sykes, 1986a, b, 1990), and by investing simultaneously in R&D and CVC develop the complementary skills to identify promising startups (Gans & Stern, 2003a). In the same line of reasoning, McGrath (1997) argues that large firms with R&D activities have the complementary technological and commercial knowledge for startups to grow successfully and create value. To further illustrate the benefits of pursuing R&D and CVC simultaneously, Dushnitsky and Lenox (2006) establish that between 1990 and 1999, CVC and R&D presented a positive significant relationship with value creation. Based on this argumentation, we formulate the following hypothesis:

H3. The more a company spends on R&D, the more it becomes prone to engage in CVC activity.

1.2.4. Financial Market and CVC Activity

External conditions influence the behavior and process of large established firms investing in startups (Aldrich, 1979; Bruton & Ahlstrom, 2003). Population ecology is a theory that takes into account the external condition factor. Hannan and Freeman (1977) studied why some corporations adapt to changing environments by applying appropriate practices not only to survive, but also to outpace competition. Using population ecology, Klepper and Simmons (1997) addressed the technological extinction of firms by studying the causes that influence firms to engage in activities pursuing innovation. Romanelli and Tushman (1994) went further to explain the organizational transformation influenced by external conditions through population ecology. In other words, managers of CVC units can increase or reduce investments to minimize or maximize the effects of financial market fluctuations representing an external disturbance to firm operations. In this way organizations seek to balance organizational structures (e.g. such as a CVC unit within a large firm interacting with startups) and external conditions that can be represented by fluctuations on the financial market.

Gompers and Lerner (1998a; 1998c) documented that the evolution of the financial market has an impact on the investment behavior of independent venture capitalists (VC), and that the VC industry is highly volatile. One study from the 1975 to 1998 period found that venture capitalists with the most industry experience increase their investments when financial market signals become more favorable (Gompers, Kovner, Lerner, & Scharfstein, 2008). These findings are consistent with the view that venture capitalists respond positively to attractive investment opportunities signaled by favorable financial market shifts. Furthermore, an increase in initial public offerings (IPOs) leads VC firms to raise and invest more funds. The high VC activity of 1969 to 1972, 1981 to 1983, and 1998 to 2000 provide illustrations of these cycles (Gompers & Lerner, 1998a; Gompers & Lerner, 1998c).

Similar to independent VC, corporate investment has also been studied and proven to be affected by volatility of stock prices (Baker, Stein, & Wurgler, 2003). An example of these cycles is the CVC activity in the USA which boomed in the early 1970s and the early 1980s and which fell off in the in-between periods growing again in the mid-1990s. These cycles seem to mirror those of VC but to a magnified extent (Gompers et al., 2008). However, despite volatility and cyclical economic downturns that can reduce the viability of CVC investment, several large firms decided to maintain their CVC units as a window on technology (Chesbrough, 2002a).

We also found studies where an increase in IPO activity attracts more potential entrepreneurs (Ritter & Welch, 2002) thereby increasing the pool of potential startup investments and the likelihood that a CVC will find an attractive startup. Therefore we formulate the following hypothesis:

H4. Favorable financial market conditions positively impact the CVC activity conducted by firms.

1.3. Data

To test our hypotheses, we explore the relationship between four internal and external factors (i.e. firm growth, cash flow availability, R&D expenditure, and financial market conditions) and CVC activity. We build a large panel data and use a Probit model. Because CVC investments are typically made by large established firms (Dushnitsky & Lenox, 2006) we focus our study on publicly listed firms investing in CVC. Due to lack of reliable data prior to 1985, our period study ranges from 1985 to 2008. To the best of our knowledge, our dataset is unique in that it provides detailed information on financial and corporate venturing activities made by international publicly listed established firms. The database contains financial information on firms drawn from the Thomson Reuters DataStream and we combine these data with CVC data collected from the Venture Economics' Venture Expert database which includes a comprehensive coverage of CVC investment, exit, and performance activity in the private equity industry. Several studies on VC and CVC have used this database (Basu et al., 2011; Dushnitsky & Lenox, 2005a, b; Gompers, 1995; Wadhwa & Kotha, 2006).

For our study we dropped the established firms when financial accounting data was missing. Our sample also evolved as some firms ceased to exist or were acquired during the sample period. We searched the population of all CVC investments made by large established firms. We collected data on the annual CVC activity (i.e. CVC investment and number of new startups in their portfolio). By applying the above criteria, we reached a total of 976 CVC units that invested US$ 54.3 Billion. In Figure 4 we report the number of CVC units being created by established firms from 27 countries, reaching a peak in 1999 and 2000 in which over 180 and 140 new CVC units respectively were created. In Figure 5 we show the total number of startups financed by CVC units, having 15,648 startups between 1985 and 2008. In 2000 the CVC activity peaked with more than 3,000 startups being financed by CVC.

In order to combine DataStream and Venture Expert, we utilized an automated matching algorithm and a hand-checking procedure. This operation resulted in 407 matches of established firm-CVC pairs. We also decided to exclude real estate and financial institutions from our CVC sample to focus on firms that pursue new product development. After these adjustments our sample had 399 publicly listed firms investing in R&D and CVC.

INSERT FIGURE 4

INSERT FIGURE 5

Previous studies on CVC have been conducted mainly with a U.S. focus (Dushnitsky & Lenox, 2005b, 2006), while our research encompasses a global scope with firms from different countries. For sample description purposes we group them by Anglo-Saxon vs. non Anglo-Saxon countries. In Table 1 we observe that between 1985 and 2008, the established firms in our sample were predominantly from Anglo-Saxon countries (i.e. 65.16%) while 34.84% pertain to Non Anglo-Saxon countries. This difference can depict country characteristics such as judicial system including the kind of law (i.e. common law or code law), language, as well as other varying characteristics such as technology transfer policy, and tax incentives (Armour & Cumming, 2006; Klette & Moen, 2000; Lerner, 2010; Poterba, 1989).

INSERT TABLE 1

Regarding business sectors prone to engage in CVC activity, Dushnitsky and Lenox (2005b) presented the total cumulative dollars invested in CVC between 1969 and 1999. Firms such as Intel, Microsoft, Cisco, Xerox, Ford Motor Co., Sony, Motorola, AOL, Dell, and Johnson & Johnson led the list in total investments revealing that the top 20 companies engaged in CVC belong to the electronics, information communication technology (ICT), automotive, and pharmaceutical business sectors (see Table 2). Our sample also comprises firms in high technology sectors (see Table 3), for example, close to 90 percent of all CVC investments by companies went into ventures within the following six sectors: ICT, business and engineering services, machinery and electronics, chemicals, devices, and pharmaceuticals. Only a relatively small portion (i.e. 11.28%) of CVC investment came from business sectors such as vehicles, metals, printing, publishing, food, beverage, and tobacco.

INSERT TABLE 2

INSERT TABLE 3

1.4. Methodology and Variables

Our dependent variable is *CVC activity* represented by a dichotomic variable taking the value of one for each public listed firm in which annual CVC investment in millions of dollars and the numbers of startups in portfolio are greater than zero. We consider independent variables to include: annual figures for the parent companies' *sales growth* representing growth, *free cash flow* for financial resources, and *R&D expenditure* measured by the annual R&D expenditure in millions of dollars. We normalized R&D expenditure and free cash flow by assets to negate the absolute variable's effect on the data, and because we had data in different currencies, hence allowing underlying characteristics of the data sets to be compared by normalizing them to a common scale. To capture the external financial market effect, we chose the *NASDAQ index* as an independent variable reflecting technology trading companies usually composed of startups conveying an IPO and large innovative established firms with intensive R&D expenditure. We also lagged by one year NASDAQ and free cash flow to capture the lag between CVC activity and both financial resource availability and external financial market conditions that could influence firms decision to invest via CVC. We consider *firm size* measured by number of employees (log) as a control variable. In Table 4, we present the description of the variables.

INSERT TABLE 4

We chose different periods because the number of firms making CVC investments and the average investor's volume of CVC activity fluctuated overtime suggesting ample within firm-industry sector variation in CVC activity. Unlike prior studies[6] this research includes expansion and contraction periods. To verify the sub-periods we performed a Chow test to see if estimates were different between periods presenting an expansion and those presenting a contraction in CVC activity. Due to the effects on the time series measuring CVC over four

[6] e.g. Zahra (1991) analyzed the CVC contraction period 1986 to 1989, and Dushnitsky and Lenox (2005a) studied the CVC expansion period 1990 to 1999.

sub-periods - 1994 to 2000 and 2005 to 2008 as expansion periods as well as 1985 to 1993 and 2001 to 2004 as contraction periods - we propose the cut-off points based on the structural breaks. An example of these cut-off points is the deep plunge that the stock market experienced in 2000 after the “Internet bubble” burst. The test statistics for Chow breakpoint confirmed a structural change in the parameters during these structural break years. The F statistics rejected the null hypothesis of no structural change for all models at the five percent level of significance (see Appendix Table A1). Using the Chow test, we determined that the independent variables have a change in parameters when comparing expansion and contraction periods; contraction period 1985-1993 vs. expansion period 1994-2000 and contraction period 2001-2004 vs. expansion period 2005-2008. For both cases the probability was significant at F (7, 450) = 2.68 Prob > F = 0.0099, and F (7, 761) = 2.06 Prob > F = 0.0842 respectively. In contrast, when comparing two CVC contraction periods and two expansion periods we cannot reject the null hypotheses as results for contraction period 1985-1993 vs. contraction periods 2001-2004, have a value of F(7, 418) = 0.48 Prob > F = 0.8507, and for the two expansion periods 1994-2000 and 2005-2008 a value of F(7, 793) = 0.81 Prob > F = 0.5808. After confirming the different periods we decided to analyze each period separately. Consequently we identified 1994-2000 and 2005-2008 as expansion periods and we consider 1985-1993 and 2001-2004 as CVC contraction periods.

INSERT TABLE A1

To test our research hypotheses we used a Probit regression. For every year a new data table was developed and we performed regression calculations for each expansion and contraction period. Following Mitchell and James (2001), we gathered financial market data that corresponded directly to the point in time at which the Venture Expert data was collected. For the regressions we considered the firm observation years with and without CVC activity. Finally, in order to choose either a fixed-effect or random-effect in our data to make our model capable of estimating the likelihood of established firms to engage in CVC, we performed a Hausman test (Hausman, 1978). The Hausman test is based on the difference between the random-effect estimator and the fixed effect estimator in which observationally equivalent firms may differ on some unobservable or unmeasured characteristic. This test enabled us to correct for unobserved heterogeneity using random- and fixed-effect estimations. The Hausman test results met the asymptotic assumptions converging to our data, and were highly significant (Prob>chi2 = 0.0001). Therefore we used the consistent estimator for fixed effect, and not the efficient estimator for random effect. For all models we implemented a firm-industrial sector fixed effect at a two-digit SIC code and included year dummies to control for unobserved period effects.

1.5. Analysis and Results

In Table 5 we present descriptive statistics for our dependent and independent variables for the total selected cyclical period between 1985 and 2008. The sample consists of 399 large established firms from 27 countries[7] and 10 business sectors[8]. *CVC activity* is a dichotomic variable taking the value of one for each observation where annual CVC

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[7] Full country sample includes: Australia, Austria, Belgium, Canada, China, Denmark, Egypt, Finland, France, Germany, Hong Kong, India, Israel, Italy, Japan, Malaysia, Mexico, Netherlands, Norway, Singapore, South Korea, Spain, Sweden, Switzerland, Taiwan, United Kingdom, and Unites States of America.

[8] Sample business sectors include: Information communication and technology, pharmaceuticals, vehicles, food beverage & tobacco, industrial machinery & electronics, chemicals, metals, printing & publishing, devices, and business & engineering services.

investment or the number of startups in which an established firm invested in a particular year is greater than zero; otherwise the dependent variable equals zero. *Sales growth* is defined as the annual change in sales ($ million) over previous year sales ($ million) presenting in our sample a minimum of 88.9% sales reduction, while at the maximum there was a firm showing an annual growth of 588% year-to-year. *Free cash flow* is lagged one year and normalized by assets and we have observations varying from -0.988 to 2.805. *R&D expenditure* is also normalized by assets and it reports years with zero expenditure in R&D and a maximum of 7.643, while the average is 0.080. *NASDAQ index* lagged one year as the stock market index for high growth technology companies shows a value range from 249.50 to 3197.29. Finally, *firm size* used as a control variable is the log of number of employees at the established firm, and it has a mean value of 4.15.

For a more comprehensive description of firms in our sample, Table 6 presents descriptive statistics on the profile of the established firms. In this table, CVC investment is the total corporate venture capital invested in ($ million) and startups is the number of young high-growth firms that were financed through CVC. Both CVC and startups reflect a value of zero as a median as in most years our observations presented no CVC activity. The average annual CVC investment and number of startups being financed by each established firm was US$ 2.67 million and 4.23 startups (in absolute terms). At the extreme, Intel Capital invested over US$ 1.28 billion during 2008. For comparing purposes we normalized sales by assets to negate the absolute variable's effect on the data, and because we had data in different currencies, hence allowing underlying characteristics of the data sets to be compared by normalizing them to a common scale. Sales normalized by assets shows an average value of 1.158. Finally the number of employees is a variable representing the *Size* of the parent company firm. Our sample has an average value of 61,836 employees, with a maximum of 536,350 employees.

INSERT TABLE 5

INSERT TABLE 6

In Table 7, we run a correlation test to identify potential sources of multicollinearity, this table reports the correlation coefficients between the dependent, independent, and control variables. The correlation matrix provides the existence of a positive relationship between the *CVC activity* dichotomic variable and the continuous independent variables: *free cash flow*, *R&D expenditure*, and *NASDAQ index*. This table indicates that *CVC activity* is more correlated with the independent variable *NASDAQ index* (i.e. 0.2098), while the parent company independent variables *free cash flow* and *R&D expenditure*, show a correlation value of 0.0100 and 0.0363 respectively. In contrast CVC activity has a negative relationship with *sales growth* (i.e. -0.0352).

INSERT TABLE 7

Due to the fact that our dependent variable CVC activity is constrained and a number of observations have a value of zero, we use a Probit regression to estimate the model. In Table 8 we report the results of our Probit regression estimating the set of factors that drive the decision to engage in CVC activity. As mentioned earlier, to operationalize our model we created a binary version of CVC activity where all levels of investment greater than zero are assigned the value of one, in this regression we assume that the decision to engage in CVC activity is driven by the availability of cash flow, the lack of growth, the R&D expenditure, and the level of the NASDAQ index. While not reported, all models include year dummies to control for unobserved period effects and a firm-industrial sector fixed effect at a two-digit SIC code.

INSERT TABLE 8

We analyze the different CVC cyclical, contraction, and expansion periods. In Model 1 (i.e. 1985 to 2008 cyclical period), the estimated coefficients of our firm-level variables, *sales growth* and *R&D expenditure*, suggest each has a significant effect on CVC activity, although it is negative for *sales growth* ($\beta=-0.112$, $p<0.1$) and positive for *R&D expenditure* ($\beta=0.763$, $p<0.01$) as hypothesized (Hypotheses 1 and 3, respectively). It is interesting to see the negative sign for *sales growth* which can be interpreted as firms are willing to pursue CVC when *sales growth* decreases. Furthermore, we find support for our hypothesis H4 that CVC activity will be higher contingent to financial market conditions (i.e. *NASDAQ index* $\beta=0.000394$, $p<0.01$). We do not find support in this cyclical period for *free cash flow* having an effect on CVC activity (Hypothesis 2).

In Model 2 and 4 (i.e. CVC contraction periods), the estimated coefficients of our firm-level variables *free cash flow* and *R&D expenditure* suggest a significant effect on CVC activity, *free cash flow* ($\beta=7.744$, $p<0.01$) for Model 2 (i.e. 1985 to 1993), supporting hypothesis H2. For Model 4 (i.e. 2001 to 2004) *free cash flow* (β=0.654, $p<0.05$), supporting hypothesis H2, *R&D expenditure* (β=2.197, $p<0.01$), supporting hypothesis H3. We find support for our hypothesis H4 on CVC activity contingent to financial market conditions (i.e. NASDAQ index β=0.000294, $p<0.01$). We find no support indicating that *sales growth* has an effect on CVC activity (Hypotheses 1).

In Model 3 (i.e. 1994 to 2000 expansion period), the estimated coefficient of our firm-level variable *R&D expenditure*, suggest a significant effect on CVC activity (β=1.008, $p<0.05$) as hypothesized (Hypothesis 3). Furthermore, we find support for our hypothesis H4 that CVC activity will be higher depending on financial market conditions (i.e. *NASDAQ index* β=0.000525, $p<0.01$). We do not find support that either *sales growth or free cash flow* have an effect on CVC activity in this expansion period (Hypotheses 1 and 2).

Regarding Model 5 (i.e. 2005 to 2008 expansion period), the estimated coefficients of our firm-level variables, *free cash flow* and *R&D expenditure*, suggest each has a significant positive effect on CVC activity, (β=0.487, $p<0.1$) for *free cash flow* and for *R&D expenditure* (β=1.387, $p<0.05$) as hypothesized (Hypotheses 2 and 3, respectively). We find no support for neither *sales growth*, nor *NASDAQ index* in this expansion period.

By analyzing the results from an independent variables perspective (i.e. *sales growth*, *free cash flow*, *R&D expenditure*, and *NASDAQ index*) rather than the different periods, findings remain consistent. Our results in Model 1 present a negative significant coefficient for *sales growth* influencing *CVC activity* for the whole 1985 to 2008 period. This can be explained by taking into account the Burgelman and Valikangas (2005) quadrant model in Figure 3, in which a "CVC desperate" situation could have been originated by not having free cash flow readily available and a lack of *sales growth.* When analyzing expansion and contraction periods, *sales growth* didn't show significance in any of the different expansion or contraction models.

For our hypothesis arguing that free cash flow positively impacts CVC activity, our Models 2, 4, and 5 support H2.

Similar to Dushnitsky and Lenox (2005a), we found a significant positive coefficient of *R&D expenditure* influencing *CVC activity* across all models, except Model 2. This suggests that since 1994 going forward internal R&D expenditure and external CVC investment act as complements. After 1994 this positive coefficient remains significant regardless of expansion or contraction CVC trends, supporting our Hypothesis H3. As suggested in the complementarity knowledge creation literature, by combining internal R&D expenditure and external CVC investment as sources of knowledge, firms benefit from the positive effects that both sources offer (Cassiman & Veugelers, 2002; Ennen & Richter, 2010). Mitchell and Singh (1992) describe the R&D-CVC combination as a way for large firms to gain information about the emerging products and markets. Moreover, Sahaym et al. (2010) also conclude that R&D expenditure has a positive effect on CVC activity. Essentially, CVC seems to provide large firms with a flexible step up investment mechanism providing the possibility to further invest should prospects for the novel technology or market appear more attractive (McGrath & Nerkar, 2004).

Although the level of the *NASDAQ index* influences CVC activity for the whole 1985 to 2008 period, when analyzed by expansion and contraction periods, it is only in the 1994 to 2000 and 2001 to 2004 periods that H4 is supported. These periods coincide with the Internet bubble, a period characterized by speculative investors. We find that for certain periods, there is evidence suggesting that external financial fluctuating conditions influence the behavior of managers of CVC units that can increase or reduce investments to minimize or maximize the effects of the financial market fluctuations (Bruton & Ahlstrom, 2003). We also find that similar to Baker et al., (2003) who found that venture capital investment activity is influenced by financial market volatility, we observe that CVC activity is also affected by financial volatility cycles. However, as noted by Chesbrough (2002a) despite the financial market volatility several large firms seem to maintain their CVC activity as a window on technology regardless of the ups and downs of the financial market.

1.6. Discussion

Several decades after its initial emergence, it seems that the CVC phenomenon will prevail. Our study reflects the relationship between CVC and companies' internal variables and external financial market forces. It is important to be aware of these determinants as CVC is a valuable vehicle for innovation, providing established firms with platforms for growth and value creation (Allen & Hevert, 2007; Burgelman & Välikangas, 2005; Dushnitsky & Lenox, 2006; Hurry et al., 1992; Maula et al., 2005; Roberts & Berry, 1985; Wadhwa & Kotha, 2006).

When analyzing the overall cyclical CVC period from 1985 to 2008 the results of our study suggest that established firms' CVC engagement behavior is influenced by their R&D expenditure, lack of growth in sales, and financial market conditions, with R&D expenditure and NASDAQ index as the main significant elements explaining CVC activity, followed by lack of growth in sales.

Regarding CVC activity explained by external financial market conditions, we observe that during the first contraction period (i.e. 1985 to 1993), the *NASDAQ index* variable shows no significance. Nonetheless the expansion period 1994-2000 and contraction period 2001-2004 highlight *NASDAQ index* as a significant determinant at the 1% level. It is interesting to note that these periods coincide with the Internet hype. The other period 2005-2008 shows no significance for *NASDAQ index* suggesting that an alternative explanation to the lack of significance for these later periods could be a less speculative opportunistic behavior from established firms and a commitment to CVC by established firms as a lever on technology.

In terms of firms' internal determinants and CVC activity, we find the variable *R&D expenditure* significant indicating firm willingness to commit resources to CVC. Particularly for *R&D expenditure*, CVC can represent the capacity to evaluate external technology which is important when reviewing emerging technology and potential investment options (Sahaym et al., 2010). Moreover, the knowledge gained through *R&D expenditure* reduces the difficulty in evaluating relatively unfamiliar technology (Cohen & Levinthal, 1990; Keil, 2002). Separately, *free cash flow* availability was more relevant during the expansion and contraction periods 1985 to 1993, 2001 to 2004, and 2005 to 2008. Finally, between 1985 and 2008 lack of *sales growth* prove to be influential to generate CVC activity, but not during each of the expansion or contraction periods.

We believe that the evidence obtained could be seen as the first base for further research to understand the fluctuating cyclical behavior of firm CVC activity. There is room for future research on the analysis of the factors influencing the mortality of specific CVC programs. This includes examining in detail the forces of getting the CVC cycle started, the length of such cycles, and the causes that would terminate the CVC program. Therefore a survival methodology can provide new insights to CVC research. Another interesting study could be to further explore the R&D and CVC relationship as our findings supporting Hypothesis H3, suggest complementarity between *R&D expenditure* and CVC investment. These heterogeneous resources (i.e. R&D expenditure and CVC investment) can have the potential to generate positive returns beyond the effect of each one on its own (Arora & Gambardella, 1990; Chesbrough & Tucci, 2004; Ennen & Richter, 2010; Granstrand, Bohlin, Oskarsson, & Sjöberg, 1992).

1.7. Conclusions

This study was motivated by limitations of existing research in CVC and the effect that internal factors and external financial market conditions have on CVC activity in different CVC expansion and contraction periods. Although, Keil (2002) indicates that gaining external knowledge sources is a way for firms to adapt to changing external conditions, research on the influential external factors to pursue CVC as a source of external knowledge is still limited. Furthermore, despite the strategy literature notion of fit between firms' internal conditions and their external environment (Andrews, 1971), few studies have explored the relationship between CVC investment activity and its external and internal determinants. In addressing these limitations, the results of this study make several contributions. First, the external financial market fluctuations analyzed in this study reveal that CVC activity is highly volatile as demonstrated by fluctuations in the investment activity over the past decades. Second, our econometric analysis indicates strong and significant positive associations between CVC activity and our independent variables *R&D expenditure* and *NASDAQ index*, as well as an existing negative significant association between CVC and *sales growth*. By focusing on the characteristics and conditions in which established firms operate as CVC investors, we complement the work by Dushnitsky and Lenox (2005a) and Basu et al. (2011).

It is also interesting to see the applicability of the Burgelman and Valikangas (2005) quadrant model (see Figure 3), as during the 1985 to 2008 period *free cash flow* was not significant and there was also a lack of *sales growth*, hence considering a "CVC desperate" situation. Such situations can potentially explain why established firms act "desperately" and invest in the "first reasonable" looking startup, which considering the substantial technological uncertainty in CVC and having CVC influenced by NASDAQ speculative investment behavior the likelihood of a failure would be high.

In line with Dushnitsky and Lenox (2005a), we also found a significant positive coefficient of *R&D expenditure* influencing CVC, suggesting that internal R&D expenditure and external CVC investment are complementary after 1994 regardless of expansion or contraction on CVC activity trends. This supports previous literature on complementarity between internal R&D expenditure and external CVC investment (Cassiman & Veugelers, 2002; Ennen & Richter, 2010; Mitchell & Singh, 1992; Sahaym et al., 2010). In essence, CVC seems to provide large firms with a flexible way to increase or decrease commitments to novel technology depending on market and technological uncertainty and attractiveness (McGrath & Nerkar, 2004).

We also found evidence suggesting that external financial conditions influence CVC investment with the aim to maximize the financial and strategic goals (Bruton & Ahlstrom, 2003). Nonetheless, in line with Chesbrough (2002a), despite financial market volatility several large firms seem to maintain their CVC activity as a window on technology.

Regarding limitations, even though we found empirical support for our hypotheses, the results may be limited to the time periods. Historically, CVC investing has been cyclical, with three different waves of activity beginning in the mid-1960s (Dushnitsky & Lenox, 2006). Our sample only covers data after 1985 and the rise in CVC activity in the recent 2005 to 2008 period. An additional limitation is that we use the data available by Thomson Reuters and it is likely that certain firms do not disclose all CVC investment information.

As for the implications for managerial practice, we suggest that managers need to have an understanding of the influential factors that drive CVC activity, and manage CVC through the different internal and external determinants to which the established firm will be exposed. Additionally, even though the CVC phenomenon has been studied as a way to capture benefits for strategic management (Burgelman, 1983a, b; Fast, 1979), in practice it still seems that CVC programs are usually terminated before investment pays off. In other words, even if barriers to wind down CVC activity are low, CVC should not be first in line for cuts when internal resources tighten up. Despite the advantages enjoyed by large scale R&D activity CVC partnerships with startups can play an important role for innovation and growth. For instance Acs and Audretsch (1990) highlight that small growing innovative startups can serve as innovation and growth platforms for larger established firms. Moreover, the speed of recent technological advances and shortening product life cycles in global industries has shifted the advantage to CVC units interacting with startups which are flexible and can move quicker to develop new products and processes (Zahra, Ireland, & Hitt, 2000). Consequently, even though we find that CVC follows the ups and downs of the economy, CVC is too important to be treated as an "on-off intermittent switch". For example if firms can manage talented qualified R&D personnel as a scarce valuable resource considering that their separation from the firm can disrupt long-run projects. CVC can similarly be managed to retain skilled CVC personnel. This can be further justified as CVC is a linking way to access a pool of scientists and entrepreneurs who would be difficult to employ in the firm.

Finally, corporate instruments functioning as vehicles to keep firms abreast of emerging opportunities are important as they can provide strategic direction (Hamel, 2002; Prahalad & Hamel, 1996). Consequently due to its exploratory and flexible step-up commitment nature, CVC requires recognition from top management as a valuable corporate instrument. Furthermore, top management attitude towards entrepreneurship and a risk adverse mentality does not favor business venturing, discouraging and hindering CVC activities. It is important to acknowledge that CVC should be managed as an exploratory process, in which technical and market risks and opportunities are gradually assessed and better understood as more information and knowledge is generated.

Tables and Figures

Figure 1. Total CVC investment in million USD.

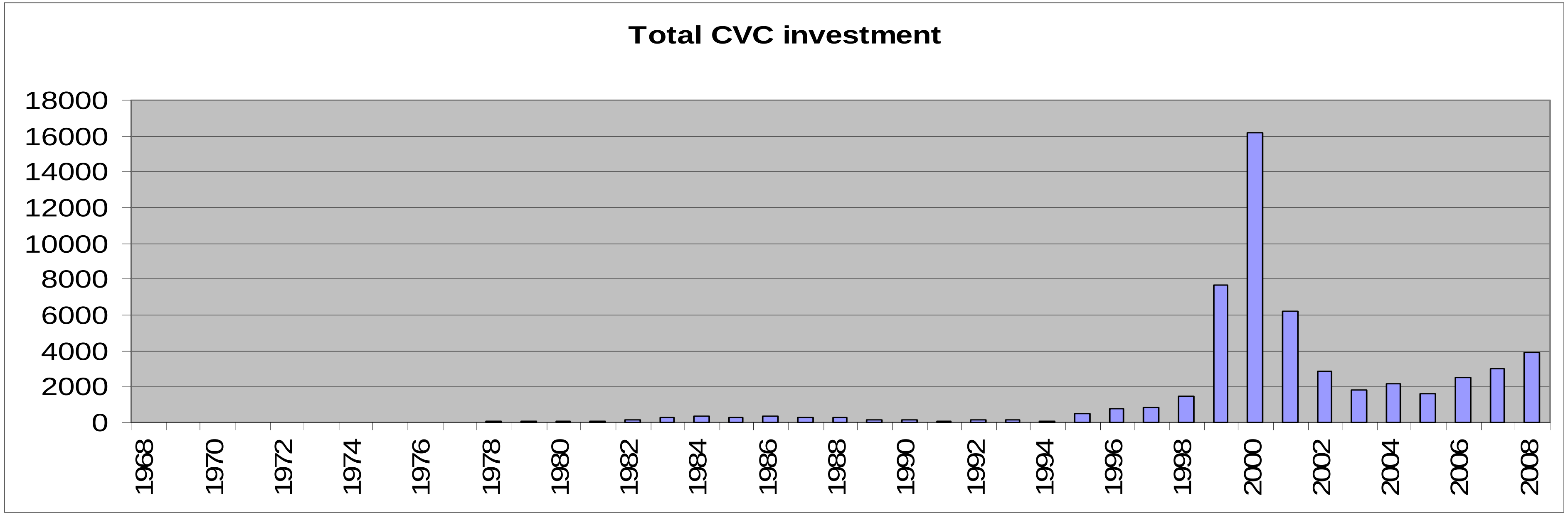


Figure 1 presents the actual amount invested in CVC, the sample consists of 1,904 CVC units owned by 938 established firms from 27 countries. Statistics based on annual available data for the years between 1968 and 2008. Data derived from Thomson Reuters Venture Expert. The CVC investment in 2000 and 2008 surpassed US$ 16 billion and US$ 4 billion respectively. Several studies on VC and CVC have used this database (e.g., Dushnitsky and Lenox, 2005a, b; Gompers, 1995; Wadhwa and Kotha, 2006, Basu et al. 2011). Country sample includes: Australia, Austria, Belgium, Canada, China, Denmark, Egypt, Finland, France, Germany, Hong Kong, India, Israel, Italy, Japan, Malaysia, Mexico, Netherlands, Norway, Singapore, South Korea, Spain, Sweden, Switzerland, Taiwan, United Kingdom, and Unites States of America.

Figure 2. Number of actively investing CVC units.

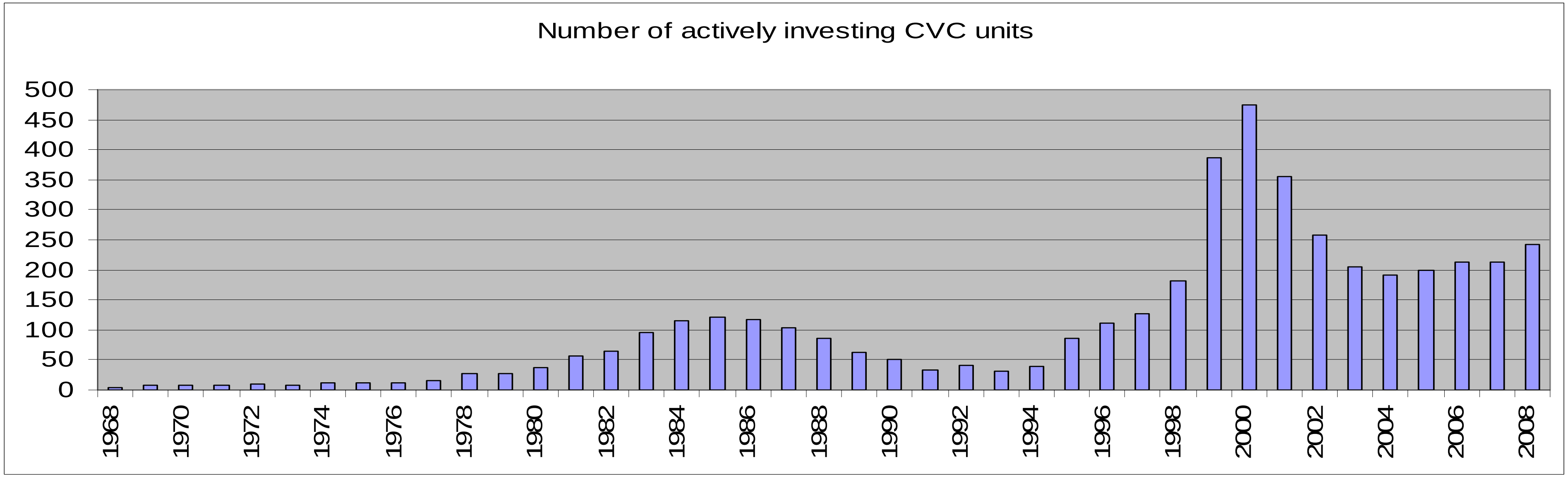
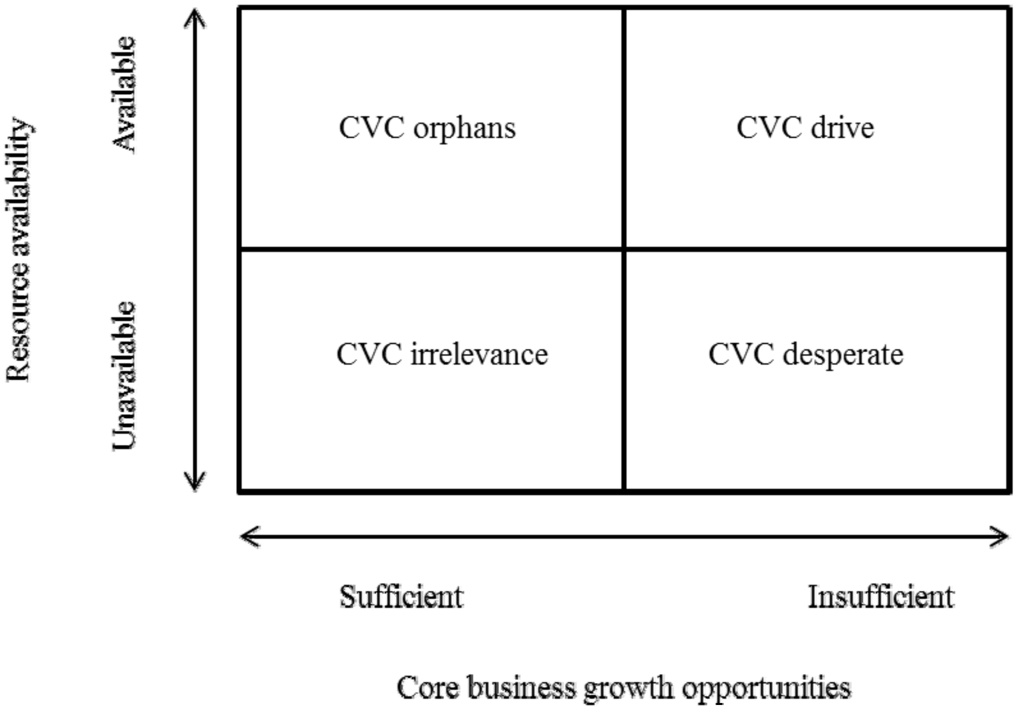


Figure 2 Same sample as in Figure 1. The graph represents the number of established firms actively investing in CVC on at least one portfolio company (i.e. startup) per year. This means that a CVC unit may still be active transferring or absorbing technology between the startup and parent company despite not reporting actual investments during a particular year. In 2000 the CVC activity peaked with more than 450 established firms actively investing in CVC.

Figure 3. Quadrant: factors driving Corporate Venture Capital (CVC).



Source: Burgelman, R. A. "Corporate Entrepreneurship and Strategic Management: Insights From a Process Study." Management Science 29, no. 12 (December 1983): 1349-1365 and Burgelman, R. A., & Valikangas, L. 2005. Managing Internal Corporate Venturing Cycles. MIT Sloan Management Review, 46(4): 26-34.

Figure 4. Number of CVC units created by established firms.

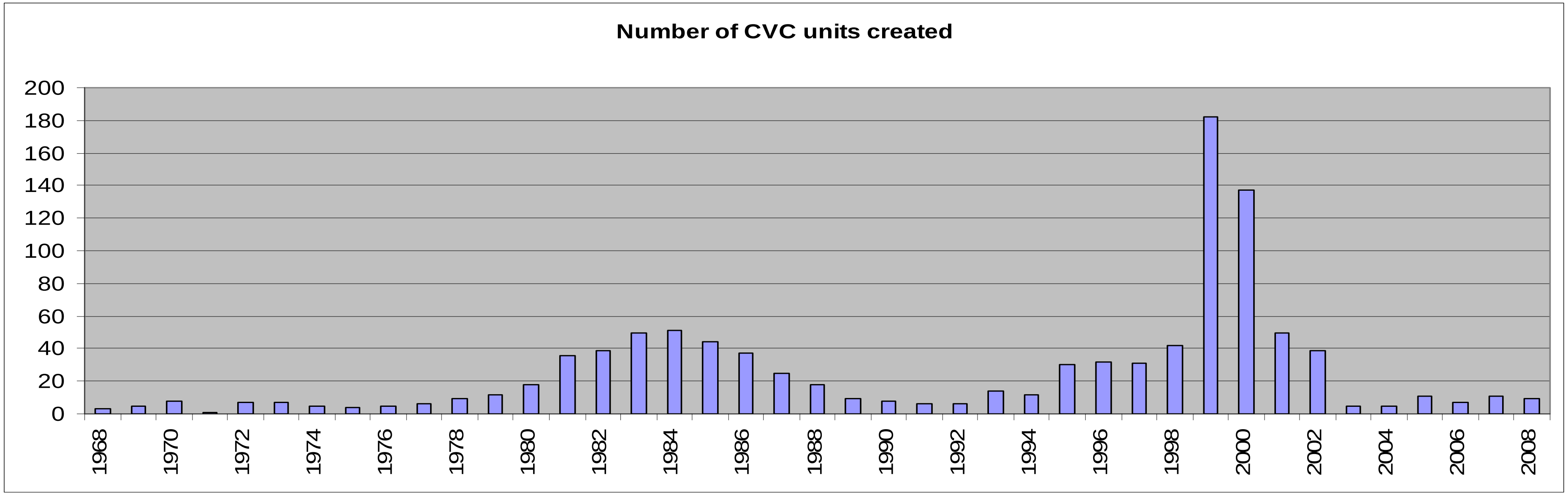


Figure 4 Same sample as in Figure 1. This figure represents the total CVC industry available data for the number of CVC units being created by established firms; note that an established firm can have more than one CVC unit or investment fund. In 1999 more than 180 new CVC units were created by established firms.

Figure 5. Number of portfolio companies (i.e. startups) financed by CVC.

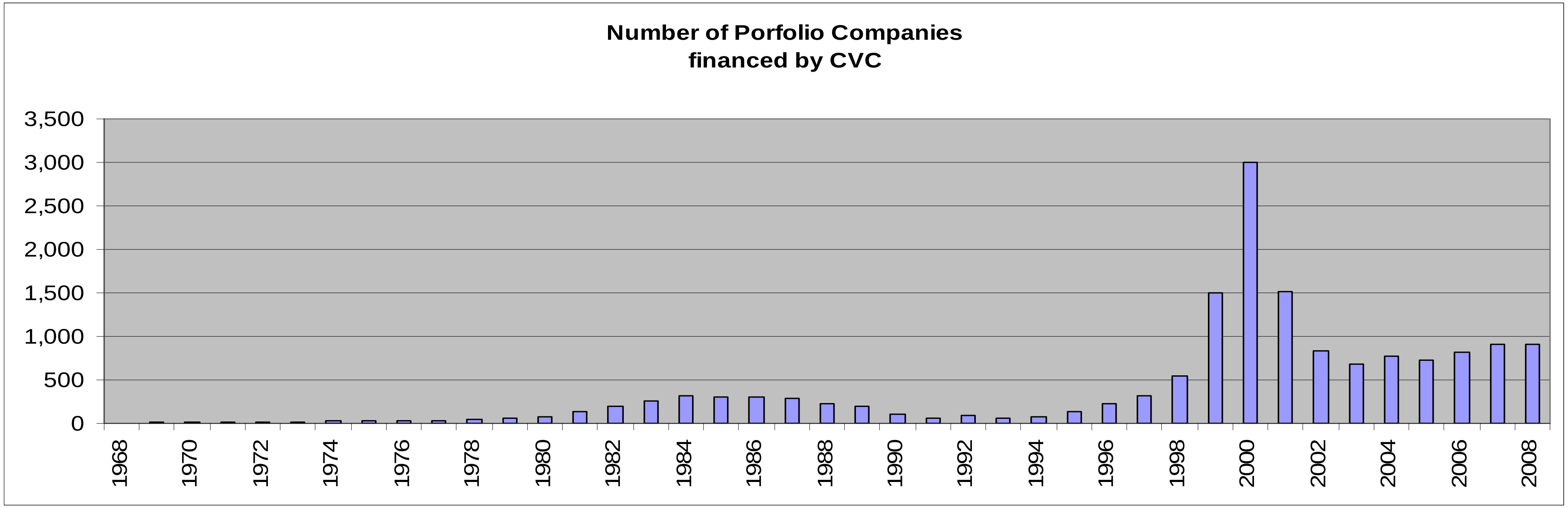


Figure 5 shows the number of portfolio companies (startups) financed through CVC. In 2000, the CVC activity peaked with more than 3,000 startups being financed by CVC. Same sample as in Figure 1.

Table 1. Countries of sample firms.

Country of established firms	Freq.	Percent
Australia	10	2.51%
Canada	2	0.50%
United Kingdom	25	6.27%
United States	223	55.89%
Total Anglo-Saxon	260	65.16%
Austria	1	0.25%
Belgium	2	0.50%
China	1	0.25%
Denmark	4	1.00%
Egypt	2	0.50%
Finland	2	0.50%
France	11	2.76%
Germany	18	4.51%
Hong Kong	4	1.00%
India	12	3.01%
Israel	2	0.50%
Italy	3	0.75%
Japan	33	8.27%
Malaysia	3	0.75%
Mexico	3	0.75%
Netherlands	3	0.75%
Norway	2	0.50%
Singapore	8	2.01%
South Korea	11	2.76%
Spain	1	0.25%
Sweden	6	1.50%
Switzerland	5	1.25%
Taiwan	2	0.50%
Total Non-Anglo-Saxon	139	34.84%
Total sample	399	100.00%

The Table presents 399 sampled parent companies. We studied firms beyond the U.S. to capture a global scope, unlike existing studies focused on the U.S. market (e.g. Dushnitsky and Lenox 2005b; Dushnitsky and Lenox 2006).

Table 2. Summary of the investment activity of the 20 largest CVC firms (1969-1999).

Firm	CVC first year CVC	Maximum annual ventures	Total dollars invested [a]	Max. annual invested [a]	Average annual rounds	Total CVC Funds
Intel	1992	179	1486	771	57	5
Cisco	1995	55	1056	730	19	1
Microsoft	1983	29	713	436	7	1
Comdisco	1992	70	554	334	24	2
Dell	1995	48	502	395	26	1
MCI Worldcom	1996	11	495	410	8	1
AOL	1993	39	333	169	10	2
Motorola	1963	33	315	177	11	1
Sony	1984	30	313	169	7	6
Qualcomm	1999	5	262	207	5	1
Safeguard	1983	21	231	118	6	3
Sun Micro	1999	31	204	180	19	1
J & J	1961	21	196	80	5	2
Global-Tech	1999	13	188	122	11	1
Yahoo	1997	5	186	163	3	1
Xerox	1960	30	184	24	13	6
Compaq	1992	21	182	113	5	3
Citigroup	1999	11	156	93	9	1
Ford Motor	1951	22	146	125	8	4
Comcast	1996	16	144	84	11	1

[a] In millions of dollars ($ million).

Source: Dushnitsky and Lenox (2005b). When do incumbents learn from entrepreneurial ventures? Corporate venture capital and investing firm innovation rates. Research Policy, 34 (5), 615 – 639.

This panel represents the total cumulative dollars invested between 1969 and 1999. Intel leads the list with total investments approaching $1.5 billion since 1992. The top 20 is dominated by the largest electronics and computer ICT related firms such as Microsoft, Sony, Motorola, AOL, and Dell.

Table 3. Sectors of sample firms.

	Freq.	Percent
Information Comm. Technology	85	21.30
Business Engineering Services	83	20.80
Machinery & Electronics	82	20.55
Chemicals	41	10.28
Devices	35	8.77
Pharmaceutical	28	7.02
Vehicle	18	4.51
Metals	10	2.51
Printing and Publishing	9	2.26
Food Beverage & Tobacco	8	2.01
Total	399	100.00

This table presents the sectors of the 399 firms of the sample (by 4 digit SIC code). Sample business sectors include: information communication and technology ICT (357*, 367*, 48**, 3663), business & engineering services (73**, 87**), industrial machinery and electronics (35**, 36** excluding 3663), chemicals (28** excluding 2834 and 2836, 29**, 3080), devices (38**), pharmaceuticals (2834, 2836), vehicles (37**), metals (33**), printing and publishing (27**), and food beverage and tobacco (20**, 21**). We created a binary version of sample sectors where sample firms present in a sector take a value of one, otherwise firms not active in such business sector are assigned the value of zero. Note that certain firms participate in more than one sector.

Table 4. Variables description.

Variable	Description
CVC activity	Dichotomic variable taking the value of one for each observation where annual CVC investment or the number of startups in which an established firm invested in a particular year is greater than zero; otherwise the dependent variable equals zero.
Sales growth	Annual change in sales ($ million) over previous year sales ($ million).
Free cash flow	Income after interest and taxes plus depreciation and amortization ($ million) normalized by assets. Variable lagged by one year in reference to CVC activity.
R&D expenditure	Annual total Research and Development expenditures ($ million) normalized by assets.
NASDAQ index	Annual average NASDAQ. This is an indicator of the performance of stocks for high growth technology companies. Variable lagged by one year in reference to CVC activity.
Firm size	Log of firm employees.
CVC investment	Annual Corporate Venture Capital invested ($ million) in absolute values.
Startups	Number of startups that were financed through CVC.
Sales	Annual sales in ($ million) normalized by assets.
Employees	Number of employees.

Table 5. Descriptive statistics (1985-2008).

Variable	Obs.	Mean	Std. Dev.	Min	Max
CVC activity	9576	0.175	0.380	0	1
Sales growth	6403	0.039	0.634	-0.889	5.886
Free cash flow	4641	0.064	0.413	-0.988	2.805
R&D expenditure	5795	0.080	0.808	0	7.643
Firm size	6479	4.150	0.960	0	5.729
NASDAQ index	9576	1312	914	249	3197

Descriptive statistics of main regression variables.
This table reports summary statistics of the main regression variables. Sample consists of 399 large established firms from 27 countries[9] and 10 business sectors[10]. Statistics based on annual data for the years between 1985 and 2008, if available. Data derived from Venture Expert and DataStream data sets. We decided to exclude financial and real estate institutions from our CVC sample limiting the study to established parent companies that invest in new product development.

[9] Full country sample includes: Australia, Austria, Belgium, Canada, China, Denmark, Egypt, Finland, France, Germany, Hong Kong, India, Israel, Italy, Japan, Malaysia, Mexico, Netherlands, Norway, Singapore, South Korea, Spain, Sweden, Switzerland, Taiwan, United Kingdom, and Unites States of America.

[10] Sample business sectors include: Information communication and technology, pharmaceuticals, vehicles, food beverage & tobacco, industrial machinery & electronics, chemicals, metals, printing & publishing, devices, and business & engineering services.

Table 6. Descriptive statistics (1985-2008)

Stats	CVC investment [a]	Startups	Sales	Employees
Mean	2.668	4	1.158	61,836
Std. Dev.	24.800	10.287	1.690	92,384
Median	0.000	0	0.926	26,000
Max	1,280	221	42.090	536,350
Min	0.000	0	0.000	0
Obs	9,131	1,956	7,420	7,327

Descriptive statistics of established firms profile variables.
This table reports summary statistics of the main profile variables. The sample consists of 399 large established firms from 27 countries. Statistics are based on annual data for the years between 1985 and 2008, if available. CVC investment is the total corporate venture capital invested in ($ million). Startups are the rounded number of startups that were financed through equity by CVC. Both CVC and Startups reflect a zero value for observations where there was no CVC activity reported. Sales are actual sales normalized by assets. We normalized Sales by assets to negate the absolute variable's effect on the data, and because we had data in different currencies, hence allowing underlying characteristics of the data sets to be compared by normalizing them to a common scale. Employees as total number of employees provide a variable for firm size. Data are derived from Venture Expert and DataStream data sets.

[a] In millions of dollars ($ million).

Table 7. Pairwise correlations (1985-2008).

(obs=4029)	(1)	(2)	(3)	(4)	(5)	(6)
1. CVC activity	1.0000					
2. Sales growth	-0.0352	1.0000				
3. Free cash flow	0.0100	-0.0425	1.0000			
4. R&D expenditure	0.0363	0.1423	-0.2853	1.0000		
5. NASDAQ index	0.2098	-0.0096	-0.0233	-0.0592	1.0000	
6. Firm size	0.1641	-0.1031	0.1592	-0.2282	0.0107	1.0000

Correlation matrix of main regression variables.
This table reports the correlations between the main regression variables. Sample consists of 399 large established firms from 27 countries and 9 business sectors. Statistics based on annual data for the years between 1985 and 2008, if available. Unless otherwise indicated CVC activity is a dichotomic variable taking the value of one for each observation in which annual CVC investment in millions of dollars and number of startups in portfolio, are greater than zero; otherwise CVC activity equals zero, Sales growth is annual change in sales ($ million) over previous year sales ($ million), Free cash flow is established firm’s income after interest and taxes plus depreciation and amortization ($ million) normalized by assets, R&D expenditure is established firm’s annual total Research and Development expenditures ($ million) normalized by assets, NASDAQ index is the NASDAQ stock market index of the common stocks used as an indicator of the performance of stocks of technology companies, Firm size is the Log of number of employees at the established firm. Data derived from Thomson Reuters Venture Expert and DataStream data sets.

Table 8. Internal and external determinants for CVC investment.

VARIABLES	Hypotheses (Predicted sign)	1985-2008 CVC Activity Cyclical Model 1	1985-1993 CVC Activity Contraction Model 2	1994-2000 CVC Activity Expansion Model 3	2001-2004 CVC Activity Contraction Model 4	2005-2008 CVC Activity Expansion Model 5
Sales growth	H1 (-)	-0.112*	2.340	-0.224	-0.0349	-0.0392
		(0.0637)	(1.686)	(0.139)	(0.103)	(0.117)
Free cash flow	H2 (+)	-0.00806	7.744***	-0.462	0.654**	0.487*
		(0.0547)	(2.831)	(0.298)	(0.298)	(0.261)
R&D	H3 (+)	0.763***	3.131	1.008**	2.197***	1.387**
expenditure		(0.251)	(2.709)	(0.506)	(0.717)	(0.585)
NASDAQ	H4 (+)	0.000394***	0.000845	0.000525***	0.000294***	(-0.00003)
index		(0.00003)	(0.00172)	(0.00004)	(0.00007)	(0.000196)
Firm size		0.328***	1.176***	0.361***	0.317***	0.352***
		(0.0286)	(0.297)	(0.0547)	(0.0511)	(0.0536)
Year and firm-sector fixed effect		YES	YES	YES	YES	YES
R-squared		0.0955	0.2633	0.1428	0.0899	0.0998
Constant		-2.559***	-8.192***	-2.409***	-2.012***	-2.892***
		(0.473)	(1.877)	(0.836)	(0.733)	(0.743)
Observations		3,849	175	1,257	1,072	1,120

This table presents probit regression results of CVC Activity measured as a dependent dichotomic variable, and internal and external CVC determinants. Sample consists of 399 large established firms from 27 countries and 9 business sectors. Statistics based on annual data for the years between 1985 and 2008, if available. Unless otherwise indicated Sales Growth is annual change in sales ($ million) over previous year sales ($ million), Free cash flow is established firm's income after interest and taxes plus depreciation and amortization ($ million) normalized by assets, R&D expenditure is established firm's annual total Research and Development expenditures ($ million) normalized by assets, NASDAQ is the current year NASDAQ stock market index of the common stocks used as an indicator of the performance of stocks of technology companies, Firm size is the Log of number of employees at the established firm. Data derived from Venture Expert and DataStream data sets. Regression variables are computed using annual level data, unless otherwise indicated. Dependent variable is CVC Activity a dichotomic variable taking the value of one for each observation where annual CVC investment in millions of dollars and number of startups on portfolio, are greater than zero; otherwise the dependent variable equals zero. Results are similar if we use the NASDAQ return year-to-year value instead of the NASDAQ index. We normalized R&D and free cash flow by assets in order to negate the absolute variable's effect on the data, and because we had data in different currencies, hence allowing underlying characteristics of the data sets to be compared by normalizing them to a common scale. We consider size measured by number of employees (log) as a control variable. Regressions are estimated using a Probit regression including year and firm-industrial sector fixed effect at a two-digit main SIC code. *, **, and *** indicate significance at the 10%, 5%, and 1% levels respectively.

Appendix

Appendix Table A1. Chow test comparing coefficients and structural break (1985-2008).

(Contraction. 1985-1993) vs. (Expansion. 1994-2000)
F(7, 450) = 2.68
Prob > F = 0.0099

(Contraction. 2001-2004) vs. (Expansion. 2005-2008)
F(7, 761) = 2.06
Prob > F = 0.0842

(Contraction. 1985-1993) vs. (Contraction. 2001-2004)
F(7, 418) = 0.48
Prob > F = 0.8507

(Expansion. 1994-2000) vs. (Expansion. 2005-2008)
F(7, 793) = 0.81
Prob > F = 0.5808

Unlike existing studies [e.g. Zahra (1991) analyzed the CVC contraction period 1986 to 1989, and Dushnitsky and Lenox (2005) studied the CVC expansion period 1990 to 1999], this panel data includes expansion and contraction periods. The table presents results from our period partition proposal based on the cyclical effects on the time series data measuring CVC activity over four sub-periods; 1994 to 2000 and 2005 to 2008 as expansion periods as well as 1985 to 1993 and 2001 to 2004 as contraction periods. The proposed partitioned cut-off points are based on the structural breaks. The test statistics for Chow breakpoint confirmed a structural change in the parameters during these structural break years. The F statistics rejected the null hypothesis of no structural change for all models at the 1 and 5 percent level of significance. In this Chow test we determined that the independent variables have a change in parameters when comparing expansion and contraction periods; contraction period 1985-1993 vs. expansion period 1994-2000 and contraction period 2001-2004 vs. expansion period 2005-2008. For both cases the probability was significant at F (7, 450) = 2.68 Prob > F = 0.0099, and F (7, 761) = 2.06 Prob > F = 0.0842 respectively, hence rejecting the hypothesis that estimators are equal, concluding that there is a structural break between these periods. In contrast, when comparing two CVC contraction periods and two expansion periods we cannot reject the null hypotheses as results for contraction period 1985-1993 vs. contraction periods 2001-2004 have a value of F(7, 418) = 0.48 Prob > F = 0.8507, and for the two expansion periods 1994-2000 and 2005-2008 a value of F(7, 793) = 0.81 Prob > F = 0.5808. After confirming the different periods we decided to analyze each period separately. Consequently we identified 1994-2000, and 2005-2008 as expansion periods and we considered 1985-1993 and 2001-2004 as CVC contraction periods.

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2. CVC Interaction with R&D and its Contribution to Value Creation

2.1. Introduction

Corporate venture capital (CVC) is defined as external equity investments made by established firms in privately held entrepreneurial startups (Gompers & Lerner, 1998b). CVC has been an important investment phenomenon in which high-tech companies (e.g., Apple, Intel, and Motorola), automotive giants (e.g., BMW, Ford Motor Company, and Honda), food and beverage leaders (e.g., Nestlé, Starbucks, and Carlsberg), machinery companies (e.g., Caterpillar and Honeywell), pharmaceuticals (e.g., Johnson & Johnson, Roche, and GlaxoSmithKline) among others invest billions of dollars in innovative startups. In its highest peak in 2000, these firms invested in close to 3,000 startups surpassing US$ 16 billion in investments representing approximately 25% of the entire venture capital market (Dushnitsky & Lenox, 2005b). By 2008 CVC still remained meaningful with a reported investment of approximately US$ 4 billion.

Interestingly, despite cyclical economic debacles numerous companies have maintained their commitment to CVC (Chesbrough & Teece, 2002). This has been reflected since the late 1960s and early 1970s when 25% of the Fortune 500 companies had a CVC program (Fast, 1978). During the mid-70s these programs where greatly reduced until 1978 when favorable changes to investment legislation led to an increase in venturing investments by independent venture capitalists as well as CVC (Dushnitsky & Lenox, 2005a). By the early 1980s established firms renewed their interest in CVC, however by the mid-1980s CVC was reduced again accentuated by the financial market downturn of 1986 and 1987. Afterwards the “bullish” Internet market period of the 1990s ignited CVC momentum and corporations re-introduced CVC (Yost & Devlin, 1993). In 2000, with the burst of the

Internet bubble, corporations once again headed-out of CVC (Chesbrough & Teece, 2002). More recently between 2005 and 2008 we observed a new CVC expansion cycle.

Regarding business sectors prone to engage in CVC activity, Dushnitsky and Lenox (2005b) presented the total cumulative dollars invested in CVC between 1969 and 1999. Firms such as Intel, Microsoft, Cisco, Xerox, Ford Motor Co., Sony, Motorola, AOL, Dell, and Johnson & Johnson led the list in total investments. The top 20 companies engaged in CVC belong to the electronics, information communication technology (ICT), automotive, and pharmaceutical business sectors. Our sample also comprises firms in high technology sectors (see Table 1), for example, 88.27% of all CVC investments by companies in our sample went into ventures in the following six sectors: ICT, business and engineering services, machinery and electronics, chemicals, devices, and pharmaceuticals. Only a relatively small portion (i.e. 11.73%) of CVC investment came from business sectors such as vehicles, metals, printing, publishing, food, beverage, and tobacco.

INSERT TABLE 1

Freeman and Soete (1997) defined innovation as a commercialized invention. Afuah (1997) determined that innovation is the use of new knowledge to offer a new product or service that customers want. Firms innovate to differentiate themselves and distance themselves advantageously from the competition (Schumpeter, 1942). In order to innovate successfully firms rely on the development and integration of new knowledge. Nowadays even the largest and most technologically advanced firms require knowledge beyond their boundaries seeking to optimally combine internal and external sources of knowledge[11] to benefit from the positive effects that internal and external sources have to offer (Cassiman & Veugelers, 2002). This innovation strategic approach is referred to in the literature as Open Innovation[12] because it broadens the sources of ideas and new product development (NPD) through cooperative agreements between firms and different types of external partners such as startups, competitors, suppliers, customers, universities and research centers.

Research and development (R&D) has traditionally been the main approach to generate innovation and it has been widely studied (Aldrich, 1979; Cohen & Klepper, 1996; Ericson & Pakes, 1995; Hall, 1992; Henderson & Cockburn, 2000; Jaffe, 1986; Klette & Moen, 2000; Levin et al., 1987; Stuart et al., 1999). However R&D is only one innovation activity. More and more scholars e.g. (Chesbrough, 2002b; Cohen & Levinthal, 1990; Davila et al., 2006; Dushnitsky & Lenox, 2005a; Teece et al., 1997) acknowledge the ability to exploit alternative external knowledge as a fundamental element of innovation management hence scholar attention has shifted towards understanding external innovation activities. For example Cohen et al. (2002a) studied partnerships with universities & research centers while Keil (2004) conducted research on mergers & acquisitions, and strategic alliances as a means to generate innovation. More importantly for our study, research on CVC is limited and has recently attracted scholar interest (Dushnitsky & Lenox, 2006).

We know that CVC represents an important potential driver for profitable growth (Allen & Hevert, 2007; Burgelman & Välikangas, 2005; Hurry et al., 1992) and that it positively impacts the creation of value (Dushnitsky & Lenox, 2006). In addition, we know that CVC offers several benefits such as increasing firm financial returns (Allen & Hevert, 2007), boosting innovation output and NPD opportunities (Maula, Autio, & Murray, 2003;

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[11] For example innovation activities such as research and development can be considered an internal source of knowledge, and CVC can be considered an external source of knowledge.

[12] Chesbrough's 2003 definition of open innovation: "a paradigm that assumes that firms can and should use external ideas as well as internal ideas, and internal and external paths to market, as they look to advance their technology. Open Innovation processes combine internal and external ideas into architectures and systems."

Roberts & Berry, 1985; Wadhwa & Kotha, 2006), and expanding access to new knowledge thereby increasing the rate of corporate learning and technological development (Hamel, 1991). CVC also provides strategic flexibility relative to R&D as it involves an equity investment that can be restructured or exited in case of changing internal or external conditions (Folta, 1998) and it also facilitates access to information that reduces market and technology uncertainties (Kogut, 1991).

Interestingly, the interaction between CVC and R&D has generated much debate. Some researchers see them as substitutes while others consider them complementary. (Hellmann, 2002) suggests that firms have to choose between CVC and R&D. On the other hand Chesbrough and Tucci (2004) state that the interaction can be complementary. In other words while availability of external CVC technology may substitute internal R&D, there are also arguments suggesting complementarity (Arora & Gambardella, 1990; Granstrand et al., 1992). Several researchers have already provided theoretical frameworks on the existence of such interaction (Chesbrough & Socolof, 2000; Gompers & Lerner, 1998b). However there are still some open questions about CVC and R&D: Are CVC and R&D substitutes or complementary? How do firms organize themselves to perform effective simultaneous CVC and R&D innovation activities? For what kind of innovation are CVC and R&D better suited? Are CVC and its interaction with R&D effective for creating value contingent to certain business sectors or geographic regions? While the decision to commit resources towards internal R&D expenditure has been studied (Hall, 1992; Himmelberg & Petersen, 1994) there remains a need to analyze firms that utilize R&D and CVC simultaneously and to assess the impact this strategy can have on value creation. Research falls short to explain the CVC and R&D interaction effect on value creation (Dushnitsky & Lenox, 2006; Gompers, 2002). Consequently these gaps represent research opportunities for us.

We measure the impact of CVC and its interaction with R&D, on value creation. We construct a robust data set and perform multiple tests studying 324 large established firms between 1985 and 2000, and find that CVC and its interaction with R&D are associated with value creation however this relationship is contingent upon business sectors and regions. We conclude that the contribution of CVC to value creation is greatest within the ICT, machinery & electronics, and engineering & business service sectors. Interestingly the complementarity between CVC and R&D also presents its value creation influence in the ICT, machinery & electronics, and engineering & business service business sectors. Similarly, we conclude that the contribution of CVC to value creation is greatest within the USA & Canada, and Asia regions.

In this paper, we extend beyond the existing literature by looking at the market and profitability value creation of CVC and its interaction with R&D. We study the business sectors and regions under which these create value. Unlike existing studies[13] the findings of our research arise not only from a panel data that includes both CVC expansion and contraction periods between 1985 and 2000, but also considers a global scope as previous studies on CVC (Dushnitsky & Lenox, 2005b) have been conducted mainly with a U.S. focus, while ours encompasses firms from different countries[14].

The paper has the following structure. In Section 2 we look at the literature relevant to our subject and develop hypotheses. In section 3 we describe our data. Our methodology and variables are in section 4. In section 5 we discuss the results obtained from our quantitative analysis. In section 6 we expand on the discussion, and finally the conclusions and managerial implications are presented in section 7.

[13] e.g. Zahra (1991) analyzed the CVC contraction period 1986 to 1989, and Dushnitsky and Lenox (2005) studied the CVC expansion period 1990 to 1999.
[14] Australia, Austria, Belgium, Canada, China, Denmark, Egypt, Finland, France, Germany, Hong Kong, India, Israel, Italy, Japan, Malaysia, Mexico, Netherlands, Norway, Singapore, South Korea, Spain, Sweden, Switzerland, Taiwan, USA, UK.

2.2. Literature Review and Hypotheses

2.2.1. Theory Review on Innovation and Value Creation

Research has linked theories of organization with firms' CVC practices. For example Basu et al. (2011) adopted a resource-based view when explaining why firms make CVC investments considering these valuable resources that allow firms to remain competitive. Moreover, firms undertake internal and external corporate initiatives[15] to build tangible and intangible valuable resources (Wernerfelt, 1984). Both R&D and CVC are valuable, rare, inimitable, and non-substitutable (Basu et al., 2011). These characteristics are critical to the resource-based theory (Ahuja, 2000; Barney, 1991a, b; Eisenhardt & Schoonhoven, 1996; Smith, Vasudevan, & Tanniru, 1996). However, alternative explanations can emerge from a different theoretical angle. For example when investigating the effects on the value creation of a firm's internal R&D and external CVC innovation activities we can also consider the dynamic capabilities theory which offers a framework for understanding a firm's value creation through its ability to integrate, build, and reconfigure innovation activities (Eisenhardt & Martin, 2000; Teece et al., 1997). This ability to reconfigure can include assembling and combining internal R&D and external CVC competences, hence firms can adapt to changes in the competitive landscape.

To explain the causal chain from R&D and CVC, to innovation, and value creation, we take into account the empirical evidence that implies a positive effect of high innovativeness on a firm's competitive advantage (Kleinschmidt & Cooper, 1991; Sorescu, Chandy, & Prabhu, 2003). Innovative product development also provides a competitive advantage allowing firms to obtain returns on innovation such as higher sales and firm growth (Bayus, 1998; Bayus, Erickson, & Jacobson, 2003). This competitive advantage effect increases with a higher degree of innovativeness (Gatignon & Xuereb, 1997) meaning that

[15] By initiatives we refer to internal and external means to acquire knowledge e.g. R&D as internal and CVC as external.

highly innovative new products are likely to better address market needs (Schmidt & Calantone, 2002) which then positively influence consumer willingness to pay and adopt new products (Rogers, 1995). Consequently, a client's willingness to pay and adopt new products and services influences firm value creation (Zahra et al., 2000).

2.2.2. CVC and Value Creation

CVC is based on corporate motivations pursuing strategic and financial goals (Block & MacMillan, 1995; Henderson, Leleux, & White, 2006). Alter and Buchsbaum (2000) reported that 85% of CVC units pursue financial value creation while 71% of the respondents claim to use CVC also as a strategic "Window on Technology". This provides important benefits to large established firms interacting with startups' new technologies that can have a positive effect on value creation (Bottazzi, Da Rin, & Hellmann, 2004; Maula et al., 2003).

Chesbrough (2002b; 2002c) also proposed that CVC can represent an important tool not only for financial returns, but also as an important catalyst to boost growth and value creation. However, in their research, Lin and Lee (2011) studied future growth opportunity as the central strategic benefit of CVC activity, finding that there was no significant relationship between CVC and growth.

There have been other studies on value creation and strategic benefits including technology acquisition (Chesbrough, 2003a, b), knowledge accumulation (Wadhwa & Kotha, 2006), and organizational renewal (Siegel et al., 1988) indicating that these contribute to company value creation. It has also been documented that CVC can be an important driver for profitable growth (Burgelman & Välikangas, 2005). And according to Zahra (1991), CVC represents a basis for corporate growth, while Tsai and Wang (2008) report that large firms eagerly seek to utilize external knowledge (e.g. CVC activity) as a source of growth opportunities.

Chesbrough (2002c) claimed that firms can justify CVC investment if such firms create value for their shareholders in ways shareholders cannot do themselves. The main argument for this is that firms can have superior knowledge with regard to technologies and commercialization due to their exposure to technology and markets. Moreover, CVC offers several benefits such as increasing financial returns (Allen & Hevert, 2007), boosting NPD output (Maula et al., 2003; Roberts & Berry, 1985; Wadhwa & Kotha, 2006), raising corporate knowledge and technological development (Hamel, 1991), and providing strategic organizational flexibility relative to R&D due to investments that can be up or down scale depending on evolving technological or market conditions (Folta, 1998; Kogut, 1991).

Previous work has also found that CVC investment may be an effective way for firms to increase their innovative output (Dushnitsky & Lenox, 2005a). There is also evidence indicating that CVC is associated with value creation, particularly when firms pursue innovative strategic technologies (Dushnitsky & Lenox, 2006).

Furthermore CVC contributes to the firm by facilitating the formation and expansion of the firm's "ecosystem" consisting of suppliers, customers and other providers, thus stimulating demand for their core products (Lin & Lee, 2011). An example of this "ecosystem" expansion is developed by Campbell et al. (2003) where Intel Capital invests in startups that in turn can increase the demand for Intel microprocessors. Another study focusing on a firm is DuPont's CVC initiative. Bhardwaj et al. (2006) reported that DuPont invested rapidly but selectively in startups to quickly explore the growth opportunities within a specific sector. In other words, when DuPont CVC invests in multiple new startups within a narrowly defined industrial sector, the aggregate growth value of those investments creates more growth potential (Vassolo et al., 2005; Vassolo et al., 2004). Finally, another recent company focus study from McGrath et al. (2006) found that firms such as Nokia consider CVC as a source of value creation. For example between 1998 and 2002 although 70% of

Nokia's portfolio company was discontinued and 21% was absorbed by Nokia business units, Nokia's innovation managers responded that in 25% of the cases, startups generated new organizational capabilities, 16% led to the introduction of new products, and most generated important intellectual property. In other words, despite the high discontinuation ratio of startups, Nokia benefited from the value generated by its CVC activities.

Hence we present the following hypotheses related to CVC and value creation:

H1. The magnitude of CVC investment is positively associated with the value of firms investing in CVC.

2.2.3. CVC and R&D Interaction and Value Creation

Previous work from Cassiman and Veugelers (2002) links transaction costs economics (TCE) with internal and external complementary innovation activities. TCE focuses on the decision to "make" or "buy". "Make" represents innovation produced through internal R&D and "buy" would be innovation acquired through external CVC. This approach suggests that in order to generate innovation, CVC and R&D operate as substitutes (Pisano, 1990; Williamson, 1985). Teece, Pisano and Shuen (1997), Roberts and Berry (1985), and Chesbrough and Tucci (2004) provide different approaches to generate NPD. For example, for technologies and markets that are familiar to the established firm, R&D is a suitable path to develop new products. While for unfamiliar technologies and markets CVC can be the advisable path to generate innovation. Consequently the established firm's market and technology position and its relation to the new business or NPD that it's trying to develop can determine which mechanism to utilize (i.e. R&D or CVC) making these substitutes for one another.

While availability of external CVC activity may substitute internal R&D technology development, there are also scholars who suggest there is complementarity between CVC and R&D (Arora & Gambardella, 1990; Granstrand et al., 1992). Ennen and Richter (2010) suggested that complementarities result from the skillful matching of heterogeneous resources which generate positive returns above and beyond the effect each resource could generate on its own. For example a large firm that has strong R&D competencies can seek access to new external technological resources via CVC investment (Ahuja, 2000). Such access to R&D resources, infrastructure, and new technology is particularly important for firms engaged in CVC as this can represent a mechanism for value creation (Hee-Jae & Pucik, 2005; Mitchell & Singh, 1992). Furthermore firms that combine internal and external sources of knowledge are more capable of identifying ways in which value can be captured from partnering with startups (Gans & Stern, 2003b). A large firm's CVC unit with access to its parent's technological and commercial resources can create value by interacting with new resources of a startup to create NPD (Hill & Birkinshaw, 2006). Such established firms can have the technological R&D competence to create value as internal R&D provides the infrastructure foundation upon which firms can learn from external CVC activities (McGrath, 1997). This can be exemplified by an established firm's R&D staff interacting with startups at the pre-investment technological due diligence (Dushnitsky & Lenox, 2005a). The benefits of these interactions between large firms and startups outweigh the potential hazards of intellectual property leaks between them (Cassiman & Veugelers, 2006). This notion is particularly problematic because CVC investors are often viewed suspiciously by startups due to the perception that a CVC investor's goal can be to expropriate a startup's technology (Dushnitsky & Shaver, 2009; Katila et al., 2008).

CVC activity can also strengthen a firm's ability to create new business opportunities as large firms gain access to proprietary technologies of startups that can then be combined with existing internal R&D technologies to create new products (Gompers & Lerner, 2001a; Gompers & Lerner, 2001b). The interaction between R&D and CVC influencing value creation has not been fully attended by scholars. There is a dearth of research to explain the effect of such interaction (Chesbrough & Tucci, 2004; Dushnitsky & Lenox, 2006; Gompers, 2002). Nonetheless, researchers have provided theoretical frameworks on the existence of such interaction (Chesbrough & Tucci, 2004; Chesbrough & Socolof, 2000; Gompers & Lerner, 1998b). However these frameworks have different views with no common conclusion. Some suggest that large firms can achieve synergies by working with startups, but can also face conflicts of interest if the interaction between the investing firms and the startup is a substitute “cannibalizing” the investing firm’s current product offering. Additionally in most cases the CVC investor often pays a higher valuation than an independent venture capitalist. In these situations established firms are faced with the decision to invest resources either via CVC or R&D suggesting that CVC and R&D compete for corporate resources implying a substitution effect (Cassiman & Veugelers, 2002; Hellmann, 2002).

There is another school of thought suggesting that access to external know-how may leverage the productivity of the internal R&D activities (Veugelers, 1997) and that such interaction can be complementary to value creation (Chesbrough & Tucci, 2004). Moreover, Afuah and Tucci (2001) and Chesbrough and Rosenbloom (2001) stressed on the need for firms to look beyond their boundaries and seek for external mechanisms to harness new technology. There are also “goodwill” intangible assets (e.g. brand and company reputation) that can leverage and complement the new technology provided by the startup. This complementarity is the rationale behind Intel Capital CVC investments (Taptich, 1998).

In a resource constrained world firms can allocate resources between internal R&D and external CVC opportunities. However a profit-seeking firm can choose to invest simultaneously in CVC and R&D for an expected higher value creation output. Hence we present the following hypothesis related to the CVC and R&D interaction influencing value creation:

> H2. The simultaneous investment in CVC and R&D, has a positive effect on the value of the firms investing in CVC.

2.3. Data

To test our hypotheses, we explore the relationship between value creation and the elements of CVC investment and CVC x R&D interaction. We build a large panel data and because CVC investments are typically made by established firms (Dushnitsky & Lenox, 2006) we focus our study on publicly listed firms investing in CVC. Due to lack of reliable data prior to 1985, our period study ranges from 1985 to 2000. To the best of our knowledge, our database is unique in that it provides detailed information on financial and corporate venturing activities made by international publicly listed established firms. The database contains financial information on firms drawn from Thomson Reuters DataStream and we combine these data with CVC data collected from Venture Economics VentureExpert database which includes a comprehensive coverage of CVC investment, exit, and performance activity in the private equity industry. Several studies on VC and CVC have used this database (Basu et al., 2011; Dushnitsky & Lenox, 2005a, b; Gompers, 1995; Wadhwa & Kotha, 2006).

In order to combine DataStream and VentureExpert, we utilize an automated matching algorithm and a hand-checking. For our study we dropped the established firms when financial accounting data were missing. Furthermore, we decided to exclude real estate and financial institutions from our sample, hence limiting the study to establish firms that invest in NPD. After these adjustments our sample had 324 publicly listed established firms investing in R&D and CVC.

Previous studies on CVC have been conducted mainly with a U.S. focus (Dushnitsky & Lenox, 2005b, 2006), while research on Europe, Asia, and the rest of the world (ROW) has been scarce. An exception is the Lin and Lee (2011) study focusing on Taiwanese based firms. Our research encompasses a global scope with firms from different countries. For sample description purposes we group them by Anglo-Saxon vs. non Anglo-Saxon countries. In Table 2 we observe that between 1985 and 2000, the established firms in our sample were predominantly from Anglo-Saxon countries (i.e. 64.51%) while 35.49% pertain to Non Anglo-Saxon countries. This difference can depict country characteristics such as judicial system including the kind of law (i.e. common law or code law), language, as well as other varying characteristics such as technology transfer policy, and tax incentives (Armour & Cumming, 2006; Klette & Moen, 2000; Lerner, 2010; Poterba, 1989).

INSERT TABLE 2

2.4. Methodology and Variables

2.4.1. Dependent Variables

We utilize a widely used measure of firm performance: *Tobin's q* is a measure of market valuation. Capital market performance data provide a metric and allow bridging the potential time lag (Lee & Grewal, 2004; Sorescu et al., 2003). *Tobin's q* was chosen as an adequate capital market metric as it measures investors' expectations concerning a firm's potential to generate future profit (Brealey, 2007). Tobin's q has recently been applied in several studies in NPD and marketing research (Firth & Narayanan, 1996; Lee & Grewal, 2004). Furthermore Tobin's q is a good proxy for a firm's competitive advantage (Montgomery & Wernerfelt, 1988; Wernerfelt & Montgomery, 1988). A Tobin's q greater than 1.0 indicates that investors have a positive outlook for the firm's growth opportunities. The higher the Tobin's q, the greater the perceived growth opportunities for such a firm, Tobin's q is defined as the ratio of a firm's market value to the replacement cost of its assets (Brainard & Tobin, 1968). We calculate Tobin's q by dividing the sum of firm equity value, book value of long-term debt, and net current liabilities by total assets (Chung & Pruitt, 1994).

For research exploration purposes we decided to include other profitability performance metrics such as return on sales (*ROS*), return on assets (*ROA*) and return on equity (*ROE*) (see Table 3 for variables description). Regarding profitability, we used return on sales (*ROS)* as an accounting-based measure (Hart & Ahuja, 1994). ROS represents a measure of firm value and is calculated by dividing net earnings by net sales. Innovations that are developed will only be launched in the medium or long term, hence assessing performance effects of innovation strategy needs to account for a potential time lag between the time the *CVC investment* was executed and the time it can take to have an impact on value creation. Consequently, to account for a time lag between the impact that R&D and CVC have on performance we consider a period of five years, i.e. (time t+5 years). The entire analysis presented in this study was replicated using Return on Equity (ROE) as an alternative measure of profitability. However Palepu (1985) mentions that ROE could create distortions depending on the focus of the research. For example, if we were to analyze innovation and value creation through acquisitions – these could be financed by cash or debt. The equity base of a company may grow very little while the absolute size of the profits increases due to the acquisition consolidation of financial statements. The use of ROE measures may introduce a bias as a consequence of factors such as the debt-equity mix used in financing such acquisitions. In contrast ROS measures avoid this problem, thus, in the context of the present study, the use of the ROS measures is probably superior to ROE measures. More importantly for a competitive advantage such as a continuous flow of new commercialization, meaning sales of new products, ROS distinguishes itself from other managerial accounting metrics. Furthermore CVC can also be considered an instrument contributing to NPD allowing firms to offer new products to market distancing themselves advantageously from competitors by being able to price products and services at higher margins, consequently influencing ROS.

INSERT TABLE 3

2.4.2. Independent Variables

One of our primary independent variables is annual *CVC investment* in millions of dollars normalized by assets. This measure is calculated as the sum of all dollars invested via corporate venturing funds of a firm in a year. This variable has the characteristic of being continuous and observable over time. The main independent variable is the interaction term between CVC and R&D for which we create the variable CVC investment x R&D expenditure (*CVC x R&D*). This identifies year observations in which firms pursue CVC investments and R&D expenditure simultaneously.

2.4.3. Control Variables

We include a number of measure controls commonly used in the analysis of financial performance (Berger & Ofek, 1995). A company's size (*firm size*) is calculated as the log of the company's assets. The amount by which a firm grows (*growth*) is calculated as the annual percent change in sales. The degree to which the firm is leveraged (*leverage*) is expressed as the ratio of its debt to assets. *Capital expenditure* represents the funds used to acquire fixed assets other than those associated with acquisitions, including, but not restricted to, additions to property, plant and equipment, and investments in machinery. Additionally we include measures of average *industry Tobin's q* for the whole industry and *sector Tobin's q* for the whole sector both to control for time-variant and industry or sector specific variation. At any point in time, differences in industry profitability may have to do with any number of factors including industry structure, technological innovation, or government regulation. *Industry and sector Tobin's q* is calculated as the average q of all firms within a firm's four-digit SIC code in a given year. We also control for *risk* represented by stock price volatility as a measure of a stock's average annual price movement to a high and low from a mean price for each year. For example a stock's price volatility of 20% indicates that the stock's annual high and low price has shown a historical variation of +20% to -20% from its annual average price. Finally, we include R&D as a control variable that we interacted with our main independent variable CVC. R&D is the traditional activity conducted by firms to generate internal knowledge and create value (Griliches, 1979; Hall, 1992; Himmelberg & Petersen, 1994). Kuratko and Audretsch (2009) consider R&D as an important factor for corporate growth, since R&D encompasses identification and exploitation of new innovative opportunities within firm boundaries fostering organizational renewal. Levin et al. (1987) studied the incentives to invest in R&D explaining that firms need to appropriate sufficient returns to make R&D expenditure worthwhile. Jaffe (1986) also conducted research on R&D

and value creation measured by profits and market value and found that firms with lower R&D activity suffer from lower profits and lower market value than firms with higher R&D activity. R&D signals a parent company's commitment to technology, which in turn generates valuable resources and outputs such as patents, laboratory facilities, and specialized technology staff that can influence value creation (Stuart et al., 1999). Furthermore, there have been studies unveiling the relationship between R&D expenditures and innovation competencies (Henderson & Cockburn, 2000). Expanding on the positive significant relationship between R&D and value creation, Klette and Griliches (2000), Ericson and Pakes (1995), and Cohen and Klepper (1996) determined that R&D expenditure is an engine for firm growth. They extended their research to incorporate other performance metrics such as productivity, patenting, profitability, and sales growth, all of which are influenced by R&D and innovations within the firm. Thompson (1996) also developed a complete model of R&D expenditure. On the basis of his model he presents an empirical analysis of the positive significant relationship between R&D and the stock market value of the firm.

2.4.4. Selection Variables

By adopting a two-stage specification, in line with Maddala (1983) and Heckman (1979), we control for the fact that firms self-select to invest in CVC, we expand on this matter on the methodology section. In brief, the first stage of this model is used to predict the likelihood that a firm will invest in CVC through a Probit regression utilizing *CVC activity* as a dependent dichotomic variable, where all levels of CVC investments greater than zero, were assigned the value of one. Otherwise, the variable was assigned a value of zero if there was no CVC investment.

For the first stage Probit regression, we used the following independent variables: *free cash flow* calculated as income after interest and taxes plus depreciation and amortization normalized by assets and the *NASDAQ index* representing a stock market index indicating the performance of stocks of technology companies.

2.4.5. Methodology

Similar to Dushnitsky and Lenox (2006), to test the research hypotheses we selected Ordinary Least Square (OLS) regressions. Following Mitchell and James (2001) we gathered public market environmental data that corresponded directly to the point in time at which the VentureExpert data was collected.

Considering the time series nature of our data, to decide whether to utilize a fixed-effect or random-effect, we performed a Hausman test based on the difference between the random-effect estimator and the fixed effect estimator in which observationally equivalent firms may differ on some unobservable or unmeasured characteristic (Hausman, 1978; Maddala, 1983). It is possible to correct for unobserved heterogeneity using random and fixed effects estimations. Our results met the asymptotic assumptions converging for our data showing to be highly significant (Prob>chi2 = 0.0001). Therefore we use the consistent estimator for the fixed effect, and not the efficient estimator for the random effect. We implemented a firm and year fixed effect.

Our sample includes only firms that have engaged in CVC and R&D. As mentioned earlier the CVC investment decision can be the result of self-selection such that only investing firms with available financial resources and access to innovative startups can engage in CVC. This could create an endogeneity problem in which regular OLS regressions could overestimate the effects of CVC (Shaver, 1998). To confront this estimation bias which could threaten the generalizability of our results to the larger population of firms, we conducted, similarly to Lin and Lee (2011) and Dushnitsky and Lenox (2006), a Heckman model (Heckman, 1979) as a robustness test before running the OLS regressions previously described. A Heckman model includes two equations: the first selection model estimates the likelihood of a company to engage in CVC. The hazard rate from that model is included in the second stage regression model to predict *Tobin's q*. This analytical approach has been widely used in the empirical literatures on strategy and performance (Geletkanycz & Hambrick, 1997; Zajac & Westphal, 1994). Similar to the OLS regressions, due to the Hausman test results, we use the consistent estimator for the fixed effect, and not the efficient estimator for the random effect. We implement a firm-industrial sector fixed effect at a two-digit SIC code.

Unlike existing studies[16] our study includes an expansion and a contraction period. A Chow test was conducted to verify whether estimates were different between the periods presenting CVC expansion (i.e. 1994 to 2000) and CVC contraction (i.e. 1985 to 1993). The test for Chow breakpoint confirmed a structural break in the parameters in 1993. The F statistics rejected the null hypothesis of no structural change at 1% level of significance (see Appendix Table A1). After confirming the structural break we decided to analyze the whole 1985 to 2000 period to observe if value creation holds regardless of the contraction-expansion structural break.

2.5. Analysis and Results

In Table 4 we present descriptive statistics for our dependent and independent variables used for the continuous regressions for the total selected cyclical period between 1985 and 2000. The sample consists of 324 large established firms from 27 countries[17] and

[16] e.g. Zahra (1991) analyzed the CVC contraction period 1986 to 1989, and Dushnitsky and Lenox (2005) studied the CVC expansion period 1990 to 1999.
[17] Full country sample includes: Australia, Austria, Belgium, Canada, China, Denmark, Egypt, Finland, France, Germany, Hong Kong, India, Israel, Italy, Japan, Malaysia, Mexico, Netherlands, Norway, Singapore, South Korea, Spain, Sweden, Switzerland, Taiwan, United Kingdom, and Unites States of America.

similar to (Dushnitsky & Lenox, 2006) we focus on 6 business sectors[18] excluding other sectors for parsimony sake. We observe that the average *Tobin's q* for the firms in our sample is 2.114. *CVC investment* represents the total corporate venture capital invested ($ million) normalized by assets. *CVC x R&D* is computed as the interaction term between *CVC investment* and *R&D expenditure*. Capital expenditures ($ million) is normalized by assets. *Growth* is represented as the annual change in sales ($ million) over previous year sales ($ million) presenting in our sample a minimum of 71% sales reduction, while maximum firm growth was over 588% year-to-year on sales *growth*. *Leverage* is calculated as the ratio of debt ($ million) to firm assets ($ million). *Industry Tobin's q* equals the average industry *Tobin's q* (by 4 digit SIC code). *Risk* is represented by the stock price volatility measure of stock's average annual price movement to a high and low from a mean price for each year. Finally, *Firm size* is the Log of firm assets ($ million) at the established firm.

For a more comprehensive description of the firms in our sample, in Table 5 we include descriptive statistics on the profile of the established firms. *Tobin's q* is showing an average of 2.114, Sales is based in millions USD ($ million) with an average of USD 10.2 ($ billion). *CVC investment* as total corporate venture capital invested in millions USD ($ million) ranging from USD 0 to 931 ($ million). *R&D expenditure* equals an average of USD 831 ($ million). Assets in our sample represent an average of USD 16 ($ billion) and for *Employees* we have a mean value of 62,319, with a maximum of 446,800 employees.

INSERT TABLE 4

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[18] Sample business sectors include: information communication and technology ICT (357*, 367*, 48**, 3663), pharmaceuticals (2834, 2836), vehicles (37**), food beverage and tobacco (20**, 21**), industrial machinery and electronics (35**, 36** excluding 3663), and business & engineering services (73**, 87**).

INSERT TABLE 5

In Table 6, we run a correlation test to identify potential sources of multicollinearity, this table reports the correlation coefficients between the dependent, independent, and control variables. The correlation matrix presents correlations for the parent company independent variables *CVC investment* and *CVC x R&D*, and the control variables *R&D expenditure, Capital expenditure*, *Growth*, *Leverage*, *Industry Tobin's q*, *Risk*, and *Size*. This table presents our dependent variable *Tobin's q* which is correlated with the independent variables (i.e. 0.3896 for *CVC investment*) and (i.e. 0.5108 for *CVC x R&D*). Regarding the correlation between the independent variables CVC x R&D interaction term and CVC investment there is the existence of a 0.2618 correlation between them.

INSERT TABLE 6

In Model 1 (Table 7) we regress *Tobin's q* including *CVC investment, R&D expenditures, capital expenditure, growth, leverage, risk, firm size, and industry Tobin's q.* Due to *Tobin's q*, reflection on public market expectations of future discounted cash flow, we use contemporaneous values for each of our independent variables. We adopt a fixed-effect specification that includes both firm industrial sector and year dummies to address stable unobserved heterogeneity across firms as well as macroeconomic trends. Model 1 in Table 7 shows that *CVC investment* is significant and positively related at the 1% level to *Tobin's q* hence supporting hypothesis H1.

For Model 2 (i.e. the interaction CVC x R&D term model). Following Cohen et al. (2003) we mean-centered the variables for the interaction regressions. The results in this *CVC x R&D* interaction subsection indicate that, consistent with hypothesis H2, firms that pursue *CVC investment* and *R&D expenditure* simultaneously are associated with value creation. This positive relationship is attributable to the combination of *CVC investment* and *R&D expenditure* significant at the 1% level. This is particularly interesting, as in the literature we found that Dushnitsky and Lenox (2006) also reported a significant positive coefficient between *R&D expenditure* and *CVC investment*. This would suggest that internal *R&D expenditure* and *CVC investment* are in fact complements and not substitutes.

For Models 3 to 6, the Heckman first stage regressions indicated that for our independent variable *CVC activity*, there was censorship causing a concentration of observations at zero values. By executing this Probit regression for the whole period 1985 to 2000 we found significant support at the 1%-level that both NASDAQ and free cash flow influence CVC engagement (see bottom section Table 7 Models 3, 4, 5, and 6. As for the second stage regression model to predict *Tobin's q*, these are presented on Models 3, 4, 5, and 6 in which we report results with no firm-sector fixed effect (i.e. Models 3 and 5) and then we introduce the year and firm-sector fixed effect (i.e. Models 4 and 6). After implementing the fixed effects the results remain significant at the 1% level for both CVC investment and CVC x R&D interaction.

INSERT TABLE 7

For research exploration purposes we decided to include other accounting performance measures as dependent variables i.e. *ROA, ROE,* and *ROS* (see Table 8). Model 8 suggests there is a relationship at the 5% level between *CVC investment* and *ROA* 10 years after *CVC investment* has been executed. However, we found no evidence suggesting a significant relationship between *CVC investment* and *ROE.* Regarding Model 11 (i.e. Table 8 ROS 5 years) CVC investment is significant at the 10% level supporting H1. One possible explanation for this finding is that for our sampled firms, CVC may be a valuable tool to influence future sales margins.

INSERT TABLE 8

Considering the benefits and limits that CVC provide to firms it is likely that the utilitarian advantages of CVC are contingent on the business sector where established firms operate (Dushnitsky & Lenox, 2006). Business sectors differ significantly in their level of technological opportunity and Cohen et al. (2002a) proposed that the marginal benefit of external CVC relative to internal R&D should be greater in business sectors with more technological opportunities. This is because in business sectors with greater technological opportunities, startups are more likely to identify valuable innovations which can represent attractive CVC investment opportunities for established firms that can be exploited and scaled up to create value (Shane, 2001). Dushnitsky and Lenox (2005a) and Levin et al. (1987) proposed that established firms will most likely invest in business sectors with rich technological opportunities where the level of technological opportunity is influenced by advancements in technology. Prior research also suggests that ICT and business service firms typically engage in CVC as a window on technology and are able to leverage innovation to reach superior financial and strategic returns (Chesbrough, 2000). For instance the ICT business sector is characterized by greater technological opportunity and is the most fertile ground for scanning and sourcing external technologies (Cohen et al., 2002a).

Our firm fixed effects capture business sector differences. However a pool sample could create an underlying heterogeneity in the coefficients. To address whether inter industrial variability influenced the results, similar to Dushnitsky and Lenox (2006), we partitioned the database sample in six business sectors: Food beverage & tobacco, Engineering & business services, Machinery & Electronics, ICT, Pharmaceuticals, and Vehicles.[19] Replicating Model 1 at the business sector level, we found that the benefits of CVC investment apply to firms in certain sectors (see Table 9). In particular, *CVC investment* has a positive significant impact on *Tobin's q* for ICT (Model 14), machinery & electronics (Model 15), and engineering & business services (Model 17), supporting hypothesis H1, at the 1% level.

INSERT TABLE 9

Following the approach replicating Model 11 at the business sector level for *ROS 5 years* after *CVC investment* has been executed, we found that the benefits of *CVC investment* also apply to firms in certain sectors (see Table 10). Similar to *Tobin's q*, *CVC investment* has

[19] Sectors are defined by SIC code: information communication and technology ICT (357*, 367*, 48**, 3663), pharmaceuticals (2834, 2836), vehicles (37**), food beverage and tobacco (20**, 21**), industrial machinery and electronics (35**, 36** excluding 3663), and business & engineering services (73**, 87**). We exclude other business sectors for parsimony sake.

a positive significant impact on *ROS 5 years* for ICT (Model 20), and machinery & electronics (Model 21) supporting hypothesis H1 at the 5% level. However it did not prove positively significant for engineering & business services.

INSERT TABLE 10

Our sample covers several countries and regions[20]: USA & Canada, Europe, Asia, and the rest of the world (ROW). We also group countries by Anglo-Saxon vs. non Anglo-Saxon groups characterized by differences such as the kind of law (i.e. code law or common law) practices and language. By considering the benefits that CVC provide to firms it is likely that the utilitarian advantages of *CVC investment* are contingent on the development of a country or region due to their legal system, technology transfer policy, and tax incentives (Armour & Cumming, 2006; Lerner, 2010; Poterba, 1989).

To address whether inter regional variability influenced the results, we partitioned the database sample in a set of comparable regressions: USA vs. Non USA, Anglo-Saxon vs. Non Anglo-Saxon; and finally continental regions. Replicating Model 25 on the different regions, we found that the benefits of *CVC investment* are applicable to firms in certain regions (see Table 11). In particular, *CVC investment* has an impact on *Tobin's q* for USA (Model 26), USA & Canada (Model 30). Model 32 for Asia also presents a positive significant relationship at the 5% level. Models 28 and 29 for Anglo-Saxon and Non Anglo-Saxon show

[20] Full country sample includes: Australia, Austria, Belgium, Canada, China, Denmark, Egypt, Finland, France, Germany, Hong Kong, India, Israel, Italy, Japan, Malaysia, Mexico, Netherlands, Norway, Singapore, South Korea, Spain, Sweden, Switzerland, Taiwan, United Kingdom, and Unites States of America.
Anglo-Saxon sample includes: Australia, Canada, United Kingdom, and Unites States of America.
Europe sample includes: Austria, Belgium, Denmark, Finland, France, Germany, Italy, Netherlands, Norway, Spain, Sweden, Switzerland, and United Kingdom.
Asia sample includes: China, Hong Kong, India, Israel, Japan, Malaysia, Singapore, South Korea, and Taiwan.
Rest of the World (ROW) country sample includes: Australia, Egypt, and Mexico.

that *CVC investment* has an impact on *Tobin's q*. All Models in which *CVC investment* was significant reported significance at the 1% level.

Regarding regressions for Non USA, and Europe (i.e. Models 27 and 31) we observe that our control variable *R&D expenditure* has a significant and positive impact at the 5% level. The coefficients for the ROW regression (i.e. Model 33) proved non-significant.

INSERT TABLE 11

For Tables 12 and 13, following Cohen et al. (2003) we mean-centered the variables for the interaction regressions. The results in this *CVC x R&D* interaction subsection indicate that, consistent with hypothesis H2, firms that pursue *CVC investment* and *R&D expenditure* simultaneously are associated with value creation. We have also documented that this positive relationship is attributable to the combination of *CVC investment* and *R&D expenditure* significant at the 1% level (see Tables 12 and 13 Models 35 and 42). This is particularly interesting, as in the literature we found that Dushnitsky and Lenox (2006) also reported a significant positive coefficient between *R&D expenditure* and *CVC investment*. This would suggest that internal *R&D expenditure* and *CVC investment* are in fact complements and not substitutes. Our firm fixed effects capture business sector differences. However a pool sample could create an underlying heterogeneity in the coefficients. To assess whether inter industrial variability influenced the results, we first partitioned the database sample in six business sectors[21] see Table 12, and secondly partitioned the database

[21] Sectors are defined by SIC code: information communication and technology ICT (357*, 367*, 48**, 3663), pharmaceuticals (2834, 2836), vehicles (37**), food beverage and tobacco (20**, 21**), industrial machinery and electronics (35**, 36** excluding 3663), and business & engineering services (73**, 87**). We exclude other business sectors for parsimony sake.

sample in the different regions see Table 13. Considering the benefits of pursuing *CVC investment* and *R&D expenditure* simultaneously, it is likely that the utilitarian advantages of such interaction are contingent on the business sector or region where the established firm operates. As mentioned earlier, the literature suggests that ICT and business service firms typically engage in CVC as a window on technology and are able to leverage innovation to create value (Chesbrough, 2000). The ICT business sector is characterized by greater technological opportunity and is the most fertile ground for scanning and sourcing of external technologies (Cohen et al., 2002a). Thus, the results presented in Table 12 are consistent with our expected results where the *CVC x R&D* interaction has an influence on value creation in sectors such as ICT (Model 37), machinery and electronics (Model 38) and engineering and business services (Model 40) significant at the 1% level supporting hypothesis H2. Even after running OLS with the interaction term, we found that the benefits of *CVC investment* have an impact on *Tobin's q* for ICT (Model 37) and engineering & business services (Model 40), while for machinery & electronics (Model 38) the *CVC investment* sign changed. One potential explanation for this is the sample data of the 994 observations adjusted by the multicollinearity introduced by the interaction factor (Laeven & Levine, 2009). Regarding business sectors such as food, beverage & tobacco, pharmaceuticals, and vehicles (i.e. Models 36, 39, and 41) we observe that the *CVC x R&D* interaction is not significant. By considering the benefits that the *CVC x R&D* interaction can provide to firms in different regions, we observe that such benefits vary contingent to the region where the firms operate. A potential explanation can be the differences in these regions as a source of influence to the simultaneous CVC and R&D innovation strategy. These differences can be the development of a country or region's judicial-court system, technology transfer policy, and tax incentives (Armour & Cumming, 2006; Lerner, 2010; Poterba, 1989). Similar to the approach explained earlier on Table 11, we now introduce the *CVC x R&D* interaction term on Table 13 where we found that the benefits of simultaneously investing in CVC and R&D are applicable to firms in certain regions. In particular, *CVC x R&D* has a positive impact at the 1% level on Tobin's q in the USA (Model 43), USA & Canada (Model 47), Europe (Model 48) as well as in Models 45 and 46 for Anglo-Saxon and Non Anglo-Saxon countries. This suggests that internal R&D and external CVC in these regions are in fact complements not substitutes. As mentioned before the *CVC x R&D interaction* benefits are expected to be greater in regions with developed legal systems, technology transfer policy, and tax incentives, while it will be more limited for regions with less developed judicial systems, technology transfer policy, and less attractive tax incentives. Thus, regions like Asia (Model 49) and ROW (Model 50) presenting less mature legal systems and less tax capital gain incentives present a negative and significant relationship between the *CVC x R&D* interaction and *Tobin's q*.

By conducting the study on different business sectors and regions we shed some light on the technological innovation strategy of simultaneously investing in CVC and R&D and the value that can be created contingent to the business sector and region in which the established firm operates.

INSERT TABLE 12

INSERT TABLE 13

2.6. Discussion

Our study examines the relationship between value creation represented by *Tobin's q* and our independent variables *CVC investment* and *CVC x R&D* interaction term. We observe that firms in various business sectors create value through internal and external innovation activities (Chesbrough, 2002a; Chesbrough & Rosenbloom, 2002; Chesbrough & Tachau, 2002; Covin & Miles, 2007; Dushnitsky & Lenox, 2006; Gompers & Lerner, 2001a; Gompers & Lerner, 2001b) and that CVC investments can provide an important foundation of knowledge for firms in different business sectors to identify, acquire and exploit new knowledge that in turn influences value creation (Cohen & Levinthal, 1990; Tsai & Wang, 2008).

We present evidence that *CVC investment* and the *CVC x R&D* interaction are associated with the creation of firm value. We find that this relationship is stronger in the machinery & electronics, engineering & business services, and ICT sectors. Previous research found that a number of firms in the R&D intensive telecommunication industry attributed their success in understanding and evaluating the value proposition of emerging technologies to CVC investments' evaluative capacity, which is cultivated by R&D investments over the years (Covin & Miles, 2007). We are aware that the soundness of *Tobin's q*, as a measure of firm value, depends on the premise that the financial market investor rationale is receptive to upcoming financial appreciation of stock based on CVC investment by the firm. To secure that the association between a firm's *CVC investment* and its *Tobin's q* is not caused by an unobserved factor, similar to Dushnitsky and Lenox (2006) and Lin and Lee (2011), we apply fixed effects to address the potential heterogeneity across firms within a sector. We also undertook the *CVC investment* self-selection decision to engage in *CVC investment* by following a Heckman selection model that required us to identify variables that explain *CVC* *investment* (i.e. *free cash flow and NASDAQ index*). After running these models and regressions, our results remain robust.

Despite these studies we need to be cautious about the results interpretation as there are limitation concerns. For instance, the generalization of the findings may be limited to the time periods studied or the sampled firms. Historically CVC investing has been cyclical with different waves of activity beginning in the mid-1960s (Dushnitsky & Lenox, 2006). Our sample period covers only data between 1985 and 2000. An additional limitation is that we used the data available by Thomson Reuters and VentureExpert reporting and it is likely that certain firms do not disclose all information concerning their CVC programs. Nevertheless we believe that the evidence obtained could be seen as the first base for future research in the domain of CVC and its interaction with R&D influencing value creation.

We also observed that CVC is positive and significant for both Anglo-Saxon and non-Anglo-Saxon countries. While, in terms of geography, there is a significant effect of CVC in USA & Canada, and Asia. When introducing the CVC x R&D interaction term, evidence suggest that the interaction is also associated with the creation of firm value contingent to regions where established firms operate, presenting for all regions a positive significant relationship with value creation, except in the case of Asia and ROW. This could be explained due to different characteristics between countries and regions, such as management practices, language, kind of law (i.e. code law or common law) which makes in certain countries risk and control on the CVC investment more controllable and predictable for CVC investors (e.g. minority shareholder rights). Alternative explanations can also be the development of the country judicial-court system, technology transfer policies, and tax incentives for CVC investors (Armour & Cumming, 2006; Klette & Moen, 2000; Lerner, 2010; Poterba, 1989).

Our CVC x R&D interaction results also provide initial evidence of the CVC and R&D complementarity effect to value creation, supporting the notion that CVC complements internal R&D activities by tapping external CVC knowledge sources leveraged by internal R&D knowledge generation (Cassiman & Veugelers, 2002; Keil, 2002; Keil, Maula, Schildt, & Zahra, 2008; Sahaym et al., 2010). However alternative methodological approaches may provide robustness to this interaction and value creation. For example, we suggest considering alternative approaches such as the ones utilized by Cassiman and Veugelers (2006) i.e. productivity (direct) approach with dummy variables for *Making* of *Buying* innovation, and the adoption (indirect) approach testing the existence of complementarity through an exclusion restriction on a bivariate probit model. Additional future questions may change from whether or not a firm ought to establish a CVC program to: How much funds should be dedicated to CVC? What is the optimum mix between R&D and CVC? How many startups should be included in the portfolio? What types of startups should be supported depending on the sectors and regions in which firms operate? We also assume there may be a threshold beyond which CVC becomes detrimental to value creation, mainly depending on capital and asset intensity, which differs across business sectors. Therefore, for certain firms establishing a CVC program, at certain levels of investment CVC could pose a threat rather than an opportunity. Another future research initiative is to follow Hart and Ahuja's (1994) approach to perform regression runs lagging the dependent variables on incremental periods, i.e. (time t + l), (time t + 2), (time t+3) and so on, to determine in which year the performance dependent variable peaks, and by introducing polynomial models to see if performance curves could be derived. The same could be done for other accounting metrics such as ROS, ROE, and ROA.

2.7. Conclusions

This study examines the impact of CVC and its interaction with R&D on value creation across six business sectors and different regions between 1985 and 2000. Our findings suggest that the effect of CVC and its interaction with R&D on value creation is positive and significant. However, this relationship is contingent upon business sectors and regions.

Some business sectors are more active in their use of CVC than others. CVC variance across business sectors suggests that the value of CVC depends on the sector context and its environment. Sahaym et al., (2010) found that business sectors with greater absorptive capacity developed by prior R&D investment display greater efforts towards pursuing innovations using CVC. Moreover when analyzing our sampled firms by business sectors, certain sector estimates support the notion that CVC can be more potent in creating market value (i.e. Tobin's q) than our control variable R&D. Such sectors are engineering & business services and ICT. While in other sectors only R&D presents a significant positive relationship with market value creation, such as food, beverage & tobacco, pharmaceuticals, and vehicles. Hence, we support, along with Qualls et al. (1981) and Eisenhardt and Martin (2000) that firms operating in business sectors characterized with rapid technological change, are motivated to develop new alternative external sources of innovation that can influence value creation. Our results also suggest that for certain business sectors, entrepreneurial external ventures harness via CVC can be an important source of innovation and value creation.

Our results also support previous research (Griliches & Lichtenberg, 1984; Kortum, 1997; Thornhill, 2006) on the rate of technological change for firms operating in business sectors with larger R&D resources exhibiting greater technological change, making firms prone to explore new external venues to capture innovation.

In terms of geography, we observe a significant effect of CVC in USA & Canada, and Asia. However in Europe only our innovation control variable R&D shows a significant positive effect.

We notice that regarding the CVC x R&D interaction, when analyzing the whole sample the regression estimates convey that R&D and CVC are complementary to value creation. Although when partitioning the sample in different business sectors the results suggest that corporations operating in ICT, machinery & electronics, and engineering & business services are better off engaging in R&D and CVC simultaneously. Hence, firms can combine CVC and R&D aiming to increase the probability to generate value creation.

Finally, for managerial practice considerations we highlight the importance of an innovation strategy that can benefit from internal and external sources of knowledge. In other words our findings support the notion that an innovation strategy that combines CVC and R&D can create value. The results of this research can be used as a reference to encourage technology and innovation managers to further explore combining CVC and R&D as complementary mechanisms for innovation and value creation.

Tables and Figures

Table 1. Sectors of sample firms.

	Freq.	Percent
Information Comm. Technology	69	21.30%
Business Engineering Services	67	20.68%
Machinery & Electronics	65	20.06%
Chemicals	33	10.19%
Devices	29	8.95%
Pharmaceutical	23	7.10%
Vehicle	15	4.63%
Metals	8	2.47%
Food Beverage & Tobacco	8	2.47%
Printing and Publishing	7	2.16%
Total	324	100.00%

This table presents the analyzed sectors for the 324 parent companies (by 4 digit SIC code). Sample business sectors include: information communication and technology ICT (357*, 367*, 48**, 3663), business & engineering services (73**, 87**), industrial machinery and electronics (35**, 36** excluding 3663), chemicals (28** excluding 2834 and 2836, 29**, 3080), devices (38**), pharmaceuticals (2834, 2836), vehicles (37**), metals (33**), printing and publishing (27**), and food beverage and tobacco (20**, 21**). We created a binary version of sample sectors where sample firms present in a sector take a value of one, otherwise firms not active in such business sector are assigned the value of zero. Note that certain firms participate in more than one sector. The percentages in this table represent the main activity by each of firms based on its SIC codes. In other words a firm like General Electric (GE) has SIC codes in Machinery & Electronics and Devices. However in order to avoid duplication for this table GE is only considered under Machinery and Electronics.

Table 2. Countries of sample firms.

Country of established firm	Freq.	Percent
Australia	8	2.47%
Canada	2	0.62%
United Kingdom	23	7.10%
United States	176	54.32%
Total Anglo-Saxon	209	64.51%
Austria	1	0.31%
Belgium	1	0.31%
China	1	0.31%
Denmark	3	0.93%
Egypt	1	0.31%
Finland	2	0.62%
France	7	2.16%
Germany	15	4.63%
Hong Kong	3	0.93%
India	10	3.09%
Israel	2	0.62%
Italy	3	0.93%
Japan	30	9.26%
Malaysia	2	0.62%
Mexico	2	0.62%
Netherlands	3	0.93%
Norway	2	0.62%
Singapore	5	1.54%
South Korea	9	2.78%
Spain	1	0.31%
Sweden	6	1.85%
Switzerland	5	1.54%
Taiwan	1	0.31%
Total Non-Anglo-Saxon	115	35.49%
Total sample	324	100.00%

This table represents our sample of 324 established companies. Listed countries consider the location of headquarters. Unlike existing studies focused on the U.S. market (e.g. Dushnitsky and Lenox 2005a; Dushnitsky and Lenox 2006).

Table 3. Variables description.

Variable	Description
Tobin's q	Sum of firm equity, long term debt, and liabilities over firm assets.
Return on Sales (ROS 5yr, 10yr)	Earnings / Sales x 100. Five and ten years after R&D expenditure and CVC investment.
Return on Assets (ROA 5yr, 10yr)	(Net Income – Bottom Line + ((Interest Expense on Debt- Interest Capitalized) x (1-Tax Rate))) / Average of Last Year's and Current Year's Total Assets x 100. Five and ten years after actual R&D expenditure and CVC investment.
Return on Equity (ROE 5yr, 10yr)	(Net Income before Preferred Dividends - Preferred Dividend Requirement) / Average of Last Year's and Current Year's Common Equity * 100.
CVC investment	Total Corporate Venture Capital invested ($ million) normalized by assets.
R&D expenditure	Total Research and Development expenditures ($ million) normalized by assets.
CVC x R&D	Interaction term between CVC investment and R&D expenditure.
Capital expenditure	Capital expenditures ($ million) normalized by assets.
Growth	Annual change in sales ($ million) over previous year sales ($ million).
Leverage	Ratio of debt ($ million) to firm assets ($ million).
Firm size	Log of firm assets ($ million).
Industry Tobin's q	Average industry Tobin's q (by 4 digit SIC code).
Sector Tobin's q	Average specific business sector Tobin's q (by 4 digits SIC code): information communication and technology ICT (357*, 367*, 48**, 3663), pharmaceuticals (2834, 2836), vehicles (37**), food beverage and tobacco (20**, 21**), industrial machinery and electronics (35**, 36** excluding 3663), and business & engineering services (73**, 87**).
Risk	Stock price volatility measure of stock's average annual price movement to a high and low from a mean price for each year.
CVC activity	Dichotomic variable taking the value of one for each observation where annual CVC investment and number of startups on portfolio are greater than zero; otherwise the dependent variable equals zero.
Free cash flow	Income after interest and taxes plus depreciation and amortization ($ million) normalized by assets.
NASDAQ index	Stock market annual average index of the common stocks, it is an indicator of the performance of stocks of technology companies.
CVC	Annual Corporate Venture Capital invested ($ million) in absolute values.
R&D	Total Research and Development expenditures ($ million) in absolute values.
Sales	Annual sales in ($ million) in absolute values.
Assets	Assets in ($ million) in absolute values.
Employees	Number of employees.

Table 4. Descriptive statistics (1985-2000).

Variable	Obs.	Mean	Std. Dev.	Min	Max
Tobin's q	2891	2.114	3.277	0.004	99.135
ROS 5yr	3669	4.041	19.029	-318.296	107.406
CVC investment	3136	0.001	0.015	0	0.452
R&D expenditure	3137	0.057	0.078	0	2.210
CVC x R&D	3136	0.001	0.002	0	0.073
Capital expenditure	3046	0.071	0.044	0	0.499
Growth	3003	0.219	1.678	-0.710	5.886
Leverage	3061	0.171	0.192	0	3.138
Industry Tobin's q	5184	3.688	0.577	2.161	4.760
Risk stock volatility	3172	0.357	0.207	0.016	3.410
Firm size (assets)	3140	9.514	0.910	5.575	11.607

Descriptive statistics of main regression variables.
This table reports summary statistics of the main regression variables. Sample consists of 324 large established firms from 27 countries and 6 business sectors. Statistics based on annual data for the years between 1985 and 2000, if available.

Table 5. Summary statistics (1985-2000)

Statistic	Tobin's q	CVC [a]	R&D [a]	Sales [a]	Assets [a]	Employees
Mean	2.114	2.732	831	10,200	16,000	62,319
Std.Dev.	3.277	26	1,210	17,400	37,000	90,698
Median	1.493	0	250	3,110	4,320	26,770
Min.	0.004	0	0	0	0.376	9
Max.	99.135	931	6,830	161,000	405,000	446,800
Observations	2,891	5,180	3,283	3,587	3,140	3,069

This table reports summary statistics of the main firms' profile variables. Sample consists of 324 large established firms from 27 countries and 6 business sectors. Statistics based on annual data for the years between 1985 and 2000, if available. CVC is the total corporate venture capital invested in rounded absolute values (not normalized). R&D, Sales, and Assets are also represented in rounded absolute values (not normalized).
[a] In millions of dollars ($ million).

Table 6. Pairwise correlations (1985-2000) including the CVC x R&D interaction factor.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
1. Tobin's q	1.0000									
2. CVC investment	0.3896	1.0000								
3. R&D expenditure	0.2461	0.0731	1.0000							
4. CVC x R&D	0.5108	0.2618	0.1186	1.0000						
5. Capital expenditure	0.0508	-0.0234	0.0975	0.0116	1.0000					
6. Growth	0.4836	0.2299	0.1457	0.2816	0.1139	1.0000				
7. Leverage	0.0663	0.1104	-0.2762	0.1319	0.0450	0.0246	1.0000			
8. Industry Tobin's q	-0.0828	-0.0276	-0.0139	0.0121	0.0740	0.0035	0.0064	1.0000		
9. Risk stock volatility	0.3482	0.1838	0.2755	0.1386	0.0128	0.3054	0.0209	-0.1030	1.0000	
10. Firm size (assets)	-0.1747	-0.1192	-0.2202	-0.0274	-0.1132	-0.2125	0.0205	-0.0129	-0.3848	1.0000

n =2668

Correlation matrix of main regression variables including the CVC x R&D interaction factor.
This table reports the correlations between the main regression variables. Sample consists of 324 large established firms from 27 countries and 6 business sectors. Statistics based on annual data for the years between 1985 and 2000, if available.

Table 7. CVC investment and R&D expenditure impact on Tobin's q and Heckman (1985-2000)

1985-2000 All Business Sectors VARIABLES	(1) OLS Tobin's q	(2) OLS Tobin's q	(3) Heckman Tobin's q	(4) Heckman Tobin's q	(5) Heckman Tobin's q	(6) Heckman Tobin's q
CVC investment	42.99***	31.73***	138.6***	129.2***	-5.100	-18.41
	(3.813)	(3.601)	(23.92)	(19.48)	(55.75)	(45.87)
R&D expenditure	13.92***	10.60***	15.55**	21.85***	-2.999	0.214
	(1.473)	(1.384)	(7.137)	(6.598)	(10.56)	(9.888)
CVC inv. x R&D exp.		572.4***			798.5***	834.0***
		(29.75)			(253.5)	(212.7)
Capital expenditure	0.893	2.323*	-17.39*	-25.86***	-16.57	-23.62**
	(1.271)	(1.187)	(9.758)	(8.888)	(12.55)	(11.25)
Growth	1.182***	0.772***	2.889***	2.636***	2.614***	2.393***
	(0.132)	(0.125)	(0.475)	(0.377)	(0.615)	(0.483)
Leverage	2.400***	1.967***	-1.264	-2.166	-3.604	-4.272**
	(0.289)	(0.270)	(1.922)	(1.579)	(2.566)	(2.076)
Industry Tobin's q	-0.0479	1.703***	-1.663	-1.400	-2.988	-2.799
	(0.0694)	(0.360)	(1.727)	(1.317)	(2.261)	(1.751)
Risk stock volatility	2.212***	1.283***	5.451**	5.897***	6.460*	7.051**
	(0.386)	(0.182)	(2.573)	(2.182)	(3.323)	(2.817)
Firm size (assets)	1.205***	-0.0493	0.741	1.225**	0.156	0.558
	(0.196)	(0.0647)	(0.613)	(0.600)	(0.806)	(0.783)
Year fixed effect (FE)	YES	YES	YES	YES	YES	YES
Firm-sector FE	YES	YES	NO	YES	NO	YES
Constant	-10.93***	-11.17***	8.111	-0.556	22.72	14.07
	(2.614)	(2.429)	(11.22)	(11.70)	(15.06)	(15.56)
Observations	2,668	2,668	1,355	1,355	1,355	1,355
R-squared	0.723	0.760				
Wald $\chi 2$			200.56***	379.51***	129.44***	242.24***

The estimates for the first Probit stage of models 3, 4, 5, and 6 are as follows:

			(3)	(4)	(5)	(6)
Free cash flow			1.284***	1.284***	1.284***	1.284***
			(0.423)	(0.423)	(0.423)	(0.423)
NASDAQ index			0.00055***	0.00055***	0.00055***	0.00055***
			(0.00004)	(0.00004)	(0.00004)	(0.00004)

This table presents regression results for indicators of CVC investment and CVC investment x R&D expenditure impacting Tobin's q. Sample consists of 324 large established firms from 27 countries and 6 business sectors. For Regression 1 and 2 we utilized ordinary least squares. In order to address firms' self-selection to invest in CVC (Maddala, 1983) we created a binary version of CVC investment where all levels of investment greater than zero are assigned the value of one. In the first stage, we assume that the decision to invest in CVC is driven by the availability of free cash flow and the NASDAQ index. Through a Probit regression we found significant support at the 1%-level that both NASDAQ and free cash flow influence the CVC engagement. As for the second stage regression model to predict Tobin's q, models 3, 4, 5, and 6 present the Heckman regressions representing that for our dependent variable there was censorship causing a concentration of observations of zero values, the results prove significant for CVC investment on models 3 and 4. Results prove significant for CVC investment x R&D expenditure on models 5 and 6. Standard errors are reported in parentheses. *, **, and *** indicate significance at the 10%, 5%, and 1% levels, respectively.

Table 8. CVC investment and R&D expenditure impact on Tobin's q, and ROA, ROE, and ROS five and ten years after actual investment (1985-2000).

All business sectors	(7)	(8)	(9)	(10)	(11)	(12)
Variables	ROA 5yr	ROA 10yr	ROE 5yr	ROE 10yr	ROS 5yr	ROS 10yr
CVC investment	9.845	79.60**	129.9	-20.77	42.58*	18.62
	(13.11)	(33.72)	(120.0)	(257.7)	(23.00)	(50.52)
R&D expenditure	-1.268	-3.496	-22.43	-24.26	9.132	13.13
	(4.852)	(6.122)	(40.39)	(46.54)	(8.527)	(9.064)
Capital expenditure	8.213*	-2.629	-34.81	20.44	-12.72*	10.67
	(4.396)	(5.059)	(36.62)	(38.93)	(7.711)	(7.587)
Growth	-0.538	1.297**	3.945	1.141	1.709**	1.632*
	(0.415)	(0.586)	(3.421)	(4.426)	(0.727)	(0.863)
Leverage	2.334**	1.968*	-3.467	7.093	-0.158	3.888**
	(1.011)	(1.169)	(8.482)	(8.945)	(1.774)	(1.743)
Industry Tobin's q	-0.112	0.594**	5.127**	0.0374	3.864***	0.442
	(0.242)	(0.266)	(2.009)	(2.049)	(0.424)	(0.398)
Risk stock volatility	2.239*	0.00510	9.249	13.26	-9.030***	-2.412
	(1.336)	(1.671)	(11.11)	(12.86)	(2.342)	(2.502)
Firm size (assets)	-4.207***	-3.638***	-1.563	-9.483	2.305**	1.754
	(0.663)	(0.820)	(5.581)	(6.453)	(1.166)	(1.225)
Year fixed effect	YES	YES	YES	YES	YES	YES
Firm fixed effect	YES	YES	YES	YES	YES	YES
Constant	33.51***	18.34	-5.109	128.8	-45.76**	-22.48
	(8.696)	(12.05)	(72.52)	(82.63)	(17.86)	(17.87)
Observations	2,722	2,480	2,708	2,470	2,729	2,493
R-squared	0.507	0.457	0.163	0.152	0.476	0.457

This table presents regression results of indicators of CVC investment and R&D expenditure impact on Tobin's q, ROA 5yr and 10 yr., ROE 5yr and 10 yr., ROS 5yr and 10yr. Sample consists of 324 large established firms from 27 countries and 6 business sectors. Statistics based on annual data for the years between 1985 and 2000, if available. These regressions were computed through ordinary least squares. We performed the regressions controlling for firm and year fixed effect. As anticipated we found that firms which are growing have higher ROS 5yr, ROS 10 yr, and ROA 10yr. Model 8 suggests there is a relationship between CVC and ROA 10 years after CVC investment has been done. Standard errors are reported in parentheses. *, **, and *** indicate significance at the 10%, 5%, and 1% levels, respectively.

Table 9. CVC investment and R&D expenditure impact on Tobin's q by sector (1985-2000)

1985-2000 VARIABLES	(13) Food Tobin's q	(14) ICT Tobin's q	(15) Machinery and Electronics Tobin's q	(16) Pharma Tobin's q	(17) Engineering and Business Services Tobin's q	(18) Vehicles Tobin's q
CVC investment	-12.63	269.8***	76.93***	-154.1	116.6***	-11.59
	(12.92)	(8.054)	(10.24)	(122.8)	(9.501)	(7.602)
R&D expenditure	31.65***	18.00***	16.86***	9.394***	7.608***	2.653*
	(3.358)	(1.932)	(1.423)	(1.939)	(2.747)	(1.537)
Capital expenditure	-1.997	1.824	1.440	3.417	2.873	1.066
	(2.301)	(1.856)	(1.238)	(2.566)	(3.083)	(0.677)
Growth	-0.0286	0.808***	0.316***	0.379	1.007***	0.720***
	(0.461)	(0.158)	(0.117)	(0.251)	(0.246)	(0.142)
Leverage	2.805***	2.544***	1.863***	2.627***	2.005***	2.500***
	(0.674)	(0.381)	(0.261)	(0.469)	(0.516)	(0.230)
Sector Tobin's q	0.358**	0.0237	-0.0200	-0.233***	-0.0501	-0.0830***
	(0.175)	(0.116)	(0.0851)	(0.0413)	(0.109)	(0.0142)
Risk stock volatility	0.659	0.834*	0.197	-0.299	3.275***	-0.0863
	(0.848)	(0.481)	(0.374)	(1.005)	(0.790)	(0.173)
Firm size (assets)	-0.257	0.749***	1.560***	-0.340	1.508***	-0.606***
	(0.470)	(0.251)	(0.196)	(0.382)	(0.394)	(0.120)
Year fixed effect	YES	YES	YES	YES	YES	YES
Firm fixed effect	YES	YES	YES	YES	YES	YES
Constant	0.476	-5.726*	-14.39***	6.512	-10.54***	7.266***
	(3.603)	(3.227)	(2.172)	(4.160)	(3.586)	(1.288)
Observations	238	1,075	994	341	960	259
R-squared	0.789	0.858	0.647	0.723	0.752	0.797

This table presents regression results of indicators of CVC investment and R&D expenditure impact on Tobin's q. Sample consists of 324 large established firms from 27 countries and 6 business sectors. Statistics based on annual data for the years between 1985 and 2000, if available.

Table 10. CVC investment and R&D expenditure impact on *ROS 5 years* by sector (1985-2000).

1985-2000 VARIABLES	(19) Food ROS 5yr	(20) ICT ROS 5yr	(21) Machinery and Electronics ROS 5yr	(22) Pharma ROS 5yr	(23) Engineering and Business Services ROS 5yr	(24) Vehicles ROS 5yr
CVC investment	140.0	122.9**	212.6**	95.90	48.84	169.2
	(92.25)	(57.26)	(105.4)	(1,104)	(43.24)	(156.6)
R&D expenditure	65.51***	9.328	12.89	30.19*	5.866	-45.39
	(23.98)	(13.62)	(14.59)	(17.46)	(12.46)	(31.43)
Capital expenditure	5.899	13.47	20.41	7.014	-35.96**	-20.54
	(16.43)	(14.02)	(12.45)	(23.11)	(14.92)	(13.97)
Growth	0.777	2.093**	2.640**	0.237	1.313	1.617
	(3.289)	(1.020)	(1.165)	(2.260)	(1.030)	(2.916)
Leverage	-9.059*	-3.398	2.491	2.624	-3.505	5.586
	(4.811)	(3.012)	(2.687)	(4.222)	(2.534)	(4.658)
Sector Tobin's q	9.925***	4.496***	-1.318	0.478	3.323***	-1.261***
	(1.251)	(0.908)	(0.858)	(0.367)	(0.528)	(0.292)
Risk stock volatility	4.331	-5.151	-11.35***	-37.17***	-11.69***	-1.590
	(6.054)	(3.557)	(3.802)	(9.049)	(3.811)	(3.568)
Firm size (assets)	-8.977***	1.736	0.597	-4.999	-0.808	12.21***
	(3.359)	(1.900)	(1.962)	(3.424)	(1.860)	(2.480)
Year fixed effect	YES	YES	YES	YES	YES	YES
Firm fixed effect	YES	YES	YES	YES	YES	YES
Constant	39.65	-23.83	14.48	81.17**	4.760	-0.00511
	(25.73)	(23.23)	(22.66)	(37.46)	(20.00)	(19.98)
Observations	238	1,129	1,035	343	979	261
R-squared	0.751	0.414	0.383	0.603	0.513	0.811

This table presents regression results of indicators of CVC investment and R&D expenditure impact on ROS 5yr. Sample consists of 324 large established firms from 27 countries and 6 business sectors. Statistics based on annual data for the years between 1985 and 2000, if available. Data derived from VentureExpert and DataStream data sets. Regressions are estimated using ordinary least squares. We performed the regression controlling for firm and year fixed effect. Our sample covers several business sectors, that when considering the benefits and limits that CVC provide to firms it is likely that the utilitarian advantages of CVC are contingent on the dynamism of the business sector or the industrial maturity context where established firms operate. CVC benefits are expected to be greater in growing business sectors with rich technological opportunities, while it will be more limited for mature business sectors where R&D may prove more effective in impacting the value creation. CVC has a stronger impact than R&D on ROS 5 years for ICT, and machinery & electronics significant at the 5% level. However it did not prove positively significant for engineering & business services. Although we consider these three sectors characterized by a dynamic and high technology operating framework it was only for models 20 and 21 that CVC seem to explain an increase on the earnings by actual sales five years after an entrepreneurial CVC investment has been structured. Regarding mature R&D intensive business sectors such as: Food beverage & tobacco, and pharmaceuticals we observe that R&D has a stronger significant and positive impact than CVC. For models 19 and 22 significant at the 1% and 10% level respectively. Standard errors are reported in parentheses. *, **, and *** indicate significance at the 10%, 5%, and 1% levels, respectively.

Table 11. CVC investment and R&D expenditure impact in different regions (1985-2000).

All business sectors Variables	(25) Tobin's q Full sample	(26) Tobin's q USA	(27) Tobin's q Non USA	(28) Tobin's q Anglo-Saxon	(29) Tobin's q Non Anglo-Saxon	(30) Tobin's q USA & Canada	(31) Tobin's q Europe	(32) Tobin's q Asia	(33) Tobin's q ROW
CVC investment	42.99***	102.1***	0.996	40.67***	58.16***	102.1***	0.779	38.45***	8.025
	(3.813)	(7.026)	(2.477)	(4.367)	(13.78)	(7.026)	(2.835)	(12.78)	(37.70)
R&D expenditure	13.92***	14.40***	4.038**	15.65***	4.737***	14.40***	4.252**	-4.310	153.2
	(1.473)	(1.847)	(1.734)	(1.813)	(1.798)	(1.847)	(2.131)	(3.656)	(134.2)
Capital expenditure	0.893	0.159	3.955***	0.306	1.794	0.159	4.696**	2.275	-0.443
	(1.271)	(1.671)	(1.325)	(1.605)	(1.438)	(1.671)	(1.979)	(2.381)	(2.103)
Growth	1.182***	1.636***	0.00969	1.826***	-0.154	1.636***	0.0349	-0.0144	0.313
	(0.132)	(0.194)	(0.116)	(0.186)	(0.114)	(0.194)	(0.136)	(0.458)	(0.502)
Leverage	2.400***	2.009***	2.263***	2.521***	2.050***	2.009***	2.214***	0.854	3.313**
	(0.289)	(0.437)	(0.226)	(0.425)	(0.224)	(0.437)	(0.272)	(0.751)	(1.280)
Industry Tobin's q	-0.0479	-0.0904	0.0112	-0.117	0.0792	-0.0904	-0.118	0.184**	0.0584
	(0.0694)	(0.0962)	(0.0602)	(0.0926)	(0.0626)	(0.0962)	(0.0885)	(0.0781)	(0.253)
Risk stock volatility	2.212***	2.103***	1.762***	2.383***	1.877***	2.103***	0.834*	2.744***	1.231
	(0.386)	(0.561)	(0.312)	(0.544)	(0.313)	(0.561)	(0.481)	(0.400)	(1.410)
Firm size (assets)	1.205***	1.349***	1.099***	1.244***	1.936***	1.349***	0.776**	1.985***	0.425
	(0.196)	(0.251)	(0.239)	(0.241)	(0.283)	(0.251)	(0.309)	(0.592)	(1.174)
Year fixed effect	YES	YES	YES	YES	YES	YES	YES	YES	YES
Firm fixed effect	YES	YES	YES	YES	YES	YES	YES	YES	YES
Constant	-10.93***	-12.22***	6.231***	-21.14***	-13.94***	-12.05***	-7.357**	-22.57***	-4.631
	(2.614)	(2.933)	(2.215)	(3.833)	(2.246)	(3.153)	(3.236)	(6.498)	(12.69)
Observations	2,668	1,739	929	1,907	761	1,741	545	343	39
R-squared	0.723	0.742	0.759	0.722	0.745	0.745	0.693	0.842	0.930

This table presents regression results of indicators of CVC investment impact on Tobin's q. Sample consists of 324 large established firms from 27 countries and 6 business sectors. Regressions are estimated using ordinary least squares. By considering the benefits that CVC provide to firms it is likely that the utilitarian advantages of CVC are contingent on the development of a country or region: judicial system, technology transfer policy, and tax incentives in terms of taxing capital gains. CVC benefits are expected to be greater in regions with developed legal systems, technology transfer policy, and tax incentives, while it will be more limited for less developed judicial systems, technology transfer policy, and less attractive tax incentives. Thus, the results present the view that CVC is most influential in countries such as the US characterized by a developed legal system, technology transfer policy, and capital gains tax incentives. Full country sample includes: Australia, Austria, Belgium, Canada, China, Denmark, Egypt, Finland, France, Germany, Hong Kong, India, Israel, Italy, Japan, Malaysia, Mexico, Netherlands, Norway, Singapore, South Korea, Spain, Sweden, Switzerland, Taiwan, United Kingdom, and Unites States of America. Anglo-Saxon sample includes: Australia, Canada, United Kingdom, and Unites States of America. Europe sample includes: Austria, Belgium, Denmark, Finland, France, Germany, Italy, Netherlands, Norway, Spain, Sweden, Switzerland, and United Kingdom. Asia sample includes: China, Hong Kong, India, Israel, Japan, Malaysia, Singapore, South Korea, and Taiwan. Rest of the World (ROW) country sample includes: Australia, Egypt, and Mexico.

Table 12. CVC x R&D interaction factor impact on Tobin's q by business sector (1985-2000).

Variables	(34) All business sectors Tobin's q	(35) All business sectors Tobin's q	(36) Food Tobin's q	(37) ICT Tobin's q	(38) Machinery and Electronics Tobin's q	(39) Pharma Tobin's q	(40) Engineering and Business Serv. Tobin's q	(41) Vehicles Tobin's q
CVC investment	42.99***	31.73***	-386.9*	75.64***	-20.78**	-159.7	53.89***	-20.26
	(3.813)	(3.601)	(230.0)	(11.02)	(8.532)	(134.0)	(16.05)	(41.30)
R&D expenditure	13.92***	10.60***	20.97***	9.580***	6.743***	8.997**	7.517***	1.965
	(1.473)	(1.384)	(7.354)	(1.626)	(1.136)	(4.261)	(2.711)	(3.570)
CVC inv. x R&D exp.		572.4***	-6,488	1,370***	1,323***	-254.8	429.0***	-463.6
		(29.75)	(3,981)	(62.37)	(49.99)	(2,436)	(89.00)	(2,171)
Capital expenditure	0.893	2.323*	-1.729	4.040***	2.026**	3.424	3.893	1.048
	(1.271)	(1.187)	(2.297)	(1.521)	(0.931)	(2.571)	(3.051)	(0.684)
Growth	1.182***	0.772***	-0.0418	0.308**	0.242***	0.378	0.820***	0.719***
	(0.132)	(0.125)	(0.459)	(0.131)	(0.0877)	(0.251)	(0.246)	(0.142)
Leverage	2.400***	1.967***	2.779***	2.342***	1.802***	2.625***	1.887***	2.501***
	(0.289)	(0.270)	(0.671)	(0.312)	(0.196)	(0.470)	(0.510)	(0.230)
Risk stock volatility	2.212***	1.703***	0.638	0.509	-0.116	-0.301	3.007***	-0.0866
	(0.386)	(0.360)	(0.844)	(0.394)	(0.281)	(1.007)	(0.782)	(0.173)
Firm size (assets)	1.205***	1.283***	-0.260	0.937***	1.067***	-0.341	1.705***	-0.605***
	(0.196)	(0.182)	(0.468)	(0.205)	(0.149)	(0.383)	(0.391)	(0.121)
Industry Tobin's q	-0.0479	-0.0493						
	(0.0694)	(0.0647)						
Sector Tobin's q			0.388**	0.344***	0.0121	-0.233***	-0.0856	-0.0826***
			(0.175)	(0.0962)	(0.0639)	(0.0416)	(0.108)	(0.0144)
Year fixed effect	YES	YES	YES	YES	YES	YES	YES	YES
Firm fixed effect	YES	YES	YES	YES	YES	YES	YES	YES
Constant	-10.06***	-11.17***	1.601	1.414	-8.079***	6.830	-11.52***	7.369***
	(2.606)	(2.429)	(3.612)	(2.637)	(1.633)	(4.162)	(3.540)	(1.266)
Observations	2,668	2,668	238	1,075	994	341	960	259
R-squared	0.723	0.760	0.792	0.905	0.801	0.723	0.758	0.797

This table presents regression results of indicators of CVC investment and R&D expenditure impact on Tobin's q. Sample consists of 324 large established firms from 27 countries and 6 business sectors. Firms that pursue CVC and R&D simultaneously are associated with value creation. We have also documented that this positive relationship (see Table 12 Model 35) is attributable to the combination of CVC and R&D significant at the 1% level. This is particularly interesting, as we found on our literature review that Dushnitsky (2003) also reports a significant, positive coefficient on R&D and CVC. This would suggest that internal R&D and CVC investment are in fact complements not substitutes. The CVC x R&D interaction benefits are expected to be greater in growing business sectors with rich technological opportunities, while it will be more limited for mature business sectors where R&D may prove more effective in impacting the value creation. The results presented are consistent with our expected results where the CVC x R&D interaction has a stronger influence on value creation on sectors such as ICT, machinery and electronics and engineering and business services as these represent business sectors characterized by dynamic technological and market conditions. Results on models 37, 38, and 40 show the CVC x R&D interaction term significant at the 1% level.

Table 13. CVC x R&D interaction factor impact on Tobin's q in different regions (1985-2000).

All business sectors Variables	(42) Tobin's q Full sample All Regions	(43) Tobin's q USA	(44) Tobin's q Non USA	(45) Tobin's q Anglo-Saxon	(46) Tobin's q Non Anglo-Saxon	(47) Tobin's q USA & Canada	(48) Tobin's q Europe	(49) Tobin's q Asia	(50) Tobin's q ROW
CVC investment	31.73***	25.80**	48.30***	33.48***	46.19***	25.75**	79.33***	56.31***	-7,168***
	(3.601)	(10.11)	(7.044)	(4.103)	(13.84)	(10.12)	(10.17)	(12.48)	(2,065)
R&D expenditure	10.60***	12.28***	7.349***	11.76***	7.506***	12.35***	8.109***	-11.82***	-2,483***
	(1.384)	(1.802)	(1.746)	(1.711)	(1.875)	(1.801)	(2.061)	(3.691)	(764.8)
CVC inv. x R&D exp.	572.4***	595.3***	1,181***	548.4***	997.4***	595.3***	1,665***	-2,911***	-0.000005***
	(29.75)	(58.36)	(165.3)	(34.37)	(220.7)	(58.36)	(208.1)	(495.9)	(0.0000016)
Capital expenditure	2.323*	0.805	4.330***	2.010	2.264	0.805	5.296***	0.673	-0.0379
	(1.187)	(1.620)	(1.288)	(1.502)	(1.422)	(1.620)	(1.863)	(2.271)	(1.521)
Growth	0.772***	1.358***	0.0496	1.245***	-0.129	1.358***	0.117	0.149	0.0281
	(0.125)	(0.189)	(0.112)	(0.178)	(0.113)	(0.189)	(0.129)	(0.435)	(0.371)
Leverage	1.967***	1.682***	2.299***	1.834***	2.087***	1.682***	2.311***	-0.136	3.244***
	(0.270)	(0.425)	(0.219)	(0.399)	(0.221)	(0.425)	(0.256)	(0.731)	(0.923)
Industry Tobin's q	-0.0493	-0.108	0.00747	-0.116	0.0808	-0.108	-0.130	0.165**	0.0891
	(0.0647)	(0.0932)	(0.0584)	(0.0865)	(0.0617)	(0.0932)	(0.0832)	(0.0740)	(0.182)
Risk stock volatility	1.703***	1.558***	1.715***	1.580***	1.955***	1.558***	0.463	1.883***	1.692
	(0.360)	(0.547)	(0.303)	(0.511)	(0.309)	(0.547)	(0.455)	(0.406)	(1.025)
Firm size (assets)	1.283***	1.492***	0.913***	1.274***	1.824***	1.492***	0.478	1.623***	0.881
	(0.182)	(0.243)	(0.234)	(0.225)	(0.280)	(0.243)	(0.293)	(0.564)	(0.857)
Year fixed effect	YES	YES	YES	YES	YES	YES	YES	YES	YES
Firm fixed effect	YES	YES	YES	YES	YES	YES	YES	YES	YES
Constant	-11.17***	-12.63***	8.101***	-12.69***	-12.78***	-12.70***	-3.882	-18.12***	-12.33
	(2.429)	(2.834)	(2.154)	(3.602)	(2.218)	(3.048)	(3.061)	(6.181)	(9.450)
Observations	2,668	1,739	929	1,907	761	1,741	545	343	39
R-squared	0.760	0.758	0.773	0.758	0.753	0.761	0.729	0.859	0.967

This table presents regression results for firms that pursue CVC and R&D simultaneously. We document the positive relationship (see Table 13 Model 42) attributable to the combination of CVC and R&D significant at the 1% level. This suggests that internal R&D and external CVC are in fact complements not substitutes. The CVC x R&D interaction benefits are expected to be greater in regions with developed legal systems, technology transfer policy, and tax incentives, while it will be more limited for less developed judicial systems, technology transfer policy, and less attractive tax incentives. Thus, the results present the view that the interaction is most influential in countries such as the USA (see Table 13 Model 43) characterized by a developed legal system, technology transfer policy, and capital gains tax incentives. The regions with less mature legal systems and less tax capital gain incentives such as Asia and ROW (i.e. Models 49 and 50) present a negative and significant relationship between the CVC x R&D interaction and Tobin's q. Anglo-Saxon sample includes: Australia, Canada, United Kingdom, and Unites States of America. Europe sample includes: Austria, Belgium, Denmark, Finland, France, Germany, Italy, Netherlands, Norway, Spain, Sweden, Switzerland, and United Kingdom. Asia sample includes: China, Hong Kong, India, Israel, Japan, Malaysia, Singapore, South Korea, and Taiwan. Rest of the World (ROW) country sample includes: Australia, Egypt, and Mexico. Standard errors are reported in parentheses. *, **, and *** indicate significance at the 10%, 5%, and 1% levels, respectively.

Appendix

Table A1. Chow test comparing coefficients and structural break (1985-2000)

(Contraction. 1985-1993) vs. (Expansion. 1994-2000)
$F(7, 450) = 2.68$
$Prob > F = 0.0099$

Unlike existing studies [e.g. Zahra (1991) analyzed the CVC contraction period 1986 to 1989, and Dushnitsky and Lenox (2005a) studied the CVC expansion period 1990 to 1999]. The table presents confirmation results of our period considering the cyclical effects on the time series data considering CVC activity over two sub-periods; 1994 to 2000 as expansion period and 1985 to 1993 as contraction period. The test statistics for Chow breakpoint confirmed a structural change in the parameters during this structural break year. The F statistics rejected the null hypothesis of no structural change at the 1 percent level of significance, with this Chow test we determined that the independent variables have a change in parameters when comparing expansion and contraction periods. After confirming the structural break we decided to analyze the complete 1985 to 2000 period to observe if value creation holds regardless of the expansion-contraction phenomenon.

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3. Management Systems and Organizational Structures to Generate Radical Innovation: A Case Study

3.1. Introduction

Schumpeter (1934) defined innovation as ideas applied successfully in practice. Later Freeman and Soete (1997) defined innovation as a commercialized invention, and Afuah (1997) determined that innovation is the use of new knowledge to offer a new product or service that customers want. Davila et al. (2009) argue that innovation is the pursuit of significant new value creation opportunities through a process managed by established firms, and that innovation is associated with taking advantage of unexpected opportunities, new relationships, uncertain outputs, and the possibility of failure. These definitions and arguments provide a delineation of the meaning of innovation. However, they do not distinguish on the degree of novelty present in innovations. The literature makes the distinction between incremental and radical innovation. Incremental innovation is represented by minor changes to existing technology, merely an extent of the current proposition introducing relatively minor improvements to the product, process or service, providing short-term market advantage (Christensen, 1997a; Davila et al., 2006; Markides & Geroski, 2005; Munson & Pelz, 1979; Utterback, 1994). In contrast, radical innovation depicts higher market and technological uncertainties[22] leading to revolutionary changes. It results to considerable improvements from existing products disrupting consumer habits and providing firms with competitive advantages and high margin economic rents (Duchesneau et al., 1979; Ettlie, 1983; Markides & Geroski, 2005; O'Connor & DeMartino, 2006; Utterback, 1994).

[22] Galbraith’s 1973 uncertainty definition: “the difference between the amount of information required to perform a task and the amount of information already possessed by the organization”.

Radical innovation is important because firms that rely on purely continuous improvement and incremental innovations could aspire to maintain their market position while firms that pursue radical innovation can position themselves advantageously apart from competition and become market leaders (Leifer et al., 2000). Day (2007) reported that incremental innovation represents 85% to 90% of new product development (NPD) portfolios. However these rarely generate the growth leading companies seek. This emphasis on incremental innovations can also affect the firm's innovative capacity by delaying projects, stressing the organization, and failing to achieve high growth revenue goals. These incremental innovation projects are necessary for continuous improvement, but they don't provide companies with a competitive edge or contribute much to profitability (Cooper, 2003).

Denning (2011) conducted a case study to describe the management systems and processes at Salesforce.com, one of the most successful examples of a company developing radical innovation impacting value creation. Between 2006 and 2011 Salesforce.com delivered a 41% annual return to shareholders. This extraordinary performance is due to their radical innovation that occurred after the firm instituted a radical set of agile, customer-driven, outcome-oriented, iterative management processes. According to a study by Kim and Mauborgne (1999) only 14% of NPD are radical innovations, but these account for 61% of all profit from innovation.

Porter (1985) described how firms gain market positions over rivals through competitive advantages. Usually a competitive advantage comes from a full range of firm processes distinguishable from competitors (Ghemawat et al., 1998). Davila et al. (2005; 2006) mentioned that firms seek competitive advantages, by improving the effectiveness of their innovation process from ideation to commercialization. However, they recognized that incremental and radical innovations are different and suggested that if firms manage incremental and radical innovation projects through the same one-size-fits-all innovation process and through a sole set of Management Control Systems (MCS[23]), those firms can almost guarantee a sub-optimization of certain systems and resources.

Chandy and Tellis (1998) studied the reasons why some firms are more successful at generating radical innovation, finding that organizational structure[24] is an important element for radical innovation output. Teece (1986) suggested that firms need to organize to appropriate the returns of their innovation strategy through internal and external complementary[25] assets. There have also been organizational developments that foster the need for firms to improve their innovation process. For example, cross-functional cooperation among individuals in the firm needs to be improved at the different organizational units i.e. headquarters, corporate innovation centers, central corporate research and development departments (R&D), external partners and business units (BU) to offer short delivery times, and a cost effective NPD (Anderson, 1997).

More importantly, radical innovation is not purely the result of luck. It can be generated in a systematic way through enablers such as processes, MCS, and organizational structures. Jelinek and Schoonhoven (1993) and Davila et al. (2007; 2006) found that innovative firms have institutionalized mechanisms for innovation, arguing that innovation cannot occur in an organic environment where flexibility and consensus are the main managerial mechanisms. They rather argue that radical innovation requires a clear organizational structure and MCS, ensuring that when developing radical innovation both discipline and creativity are present.

Davila et al. (2009) identify research opportunities for innovation management and provide a list of pending issues such as: How do companies manage the process for radical

[23] Simons' (1995) definition of Management Control Systems: "formal, information based routines and procedures managers use to maintain or alter patterns in organizational activities".
[24] Child's (1972) organizational structure is defined as the formal allocation of work roles and the administrative mechanisms to control and integrate work activities including those which cross formal organizational boundaries.
[25] Cassiman and Veuglers' (2006) complementarity implication to performance is "adding an activity while the other activity is already being performed and has a higher incremental effect on performance than adding the activity in isolation".

and incremental innovation? What are the performance measures companies use to manage radical ideas and how do they select them? The fundamental objective of this paper is to address the following research question: What are the processes, MCS, and organizational structures for generating radical innovation? Research on innovation management focuses mainly on either the firm level (Birkinshaw et al., 2008a) or at the project level examining appropriate management techniques associated with high levels of uncertainty (Burgelman & Sayles, 1988; Dougherty & Heller, 1994; Jelinek & Schoonhoven, 1993; Kanter et al., 1990; Leifer et al., 2000). Therefore, we embark on a novel process-related research framework to observe the process stages, MCS, and organizational structures that can generate radical innovation. Through abductive reasoning we obtained an understanding of what a firm does and the reasons for acting in specific ways. Consequently, we present some insights and findings on the processes, MCS, and organizational structures firms can implement to generate radical innovation.

The paper has the following structure. In section 2 we look at the literature relevant to our subject. In section 3 we describe our method and provide reasons for selecting an in depth field research approach and Alcan Engineered Products (Alcan EP) as our unit of analysis. In section 4 we provide the background of our case study with a description of the company, its MCS, its innovation process, and its organizational structure for radical innovation. The key findings are in section 5 where we discuss the results obtained from our observations and interviews. The conclusions are in section 6. Our exploratory research found evolutionary advanced MCS, processes and organizational structures to generate radical innovation.

3.2. Literature Review

The dynamic capabilities framework studies the resources and processes that create and capture value by firms operating in environments of rapid technological change (Teece et al., 1997). Eisenhardt and Martin (2000) describe dynamic capabilities as organizational and strategic processes that transform knowledge into value for the firm. Kelley et al. (2011) recognize that firms need to periodically renew their business processes as the advantages of their current ones diminish over time. More broadly dynamic capabilities are repeatable and comprise sets of business processes that allow firms to explore new ideas (Stalk, Evans, & Shulman, 1992; Zollo & Winter, 2002). As a result, dynamic capabilities enable firms to engage in radical exploration projects into the unknown (Schreyögg & Kliesch-Eberl, 2007).

It is in the context of dynamic capabilities that we set the theoretical framework of this paper as we elaborate and distinguish between incremental and radical innovation and present the state of research through our literature review on MCS, processes, and organizational structures.

3.2.1. Incremental and Radical Innovation

Innovation has been defined as an idea, practice, or product that is perceived to be new (Zaltman, Duncan, & Holbek, 1973). Jolly and Vijay (1997) refer to innovation as a process of going from mind to market. However these definitions do not distinguish the degree of novelty. This could be further clarified by the notion of radicalness. Radical innovation depicts changes that represent revolutionary change in technology and considerable improvements from existing products (Duchesneau et al., 1979; Ettlie, 1983; Markides & Geroski, 2005; O'Connor & DeMartino, 2006; Utterback, 1994). In contrast, incremental innovations are represented by minor changes or adjustments to existing technology (Davila et al., 2006; Markides & Geroski, 2005; Munson & Pelz, 1979). Meyer et al. (1986) and Gatignon et al. (2002) also contributed with proposals to differentiate incremental and radical innovations based on technological newness and innovative business models. These kinds of innovations have different competitive effects. Incremental innovation is an extension of the current proposition facing consumers with minor changes to the product or service, while radical innovation introduces major new value propositions that disrupt existing consumer habits and behaviors (Markides & Geroski, 2005). Furthermore, radical innovation encompasses disruptive technologies with lower cost and additional performance features (Christensen, 1997a). Utterback (1994) explained the importance of radical innovations by highlighting the powerful means for enlarging markets and providing new valuable functionalities.

Although the literature on innovation usually focuses on technology (Henderson & Clark, 1990), innovation is not only about changing technologies, but also about meeting customer needs through new processes, services, and business models. More important to our research focusing on the causality derived from the crossroads of MCS, processes, and organizational structures to generate radical innovation, Davila et al., (2009) argue that incremental and radical innovation require different systems to manage project initiatives from top management vs. creativity "bubbling up" from the rest of the organization. Furthermore, they suggest that incremental and radical innovation require MCS that can provide a structure for the innovation process without becoming rigid mechanisms, hence being flexible enough to take advantage of unexpected opportunities but strong enough to continue in one direction. Brown and Eisenhardt (1997) describe this balance as the ability to blend flexible-structured MCS which can enable change but can also prevent chaos when generating radical innovation.

3.2.2. MCS and the Innovation Process

MCS are generally known as procedures, policies, and information mechanisms across the organization enabling processes to operate. In this paper MCS are interpreted as 'formal, information-based routines and procedures managers use to maintain or alter patterns in organizational activities' (Simons, 1995). MCS range from basic controls such as budget and pricing, to additional controls such as cost and risk control (Sandino, 2007).

MCS are grounded on firm strategy. Their goal is to assist implement and monitor strategic initiatives and reduce uncertainty (Simons, 1999). Ansoff (1965), O'Connor (1998), Veryzer (1998), and Christensen (1997a, b) argue that developing radical innovation involves considerable risk and requires insight and foresight mainly due to the high technology and market uncertainty present in radical innovation. Jorgensen and Messner (2010) studied the kind of MCS and the type of innovation strategy, observing a contingency route for MCS adoption based on market and technology uncertainties. Argyres and Silverman (2004) and Zwerink et al. (2007) found that by implementing MCS over R&D budgets and NPD, there was a positive effect on innovation output. Nonetheless, Hayes (1977) and Brownell's (1985) research on MCS and innovation established that R&D organizations utilize accounting measures. However, the outcome of such research concludes that accounting measures have little impact on generating innovation. Furthermore, Kaplan and Norton (1992) studied performance measures related to innovation, and found that traditional financial accounting measures like return on investment (ROI) can mislead organizations when measuring innovation. For example, managers can be induced to delay investment in facilities or equipment necessary for innovation, because of the negative effects it might have on ROI in the short run. Moreover, they identified that leading innovative companies use non-financial performance indicators such as the percent of sales from new products, time to develop NPD, and new product introduction, as performance indicators for innovation.

Davila et al. (2009) developed arguments on the relevance of MCS to foster innovation. These arguments are contrary to the traditional MCS paradigm in which due to MCS's explicit contracts, hierarchical organizations and extrinsic motivations designed to eliminate variation. The common understanding is that MCS are detrimental to innovation, particularly radical innovation, due to the likelihood of failure and high uncertainty outcomes. For example, in his research on determinants of innovation, Damanpour (1991) offers empirical evidence that MCS are adverse to innovation. Quinn (1993) also argues that MCS limit firm innovation, suggesting that MCS are unfavorable to innovation. Innovation relies on intrinsic motivation, freedom, experimentation, and flexibility (Amabile, 1998; Davila et al., 2009). However, Simons' (1987; 1991, 1994, 1995) empirical work led to the development of the levers of control model creating a paradigm shift by identifying interactive flexible systems as tools to engage the organization in the exploration of strategic uncertainties. This led to the development of a concept in MCS literature aimed at creating the variation required to generate innovation. Later, Andrew and Sirkin (2007) conducted research on managing innovation, MCS and measurement of resources such as cash flow and development time which impact the innovation development cost. This cumulative invested cash and development time from ideation to commercialization has been determined as an important performance metric for innovation management. The cash curve represented in Figure 1 considers pre-launch investment, speed (time to market), scale (time to production volume), and post launch innovation expenditures.

INSERT FIGURE 1

Organizational processes are composed of inputs such as information, a transformation process that utilizes inputs to convert them into something of value, and outputs such as products or services (Simons, 1999). Innovation processes are organizational processes. Davila et al. (2009; 2006) explained that innovation is not a monolithic phenomenon but various processes that coexist, each one requiring different types of MCS and that the main goal of the innovation process is to move promising ideas from concept to commercialization with speed and minimum use of resources.

The most innovative organizations excel not just at generating ideas, but in the set of capabilities necessary to transform their ideas into profits. For example, Markides (1997) studied the case of Canon which in the 1960s was a camera manufacturer that decided to enter the photocopier market, at the time dominated by Xerox. However, by the 1980s, despite strong attacks by rivals such as IBM and Kodak trying to penetrate this market without much success, Canon with its innovative capabilities emerged as a market leader. A more recent example by Dedrick et al. (2007) is the introduction of the iPod, which in 2001 was not the first integrated portable music player. The market had a combination of new technologies such as MP3, small hard drives, and flash memories which made it possible to store music rather than carry CDs or tapes. Nonetheless, Apple innovative technology combining capability allowed them to put together existing technologies so as to capture consumer interest and to become a commercial success. These sorts of companies are successful in implementing the innovation process. Figure 2 illustrates the complete process defined by its stages: idea generation, idea selection, project execution, and commercialization (Davila et al., 2006). In the literature, there is a general agreement on the stage nature of the innovation process with variations on the number of stages (Dougherty & Heller, 1994). However, the literature addresses the innovation process as linear, although in reality the ideas and projects move in non-linear cycles referred to as a set of concentric circles that flow through the process (Kaufmann & Tödtling, 2001). Each of the stages requires active MCS to execute and transform the distinct inputs into the output on its way to the next stage, the process could be seen as a funnel flow from many ideas to a few that reach market commercialization (Davila et al., 2009; Davila et al., 2006).

INSERT FIGURE 2

3.2.3. Organizational Structures for Radical Innovation

Simons (1987; 1999) stated that, in order to perform, firms need to define a strategy (e.g. to generate incremental or radical innovation), and once a strategy is defined firms must decide how to organize individuals and resources to execute such a strategy. Organizations are comprised of individuals who work together to perform specific functions that are monitored and controlled by MCS. MCS are important for organizations because MCS must be aligned with the underlying organizational structure to monitor and control organizational performance (Simons, 1999). We recognize from previous literature that individuals at organizational structures can have multiple roles and that it is unlikely that one individual will be the sole contributor to a project's outcome, but rather a cross-functional organization (Day, 1994; Leifer et al., 2000). Abernethy and Brownell (1997) studied a broader approach attempting to measure the performance of organizations by studying organizational goals contingent to organizational structures. Their findings suggest that organizational goals can be reached if there is an appropriate functional organization.

Scholars such as Benner and Tushman (2003), Campbell et al. (2003) and Kanter (1985), have identified aspects of organizational structures based on the goal to generate innovation. They argue that the organizational unit responsible for radical innovation must be physically separate from the mainstream organization that is under stress to deliver immediate results. Heller (1999) makes references to case studies that have presented evidence that physical separation at the project level may work for a time but that complete isolation may be counterproductive since the purpose of a radical innovation process is to leverage current organizational competences. Consequently, the interface between innovation centers and the rest of the organization is important and isolation of the innovation center from the rest of the organization can hinder the generation of radical innovation.

Ettlie et al. (1984) conducted research on firms' organizational structures for generating radical and incremental innovation. Their findings suggest that when generating radical innovation firms require a specifically defined project organizational structure on a case-by-case basis, while a more traditional-standard organizational structure tends to support incremental innovations. Furthermore they propose that incremental innovation projects tend to be promoted in large, decentralized organizations with low top management involvement. While for radical innovation a central organization and greater support of top managers is necessary. Argyres and Silverman (2004) went further to unveil the organizational competency to acquire technological knowledge, by analyzing centralized vs. decentralized R&D structures and the type of innovation they produce. These scholars suggest that, centralized R&D organizations will generate innovations that have a larger and broader impact on subsequent technological evolution than will a decentralized R&D organization.

O'Connor and DeMartino (2006) conducted research on organizational structures at large established firms seeking growth through radical innovation. They found that in order to generate radical innovation firms need to evolve their innovation capabilities, and for this to happen firms need to make their organizational structures adjustable mechanisms that can adapt depending on specific project requirements. This dynamic capability exposed to the high-uncertainty of radical innovation requires processes that need to be constantly attended by individuals within the organization. If this is not done the innovation competence of the firm will be diminished (Eisenhardt & Martin, 2000). Therefore, a clear set of roles and responsibilities is required for individuals to effectively sustain the organizational effort of generating radical innovation (Amabile, 1998; Jørgensen & Messner, 2010; O'Connor &

DeMartino, 2006). Organizational capabilities also play a key role in developing radical innovation. Based on Eisenhardt and Martin (2000), organizational capabilities allow firms to transform knowledge into value for the firm. Organizational capabilities involve a complex combination of organizational roles (O'Connor, 2008). The direct role in managing individuals for radical innovation projects was studied by Kelley et al. (2011) suggesting that managers use performance-based metrics to select and interact with innovation project individuals.

From a sociology perspective, Mouritsen (1999) develops the concept of the “Flexible Firm” as a firm committed to lateral relations, customer orientation, new technology and innovation. Brown and Eisenhardt (1997) describe a flexible firm, as one with the ability to enable change and undertake emergent opportunities but that can also prevent chaos.

3.3. Research Design and Methodology

The literature on management of innovation has been developed mainly either at the firm level (Birkinshaw et al., 2008a) or at the project level (Burgelman & Sayles, 1988; Dougherty & Heller, 1994; Jelinek & Schoonhoven, 1993; Kanter et al., 1990; Leifer et al., 2000). Davila et al. (2009) argue that deeper case studies at the project level can unveil insights on new topic areas such as the emergence of MCS, processes, and organizational structures as enablers of radical innovation. Consequently, we chose a case study focusing on the process level to study the MCS, and organizational structures that can generate radical innovation. We are aware of the limitations on lack of generalization and non-universal validity of case studies. However, this approach is especially appropriate in new topic areas (Eisenhardt, 1989). As suggested by Ahrens and Chapman (2006) and performed by McCutcheon and Meredith (1993) through a descriptive exploratory case study, we analyze and try to understand the process, MCS, and organizational structure to generate radical innovation. We obtained an understanding of what the organization does and the reasons for acting in particular ways. Our findings follow a narrative approach. Critics of narratives often consider this method purely "storytelling". However, a scientific narrative serves as a reference framework that potentially can be reinterpreted and which can become relevant to other settings (Llewellyn, 1999). To conduct our research we also took into account a practice theory perspective applied by Ahrens and Chapman (2007) and Jorgensen and Messner (2010) to study the linkages between NPD and MCS.

We chose Alcan EP, a division of Rio Tinto Alcan Group, as our unit of analysis due to their systemic Open Innovation[26] approach delivering radical innovations to the market. In 2007, Alcan EP was recognized as an innovative firm by the University of St. Gallen's Technology Management Transfer Center (TECTEM) in Switzerland. Alcan EP was selected as one of the top five companies to demonstrate its status as a successful enterprise for practicing innovation management. The benchmarking survey of 63 European companies ranked Alcan EP as one of the leaders. The other companies that ranked in the top five were IBM Research, Lufthansa Technik GmbH, F. Hoffmann-La Roche Ltd. and Volkswagen AG. The award recognizes the progress Alcan EP made to meet its goals for profitable growth through innovation. Furthermore, in 2008 Alcan EP decided to adapt its organizational structure and set up an innovation support unit dedicated to radical innovation referred to as Alcan Innovation Cells (IC), which assists the different BUs to develop their radical ideas into projects that could evolve into actual products to be commercialized. We were particularly interested in this dedicated radical innovation unit as studies have shown that specific dedicated units can be advantageous to foster radical innovation, because they are not subject to the short term result orientation that BUs have (O'Connor & DeMartino, 2006).

[26] Chesbrough's 2003 definition of open innovation: "a paradigm that assumes that firms can and should use external ideas as well as internal ideas, and internal and external paths to market, as they look to advance their technology. Open Innovation processes combine internal and external ideas into architectures and systems".

To exemplify the radical innovation outcome of Alcan EP, we present some examples of the latest radical projects. The "Aluminum Foam" project involves a food process external partner to produce dough with a mix of salt, flour, water and aluminum. The final application is to produce high efficient heat exchangers offering superior heat transfer capacity with less volume and weight. Another example of radical innovation is "Smart Material" with the vision to revolutionize the aerospace industry by providing materials that could be used for airplane wings allowing these to change shape adapting to flight conditions, thanks to an electromechanical interaction between the mechanical and the electrical state in crystalline material state. These materials can also "heal" themselves after they crack, thanks to integrated capsules able to sense their environment and adapt their mechanical properties accordingly.

We were involved in a project carried out as part of a university program to develop new markets, technology, services, business models and applications. The research was conducted through active interaction with Alcan EP for six months, and two follow up rounds of interviews over a two-year period. We used four research methods: interviews, analysis of internal documents, observation of processes, and study of public records. We first researched the antecedents of Alcan EP, studying documents and formal reports used to manage radical innovation. We also examined external public available documents, including annual reports, stock analyst reports, press releases, public statements, and public presentations by top management. The case study exploration research methodology requires proximity to the field (Garfinkel, 1994). Therefore we visited operational units and innovation support units to get better access to the organization. There were meetings and frequent informal discussions with company managers. Eleven key participants were selected to be interviewed from corporate offices, central R&D, BUs, innovation center, and external partners (see Table 1). The interviewees were chosen to meet the objectives of the research to gain a comprehensive understanding of the organizational structures, managerial roles, MCS, and processes involved in generating radical innovation. In all, a total of 18 interviews were completed. We employed a methodology where qualitative semi structured interviews were conducted utilizing a questionnaire (see Appendix). All interviews began with open-ended questions addressing the strategic reasons for Alcan EP to generate radical innovation, and the process, MCS and organizational structure utilized to manage radical innovation.

INSERT TABLE 1

3.4. The Case Study

3.4.1. The Company

Rio Tinto is one of the world's leading mining conglomerates with aluminum, gold, copper, diamonds, energy products, minerals and iron ore extraction and transformation activities. Rio Tinto Alcan Group is responsible for managing the aluminum business, and it is a leading global materials company with 68,000 employees operating in 61 countries. It provides innovative materials and technology worldwide through four divisions: Bauxite and Alumina, Primary Metal, Engineered Products and Packaging. Figure 3 illustrates the corporate organizational structure and our unit of analysis. Alcan Engineered Products (Alcan EP) manufactures engineered materials and solutions for a wide range of industrial sectors, including aerospace, automotive, mass transportation, building and energy. It has 15,000 employees located in 34 countries. Alcan EP is an innovative global leader in most of the markets it serves (see Figure 4), offering a variety of category leading brands for the display and graphic arts, construction, wind energy, marine and other transportation markets. Alcan EP is composed of operational business units (BU) dedicated to produce materials such as aluminum rolled products, aluminum extrusions, aluminum cable, composite products, and automotive and aerospace components. Alcan EP is headquartered in Paris, France and has two innovation support units, a corporate central R&D organization referred to as Technology & Innovation (T&I), responsible for R&D and technology development for long term future business growth employing over 300 researchers in two facilities in Neuhausen, Switzerland, and Voreppe, France. The second innovation support unit is Innovation Cells (IC) which was created in 2008. At that time Alcan EP identified that in order to grow and create more value they needed to organize differently, especially to generate radical innovation. T&I has traditionally delivered innovations related mainly to alloy development and surface finish. Alcan EP management realized that to embark on radical innovation new links and partnerships would have to be developed with research institutes, consultants, and companies from unrelated business sectors and it was conscious that T&I didn't have the capacity to develop such strategic partnerships. Furthermore, Alcan EP was advised by consultants that to generate radical innovation, the company must have a dedicated unit to produce radical innovation and that such a unit must be physically separate from the mainstream organization to avoid a short term vision. Consequently, Alcan EP established its radical innovation unit (i.e. IC) at the Science Park "Parc Scientifique" (PSE) of the École Polytechnique Fédérale de Lausanne (EPFL). IC facilitates complementarity between Alcan EP units and EPFL through an open innovation approach. IC is composed of a multidisciplinary team where commercial, business development, technical, and scientific experts work together to deliver market-ready prototypes and innovative business plans in small timeframes. IC main services comprise materials engineering, innovation management, and NPD. Figure 5 represents the scope of Alcan IC services.

Two operational BUs participated in this research, Alcan Composites (Composites) and Alcan Specialty Sheet (SSH). Composites develops advanced technologies and combines lightweight materials such as aluminum, paper, plastics and balsa wood into a unique and broad range of aluminum composite materials. On the other hand SSH is a leader in the aluminum rolling industry, serving markets such as beverage cans and closures, automotive, customized industrial sheet solutions including high quality functional surface products. An example of their innovative products is Alcan SSH solar surface products underlying Alcan's concern for the environment. These products are designed for a variety of solar applications, such as parabolic mirrors that capture solar energy and portable solar cookers. These products are produced at the rolling mill at Alcan Singen, Germany, which has established a solid reputation in many product areas most notably in the area of high-gloss surfaces for the lighting and cosmetic industries.

Throughout 2010 Rio Tinto decided to restructure Alcan EP as of early 2011. This initiative resulted in merging Engineered & Automotive Solutions with Extruded Products. The new unit, along with Global Aerospace, Transportation and Industry and Specialty Sheet reports to Alcan EP, which, in mid-2011, became Constellium with a stronger vision towards radical innovation. The Cable unit is for sale under Rio Tinto Alcan Group, and Composites was sold and became 3A Composites, a division of the Swiss Schweiter Technologies Group.

INSERT FIGURE 3

INSERT FIGURE 4

INSERT FIGURE 5

3.4.2. Alcan Management Systems and Performance Measurement

In 2004 Rio Tinto Alcan Group introduced the Alcan Integrated Management System (AIMS), comprised of three key corporate building blocks: Value-Based Management, Environment Health and Safety (EHS FIRST), and Continuous Improvement. These blocks are aligned into an integrated business management system with the objective of maximizing value. Value-Based Management is the basis for all strategic investment decisions and value-generating initiatives worldwide. It enforces rigorous financial discipline, allowing BUs to fully identify and capitalize upon opportunities and make the best use of all available resources. EHS FIRST incorporates the common standards, procedures and a mindset for achieving excellence in environment, health and safety performance for the benefit of their employees and for the communities in which they operate. Continuous Improvement aims at maximizing opportunities by improving the company's competitiveness and efficiency. Incremental innovation initiatives run through the Continuous Improvement program combining two complementary approaches – Lean Manufacturing and Six Sigma – providing a full range of tools for their businesses to choose the most appropriate techniques for each incremental innovation project. We observed that AIMS is the management system platform from which strategic planning, innovation funding, performance measurement, and incentives and reward systems are deployed through the organization. However, according to our interviews AIMS induced mainly incremental innovation opportunities represented by minor changes to existing aluminum alloys or merely an extent of the current metal surface finishing. Consequently BUs such as Composites developed their own management system for radical innovation.

At Composites, an example of a management system to support both incremental and radical innovations is the Innovation Management at Composites (im@c), which gets executed over a collaborative online tool that allows real-time sharing of incremental and radical project information. The im@c establishes secure access through an encrypted virtual private network, this secure access allows to control the rights to view or edit a specific project by the different members collaborating in the team. Composites also utilize electronic Internet tools to facilitate global dispersed teams to work simultaneously and to document, and reuse the output from team sessions. In addition they provide telephone conferencing for verbal communication, and public or private chat. These electronic tools ultimately assist individuals to review team calendars, team member capabilities, access databases, and review project status displays.

In terms of planning management systems, Composites utilizes an Innovation Roadmap showing innovation market fields, technologies and organizational competences. The roadmap also captures market insights, allowing Composites to better understand current and future customer needs. Composites maps out innovation projects to define the next multiple years of new initiatives and keep track of budgets and development timelines. Through Innovation Roadmaps Composites match short-term and long-term goals with specific technology and market solutions. Roadmaps also facilitate decision making about resources required to reach specific milestones, provide a mechanism to help forecast technology developments, and render a framework to help plan and coordinate technology developments.

"*For each of our business units there is a specific Innovation Roadmap that functions as the basis for future planning regarding products, markets, technology and competences. The innovation roadmaps are reviewed every year and adjusted according to external market conditions and internal organization circumstances, allowing the flexibility to capture viable opportunities".*

Director Technology & Innovation, Alcan Composites.

Through our observations we consider performance measurement as a key element for radical innovation. IC utilizes two comprehensive sets of measures to indicate their radical innovation progress. These are linked to the input and output of the innovation process. For the input it is the number of "good ideas[27]" that are being generated and for the output the profitability of radical innovations being commercialized. At IC they also acknowledge that each project is different and they adjust the development stages on a case-by-case basis. However their goal is not to exceed six months between the project setup and handing over the project to the BU (see Figure 6).

At Composites they indicated that a significant portion of their organic growth was derived from new products introduced within the last five years and that regarding performance metrics for the innovation process, development cost and cycle time are the most commonly tracked measures. However, there are other metrics that apply more specifically to radical innovation such as percentage of revenue from radical innovation, sales

[27] Good ideas need to present initial production feasibility through a simulation, a trial, or a prototype and have an important market potential. Should these criteria not be met, then the idea is considered "not a good idea".

margins, time to market, R&D expenditure as a percentage of sales, and number of radical ideas.

SSH innovation performance measures indicate increased productivity that will result in improved profitability. Innovation performance metrics enable SSH to make timely and educated financial decisions. They track gross margin, total portfolio value, and the number of patents filed annually.

"*Alcan Specialty Sheet is looking to develop a broader innovation program to facilitate radical innovation without requiring the degree of business case and ROI rigor required for larger investments. An important consideration for us is to ensure not to be overly dependent on processes to the point that the process becomes the end itself. Instead, the concrete commercial success of a new product launch should always be the ultimate performance metric*".

Director Strategy & Innovation, Alcan Specialty Sheet

INSERT FIGURE 6

3.4.3. Incentives and Rewards

In its effort to achieve organizational alignment, Alcan EP employs performance measurements linking strategic goals with innovation objectives to drive their personnel towards innovation. Alcan EP does not consider innovation as a separate function but rather part of its overall strategy. The company states that alignment to the business goals is a key success factor in meeting innovation objectives. Additionally, Alcan EP recognizes teams as well as individuals by offering a performance based compensation. Each employee has an individual performance management plan that defines goals and deliverables that must be accomplished during the year. There are competencies to be developed such as acting upon opportunities for change and innovation with scales from one to five where managers can assess the employee’s contribution to innovation. Each employee then has performance reviews that are quantifiable and depending on this evaluation employees are eligible to earn a financial bonus compensation.

In terms of intrinsic non-financial stimulus, Alcan EP promotes the Alcan “Thank You” Award. This award represents the highest tribute to individual employees or teams of employees in three categories: Environment Health and Safety (EHS First), Customers-Innovation-Growth, and Operational Excellence. Employees nominate candidates and a committee composed of cross-functional members assigns the gold, silver and bronze awards. Alcan EP believes that through the Alcan “Thank You” Award, the company can further align the organization to its innovation goals.

3.4.4. Process for Radical Innovation

To manage both incremental and radical innovation, Composites’ im@c management system distinguishes between incremental and radical ideas and it processes them differently. For an incremental innovation (i.e. SMARTinno) and for a radical innovation (i.e. RADinno) (see Figure 7). im@c explicitly recognizes that it needs to follow a different approach when processing incremental and radical innovation, hence avoiding a “one-size-fits-all” process that can almost guarantee a sub-optimization of resources. We observe that through MCS based on market and technology uncertainties Composites assess the idea to identify if an innovation is incremental, which means that it needs to have low complexity, existing market accessibility, and minor adaptation of existing products and processes. In contrast a radical innovation has high technical challenges, undefined market access, and challenging development of new radical processes, products, and services. Composites developed an adaptation of its incremental stage-gate process SMARTinno for processing RADinno radical innovations. The first quality gate (QG1) is the same for all ideas. At this gate it is determined if the idea should follow the incremental path, the radical route, or whether it is a non-innovative non-viable idea. From that point forward the quality gates for SMARTinno (QGS) and RADinno (QGR) are different. In QG1 the criteria includes the maturity of the idea being developed. It may be a quick short-term win, or it may a future attractiveness in terms of market size and growth. As the focus of this research is radical innovation we now describe the next gates applied exclusively to the radical innovation quality gates (QGR). At QGR2 the factors that influence whether a project obtains the go-ahead are long-term profitable market growth, and compatibility with the product portfolio strategy. The next gate is QGR3 where feasibility, technical specification, and customer benefits are verified. At QGR4 the technical specifications are determined, there is a feasibility market and product introduction plan, and an attractive strategic position is confirmed. The last quality gate is QGR5 where the customer feedback needs to be positive, cost calculations are verified, the documentation for industrial production is defined and the market introduction plan is finally completed.

INSERT FIGURE 7

Taking the theoretical innovation process framework from Davila et al. (2006) as a reference we describe in the following sections the four stages of the innovation process (i.e. idea generation, selection, execution, and commercialization). By adapting the four stages to our observations at Alcan EP radical innovation generation, we document insights and observe similarities to literature on technology and innovation management.

3.4.4.1. Idea Generation

T&I has a management system for innovation called "Step Change Program". It is within this management system that a program for the idea generation stage resides, defined as Ideation. T&I captures ideas from two venues: firstly, via employee innovation scouts from the BUs who are individuals with formal training within the organization and have a technology and product application background; secondly, through "Kaffe Kreativ" sessions, in which individuals meet in a relaxed atmosphere to brainstorm ideas with the philosophy of not discarding any idea at this stage. Participation in these sessions is not only reserved for Alcan EP employees, but also external partners are invited to participate. These two approaches, a formal rigid one (i.e. innovation scouts) and a more relaxed creative brainstorming one (i.e. "Kaffe Kreativ") represent a balance between rigidity and creativity for idea generation.

"Alcan identifies that being too strict on the idea generation stage of the radical innovation process, can be the exact wrong approach when trying to foster and create radical innovation. That's why we try to balance rigidity with creativity".

Director Corporate Technology & Innovation

The idea generation stage utilizes several enablers. The process begins when an idea is submitted to the administrator of T&I. Then the idea is stored electronically on the online database tool for IDEATION, specifying what the idea is, what the target market is, and how it works. Once an idea is entered into IDEATION, T&I processes it further to assess feasibility for market and technology proof of viability. T&I develops an initial budget and defines objectives and its organizational structure such as a cross-functional team formation. T&I also develops a project plan defining resources such as time, cost, headcount and strategic decisions including marketing, regulatory framework, operations, and project risk. The idea is approved in the system by changing its designation from idea to project. All project information is available online for individual team members to access and so that it can be further refined. T&I can also transfer the project to the BU directly in case the project is incremental, or to IC if the project is considered a radical innovation.

T&I encourages its technical personnel to get a closer view of existing and new customers and end-users. T&I is increasingly involved in meeting customer needs, and in some projects technical personnel attend sales meetings. The value of collaboration and interaction with existing customers has been recognized for idea generation. However, this interaction has been more productive for incremental ideas than for radical ones. Consequently, for radical idea generation the organization goes beyond existing customers to establish partnerships with external collaborators. This matter will be explained further on in section 3.4.4. i.e. Organizational structure for radical innovation.

3.4.4.2. Selection of Radical Projects

As part of the selection stage for radical projects the more important items considered are strategic alignment, market size, growth potential, and unique fit to the organization. This last item means that Alcan EP has to identify its unique competitive advantage against its competitors before deciding to select a particular radical innovation project. The uniqueness can be in terms of manufacturing capabilities, markets where the firm operates, or intellectual property protection. To select projects Alcan EP utilizes both quantitative and qualitative metrics (see Tables 2 and 3). The qualitative selection criteria for radical ideas include a set of principles. One such principle is that for an idea to fit Alcan EP's strategy that idea should not be a new market for an existing product, and there should be proof of concept at least at laboratory scale. On the other hand the quantitative selection criteria for radical ideas include: market attractiveness (size and growth), required investment, time-to-market, and, commercial and technological feasibility risk assessments. Interestingly, it is in the selection stage that the CEO of Alcan EP participates more actively providing input and direction.

When selecting radical innovations SSH assesses projects with additional qualitative and quantitative criteria. In addition to the corporate Alcan EP criteria, SSH qualitative metrics include the strategic significance in terms of the balance of power against its customers, meaning that for certain radical innovations such as specialty sheets for solar collectors, the entry barriers for customers to manufacture aluminum sheets is prohibitive due to the high investment required to setup an aluminum rolling mill. The presence of entry barriers helps a radical project to get selected and move into the next stage. On the other hand, SSH quantitative criteria rank radical project opportunities according to net present value.

"MCS are important because in our innovation efforts, we usually start with an abundant number of ideas, more than can be executed, and Alcan needs MCS to select which ideas to pursue. Without MCS, innovation efforts become ineffective demoralizing the organization".

Director Corporate Technology & Innovation.

INSERT TABLE 2

INSERT TABLE 3

3.4.4.3. Execution

Once a project passes the selection stage, a project team is assigned to develop the project into a market-technical tested product offering. To execute radical innovation IC involves several project stakeholders including individuals from T&I, BUs and external partners on a fully dedicated or part-time basis. Functional areas include sales, R&D, finance, marketing, purchasing, and manufacturing. The project team is responsible for working on marketing and technical details of the radical project to reduce project uncertainties.

There are formal monthly assessments to evaluate marketing and technical progress. At IC there is a rigorous assessment of every project to be on-time and on-budget. Any project that creates a new business platform, replaces a major existing product, involves an acquisition, license, alliance, or partnership, must apply the Innovation Cells Project Guidelines, in which project progress is milestone-based. Funding continues upon performance and deliverables of market and technical feedback.

The market and technical project tasks include evaluation of existing intellectual property such as patents, publications, and trademarks. The project team also determines the target market and considering that Alcan EP products are mainly business to business, the team identifies who are the decision makers and influencers in the purchasing process. To do this the individuals in the project team are required to interact with target customers and competitors by attending conferences and tradeshows that can provide information to estimate the selling price and generate preliminary knowledge for the commercialization strategy. There are other considerations related to the high volume manufacturing scale up production, such as defining the process in which the product can be manufactured in a cost effective way, proving technical feasibility through simulation or prototypes, and specifying engineering operations planning, department scheduling, and supplier value chain. Once the radical project team has this information the project team can calculate profitability and breakeven point scenarios more accurately.

In case core metallurgic competences are required to minimize the technology uncertainty, T&I is engaged early in the execution stage. In these situations T&I will lead the project execution, and be responsible for executing the technical challenge, project definition, prototyping, project timeline, and product development. In case the BU and T&I require support from corporate resources to further address the market uncertainty IC can assist with commercial and business development capabilities.

"Alcan Innovation Cells can help BUs execute radical projects by defining risk management plans, and conducting formal design reviews including demonstration of technical feasibility and commercial-financial viability".

Managing Director, Innovation Cells

3.4.4.4. Commercialization

Kelm et al. (1995) conducted research on commercialization of innovation and determined that during the commercialization stage the cash flow resulting from NPD is less dependent on a firm's technological capability, but rather on whether the firm is commercially appropriately positioned to take advantage of the new product or service. At this stage firms determine the right time to launch the product to market (Leifer et al., 2000). Moreover, when commercializing radical innovation firms tend to initiate sales within niche markets before the innovation can be successfully commercialized in broader markets (Christensen, 1997a, b).

At Alcan EP, during the commercialization stage the marketing department prepares marketing and communication materials (e.g. brochures and website), the sales team gets trained and if applicable training is extended to distributors and subcontractors. Meetings are held at major potential clients to validate sales forecast and pricing.

IC participates as part of the team to develop the commercial implementation plan, scale-up, and launch preparation. It goes as far as identifying the marketing and sales human resources gaps that the BU has and proposes potential candidates for sales functions. IC is also responsible for identifying and testing the primary target costumer group along with specifying the breakdown of the early adopters and heavy users. IC in a case-by-case basis engages with market opinion leaders to increase the probability of new product adoption by influenced buyers. A key aspect during this stage is that the company has to decide on an action plan for introducing the product and IC assists the BU to develop a viable marketing-sales plan and to create a respective marketing budget. Its objective is to build value for customers and deliver it through differentiated branded offerings.

At the commercialization stage BUs and IC identify the right time to introduce the new product or process, BUs have to manage internal conflicts with existing product lines as there is danger of cannibalizing existing sales. Furthermore, timing is also influenced by the state of the economy or the financial condition of target customers. Another key aspect of this stage is the location where the product will be launched. Alcan EP BUs cater market segments with concentrated few large industrial customers operating globally. However BUs also serve a disperse smaller size clientele. The target customer and location decision is also influenced by the BU operational and distribution capabilities, as well as financial resources and competitive position on the target market. In cases in which Alcan EP developed the radical innovation with a key client, they follow a "leading-client" strategy, introducing the new product only to a single customer while both learn to process and commercialize the new product.

3.4.5. Organizational Structure for Radical Innovation

Our observations of the Alcan EP organizational structure presented differences for radical and incremental innovation. When generating radical innovation projects a centralized organization including T&I and IC is required, as well as support from top managers, while incremental innovation projects tend to be processed at the BU level (i.e. decentralized organization) with low involvement from top management. Moreover, Alcan EP has learned through past experience that it needs to have a mix of centralized and decentralized organization focusing on innovation around the company's competences. In the early 1990s, T&I employees were in a corporate technology organization located in R&D headquarters. By the mid-1990s the company decided to decentralize their technology competence to a certain degree and placed engineers and scientists at the BUs. Nevertheless Alcan EP was still concerned about long term opportunities and decided to keep some T&I personnel as a centralized unit to avoid neglecting projects that would require a long term commitment.

In order to determine the organizational structure and the unit that will lead an innovation project, Alcan EP takes into account two characteristics of the project: firstly the stage of development, and secondly the level of radicalness which determines whether the project remains within the decentralized BU or requires centralized support from T&I and IC. It is important to note that unless there is a recipient BU willing to adopt the innovation project, the project is considered to have a sponsor within the organization. If no BU undertakes a project, then the project gets registered as abandoned and no further resources are spent on it. This is different from other companies such as Nestlé when they developed

Nespresso. Markides and Oyon (2000) studied the Nestlé's radical innovative idea to make coffee out of a capsule cartridge based on the work of a group of external engineers. At that time Nestlé decided to acquire the rights for that new technology, probably to prohibit any competitor from acquiring such innovation. The most relevant differentiation between Nestlé and Alcan EP in this case is that Nestlé decided to establish a separate BU (i.e. Nespresso) with full support from top management to tackle organizational resistance as Nespresso was seen as cannibalizing Nestle's main products. They did this despite being challenged by entering a hardware market (i.e. Nespresso machines) and not having a well-established organization to generate radical innovate internally, or a BU willing to adopt the Nespresso project.

In the case of Alcan EP, the company expressed that there is an important distinction between R&D (i.e. T&I) and innovation (i.e. IC). R&D aims at developing core material science and long term research, while innovation pursues radical innovation and commercialization of new products and services. Figure 8 represents our observations of the units involved. The horizontal axis in Figure 8 refers to stage of development, ranging from "Exploratory" to "Industrialization & Market Launch". Exploratory means that R&D is exploring at the laboratory scale and the technology has not yet been demonstrated, while industrialization & market launch is a developed stage of industrialization, for instance prototypes are available and there is a viable commercial business case. The vertical axis (i.e. level of radicalness) refers to incremental projects such as a product extension or minor process improvement. Semi-radical innovations can be projects of major cost reduction or quality improvement, and in radical innovations new product categories are created. The important finding was that T&I and BUs were able to develop and launch products to market for incremental projects. However, for projects with a higher level of radicalness IC participates more actively to bridge core material science with market applications from BUs.

It is important to mention that during our interviews we were told that the central radical innovation unit (i.e. IC) needs to report to Alcan EP headquarters and not to an R&D support unit (i.e. T&I), because T&I tends to be risk adverse and lacks commercial capabilities and experience.

In case of developing radical innovation, both corporate central innovation support units (i.e. T&I and IC) participate to address the technical and commercial challenge respectively. Specific individuals are assigned to teams and organized on the basis of the competences required for each radical project. The team then specifies the technical challenges, prototyping, project timeline, and product development.

Brown and Eisenhardt (1995) studied the innovation process performance and its relationship to organizational structures including internal and external project collaborators such as project leaders, senior management, R&D, customers, suppliers, and external consultants. Similarly, Alcan EP employs a cross functional organization (see Figure 9). Alcan EP looks beyond their walls to find ideas and develop radical innovation, by fostering Open Innovation to broaden the sources of ideas, and to increase cooperation with academic and industrial partners. Alcan EP mainly utilizes external partners for the stages of idea generation and project execution, leaving selection and product commercialization to be executed within the company units. In Figure 9 the dark color indicates a high interaction by the corporate unit or external partner executing and leading a particular radical innovation process stage. A lighter color indicates a lower intensity, and the color white represents a low relationship. This organizational approach is referred to as the holistic sequential model (O'Connor & DeMartino, 2006) in which the scope of the organizational structure for radical innovation encompasses incubating radical innovation opportunities, and coaching these opportunities to evolve into commercially self-sufficient radical projects at the BUs. The term holistic sequential organizational model comes from the fact that the organization is structured so that a project will pass from one unit leading the project to another one in a sequential way as the project develops through the process.

External partnerships were observed during our study. For example, In 2008 Alcan EP signed a multi-year cooperation agreement with the EPFL in Switzerland, to help identify new ideas for growth and benefit from complementary competences for the development of new lightweight materials and solutions. Alcan has direct formal contact and access to researchers and their scientific knowledge. It also benefits from informal social access made possible only through the proximity of being on campus and having hired some EPFL graduates who are well connected to the EPFL. Furthermore, Alcan EP has access to laboratory equipment to perform trials or project simulations. An example of these external partnership interactions is the development of a unique process to produce aluminum foam, using salt dough by the mechanical metallurgy laboratory at EPFL. Alcan EP believed in the EPFL concept, and asked IC to lead the scale-up of the process from the laboratory low volumes to the factory full scale production. This project required participation of "unfamiliar" external partnerships from the world of food processing. For instance, IC entered into collaboration with a world leading manufacturer of pasta extruders to produce salt dough molds at an industrial scale. In this project IC designed the industrial process, identified partners, set up multiple collaborations, identified applications, and assessed market potential.

"By being located at the EPFL we live in Open Innovation. Our connection to EPFL helps us stay informed of the latest scientific discoveries. And by working alongside other leading technology companies we've been exposed to many opportunities to explore radical projects through external collaborations".

Project Manager Innovation Cells

INSERT FIGURE 8

INSERT FIGURE 9

3.5. Discussion

Davila et al., (2009) highlighted that the crossroad of MCS, organizational structures and innovation offered an important field of research opportunities to be explored, in particular at the process level. This research examined how an established firm develops the innovation process, MCS and organizational structure to generate radical innovation. The findings include employing a well-defined, disciplined and systematic process for radical innovation at Alcan EP. More importantly we found that radical innovation can be generated through enablers such as MCS, processes, and flexible organizational structures. We also found that incremental and radical innovation need to be managed through different processes (Davila et al., 2006) and by organizational flexible structures (O'Connor & DeMartino, 2006) that can adapt and activate contingent to the type of innovation that is being pursued (i.e. incremental or radical). In Figure 10, we present a new process architecture of an innovation process capable of managing both incremental and radical innovations. The model illustrates that within the process at the ideation stage a decision whether an idea is incremental or radical is taken, and that determines the incremental or radical path the idea takes as it matures into a project. By utilizing this process, a firm manages its innovation projects systematically, avoiding diluted resources in several unrelated projects and a one-size-fits-all process that can almost guarantee a sub-optimization of certain resources (Davila et al., 2006).

Regarding blending qualitative and quantitative metrics we consider the literature by Werner and Souder (1997) in which they report integrating metrics combining quantitative and qualitative measures through an extensive search of the literature between 1956 and 1995 finding this approach not only effective, but also complex and costly to develop and use. Integrated qualitative and quantitative methods of innovation evaluation enhance the advantages of both types of measurement. These provide information that can improve innovation effectiveness (Blau, 1995; Bosomworth & Sage Jr, 1995; Schumann Jr, Ransley, & Prestwood, 1995). Alcan EP blends qualitative and quantitative metrics. Particularly in the project selection stage these two types of metrics allow decision makers to utilize quantitative hard data results and qualitative business intuition inputs into the variables that will determine the radical projects that will be selected. This is consistent with literature on qualitative and quantitative evaluation criteria for formal portfolio project selection (Cooper, Edgett, & Kleinschmidt, 2001).

We also noticed at Alcan EP that radical innovation requires more time to develop as both technology and market uncertainties increase with the degree of radicalness, influencing development time (Abetti, 2002). Furthermore, Laurie (2006) argued that the planning horizon for radical NPD is significantly longer as there are more hurdles to come across before the product gets commercialized.

During our study at Alcan EP we detected conflicts and tensions among individuals in the project team. Similar to Takeuchi and Nonaka (1986), we observed these conflicts and tensions tend to arise when radical projects “changed hands”, in other words when T&I handed over a project to IC, or IC to a BU. The project individuals or units did not always agree on the level of development of the deliverables. There were also other tension and conflict considerations such as budget constraints, cost allocation, and discrepancies on delimiting the scope or goal of a project. We also perceived conflicts and tensions when the organizational structure tried to integrate units, defined the division of labor, and determined project ownership and accountability. Under these circumstances Alcan EP top management played a major role to reduce and mitigate these organizational conflicts and tensions through making a final determination in case the participating project units could not reach an agreement or reconcile different interests or points of view.

Quintana-García and Benavides-Velasco (2011) analyzed configurations of innovation partnerships influencing product innovation. Their evidence highlights the importance of collaborating with key partners through R&D partnerships to develop innovative competences. Similarly, Alcan EP develops partnerships with academic institutions and innovative companies that have the technology or market competences that are needed for a particular radical project. One example is 3M which works with Alcan EP to develop advanced surface finishing for lightweight materials. Alcan EP is aware that entering into external partnerships can create additional challenges and risks in terms of loss of control or intellectual property ownership. Therefore, it will only enter into partnerships if there is a clear lack of competences within their organization to develop a specific radical project.

We also found that to generate radical innovation the role of a corporate innovation unit (i.e. IC) is different from that of an R&D unit (i.e. T&I). Their participation and involvement as leading radical innovation support unit is contingent to the degree of radicalness and the technology development stage. We also observed that Alcan EP leans on R&D for exploratory science, while Alcan EP depends on BUs development capabilities for technology proven prototypes. Only when a project is considered to have a high level of radicalness does IC initiate their involvement. This organizational structure framework supports Ettlie et al.'s (1984) research on organizational structures for radical innovation as they proposed that when generating incremental innovation and development stage is advanced, organizations utilize decentralized organizations (i.e. BUs). For radical innovation, a more central R&D and innovation corporate support units are required.

In terms of future research, we identified that the role of project leadership and organizational structures can be an important factor to generate radical innovation. This line of research was recently developed by Lin and McDonough (2011), and Kelley et al. (2011). Consequently, investigating the role of leadership and organizational structures at the process level can provide further insights on enablers of radical innovation.

INSERT FIGURE 10

3.6. Conclusions

Our research leans on the perspective that management of radical innovation constitutes a dynamic capability which fundamentally represents a firm's ability to exploit and develop resources and processes that create and capture value, while operating in rapidly changing technological environments (Eisenhardt & Martin, 2000; Teece et al., 1997; Zahra, Sapienza, & Davidsson, 2006). Moreover, our study on Alcan EP focuses on the development and utilization of processes, MCS and organizational structures as a source of dynamic capabilities to generate radical innovation via internal knowledge exploitation or external knowledge exploration through an open innovation approach. The observed interaction between Alcan EP and external partners such as EPFL, consultants, and other companies in the value chain reinforces the complementarity that can be found on external partnerships described by Cockburn and Henderson (1998), and Cassiman and Veugelers (2002), advocating for external partnerships complementing internal innovation capabilities, which allows established firms to get better access to new technologies and markets.

We found that when generating radical innovation, the organizational structure at Alcan EP is flexible depending on the kind of innovation project (i.e. incremental or radical) as suggested by Chandler (1962) who stated that organizational structures evolve to fit company strategies. Similar to O'Reilly and Tushman (2011), Chandy and Tellis (1998), and Teece (1986), we observed that in order for Alcan EP to generate radical innovation, an organizational structure adaptation is required to cope with technology and market uncertainties. Furthermore, supporting Benner and Tushman (2003), Campbell et al. (2003) and Kanter (1985) we observed that at Alcan EP, the organizational unit responsible for radical innovation (i.e. Alcan Innovation Cells) was physically separate from the mainstream organization. However, in line with Heller (1999) IC maintains strong links and an active interface between them and the rest of the organization.

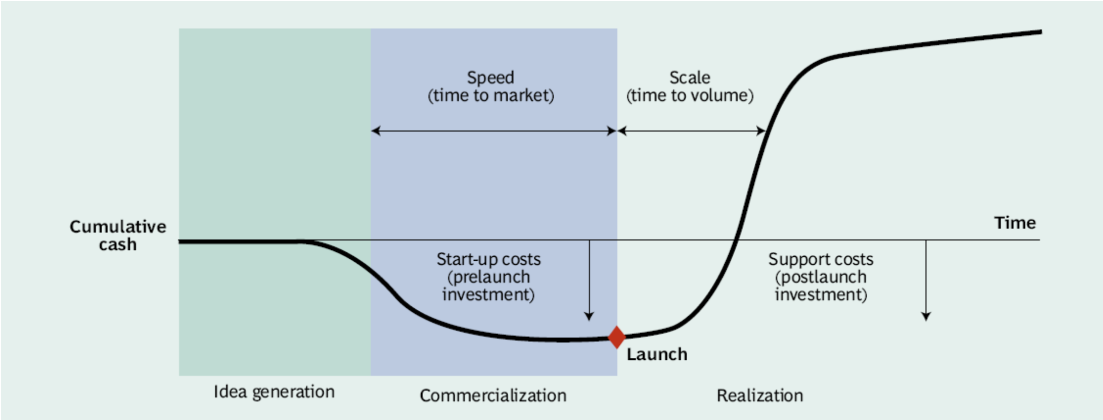
This research is also in line with innovation management that has been defined as the implementation of management processes, structures, or techniques intended to generate innovation and reach organizational goals (Birkinshaw et al., 2008a). Our findings allow us to explain the different approaches of the innovation process, in which in order to optimize resource allocation and outputs, incremental and radical innovations need to be managed through different processes, MCS, and organizational structures. Otherwise as described by Davila et al. (2006) by processing incremental and radical innovation projects through the same “one-size-fits-all” innovation process, firms can almost guarantee a sub-optimization of certain resources.

Cabello-Medina et al. (2011) also performed research on organizations generating innovation. Their study focused on the prevailing “simplistic” belief that MCS hinders innovation. However, their results show that the relationship between MCS and innovation performance is positive when innovation radicalness is high. Our observation at Alcan EP supports these results as both MCS and processes are needed to generate radical innovation. Moreover, Alcan EP has an institutionalized process for radical innovation making an argument in line with Jelinek and Schoonhoven (1993) that radical innovation cannot occur in an organic environment where flexibility and consensus are the main managerial mechanisms to generate radical innovation. This suggests that radical innovation requires structure and organizational relationships to ensure that both discipline and creativity are present. In this regard we add to Pisano (1996a, b) and Markides' (1997) research on the areas of innovation management, organization for innovation, and strategic innovation.

We are aware of the limitations of this case study (i.e. lack of generalization and non-universal validity). However, this approach is especially appropriate in new topic areas (Eisenhardt, 1989). We obtained an understanding of what the organization does and the reasons for acting in such a fashion. Consequently we present some insights and qualitative findings on the processes, MCS, and organizational structures firms can implement to generate and manage radical innovation.

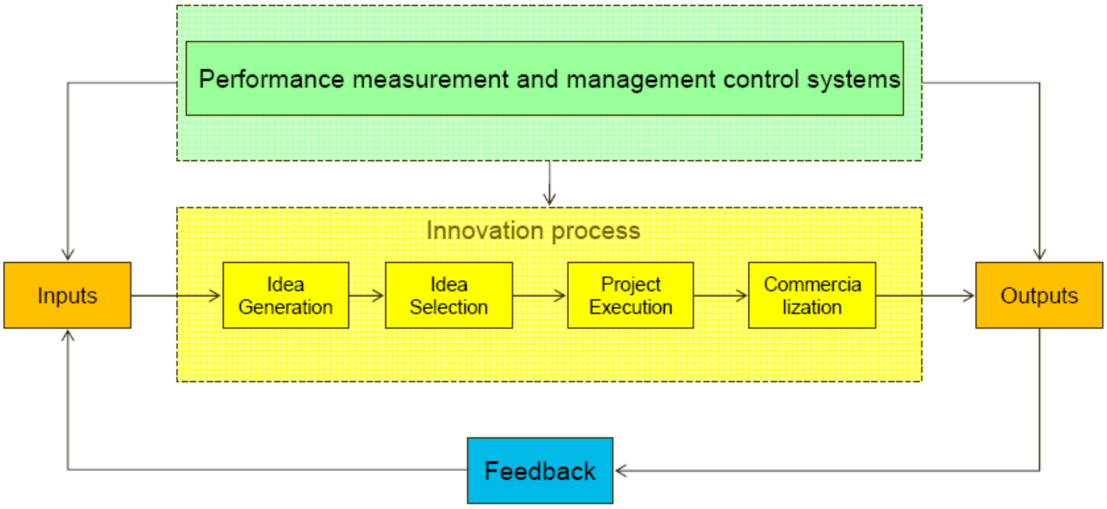
Tables and Figures

Figure 1. The cash curve (Andrew and Sirkin, 2007).



Source: Andrew, J. P., and Sirkin, H. L. 2007. Using the cash curve to discuss and discipline innovation investments. Strategy & Leadership, 35(4): 11-17.

Figure 2. Innovation process adapted from (Davila, 2006).



Source: Davila, T., Epstein, M., and Shelton, R., 2006. Making Innovation Work: How to Manage It, Measure It, and Profit from It. Wharton School Publishing.

Figure 3. Rio Tinto organizational structure & Alcan Engineered Products unit of analysis.

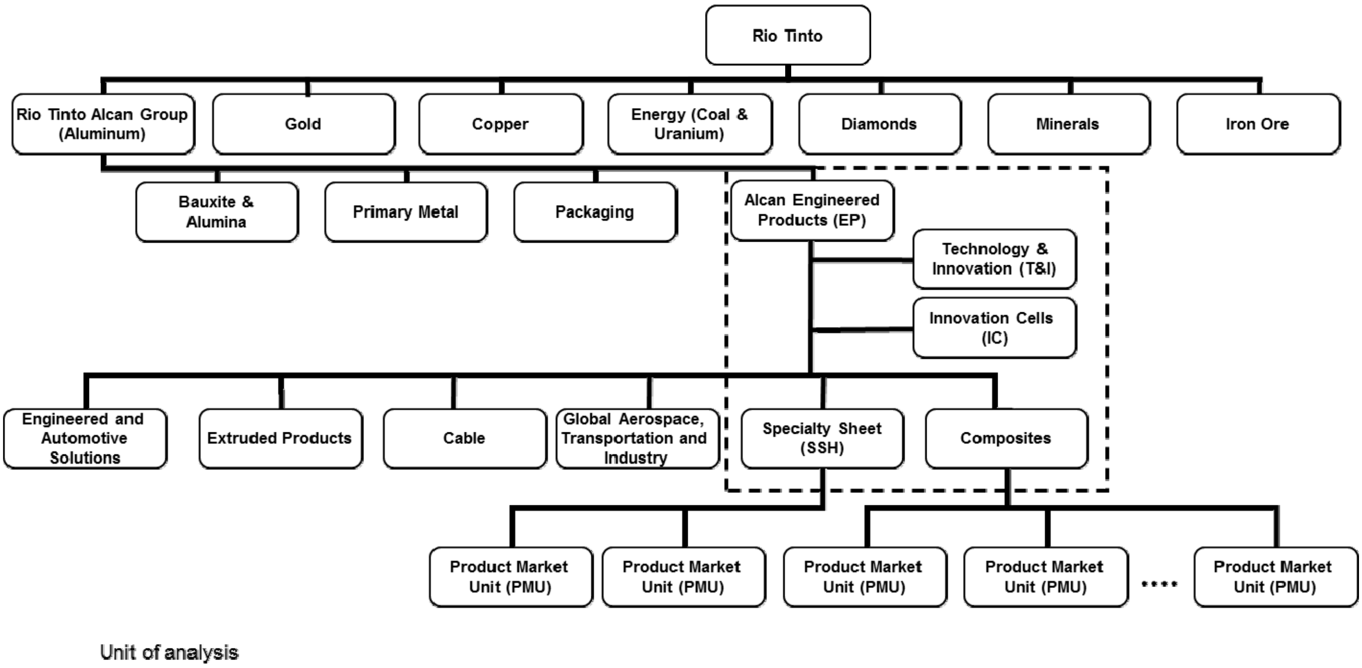


Figure 4. Alcan EP a market and innovator leader.

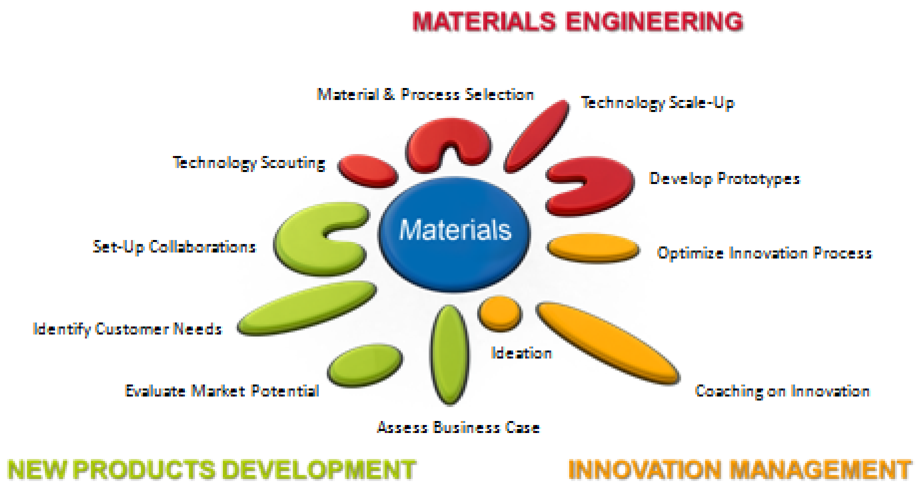
Alcan Engineered Products

ALCAN ENGINEERED PRODUCTS

Leadership in Several Sectors		
No.1	Core materials/composites	Global
	Display	Europe
	Canstock & closures	Europe
	Display	Americas
	Large profiles	Europe
	General engineering plate	Global
	Architecture panels	Global
No. 2	Aerospace plate	Global
	Aluminium energy cable	US
	Specialty profiles	Europe
No. 3	Auto sheets	Europe

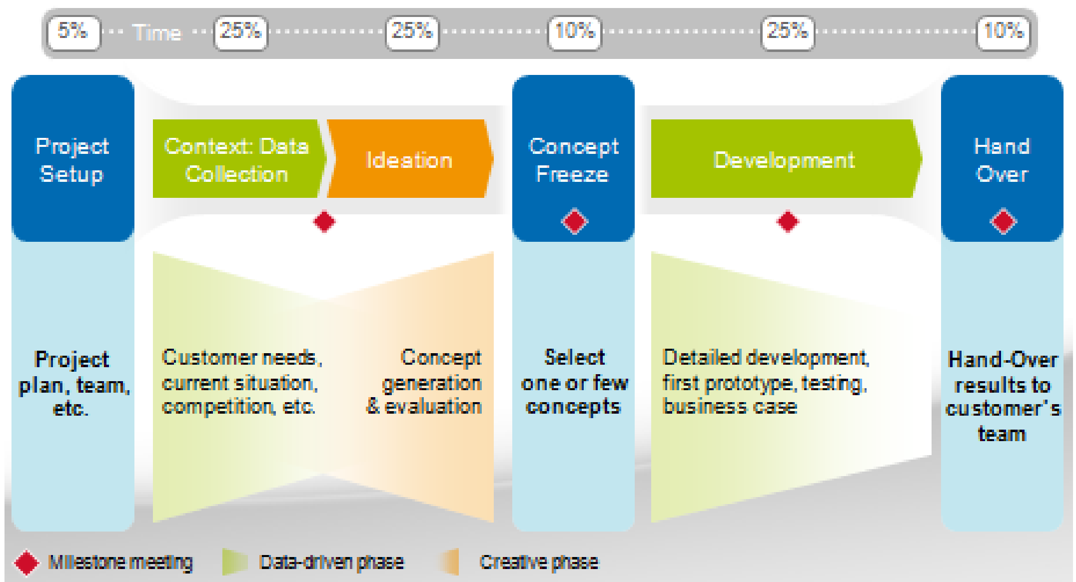
Source: Alcan Engineered Products 2009. Corporate brochure.

Figure 5. Scope of Innovation Cells services.



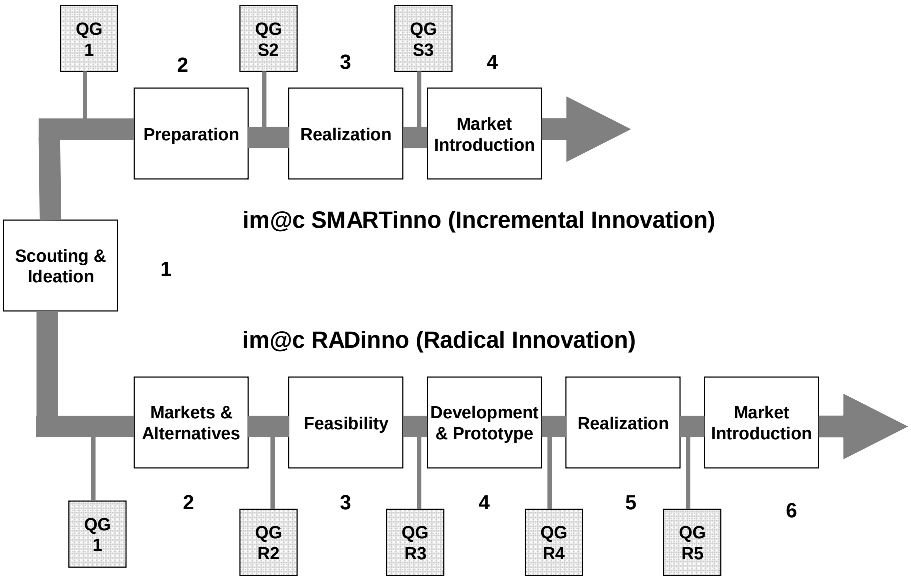
Source: Alcan Innovation Cells 2010. Brochure succeed with materials.

Figure 6. Project plan for new product development at Innovation Cells.



Source: Alcan Innovation Cells 2009.

Figure 7. Process for incremental & radical innovation



Source: Alcan Composites 2008, Innovation Management at Composites (im@c).

Figure 8. Leading organizational unit contingent to "radicalness" and development stage.

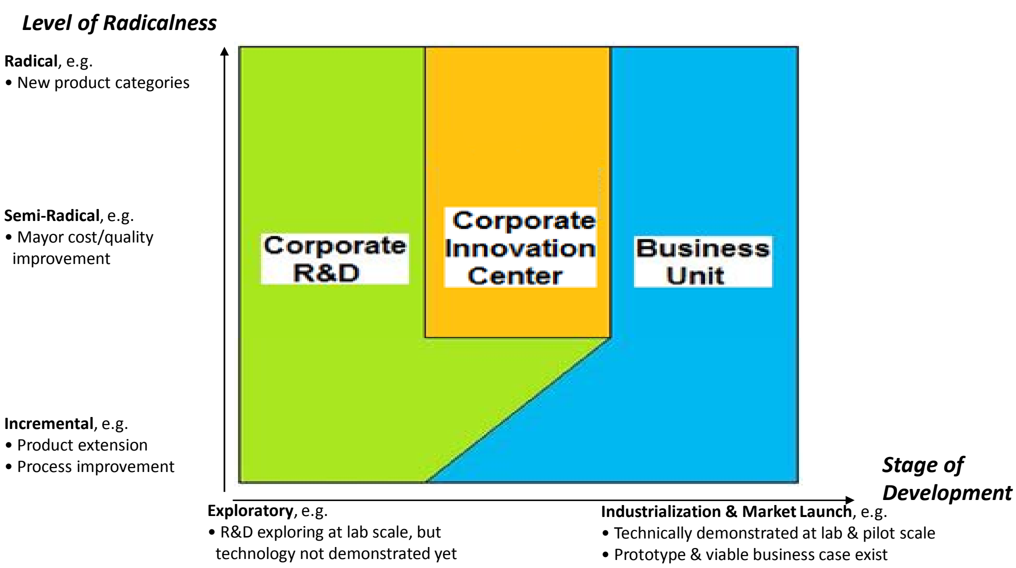


Figure 9. Internal and external collaboration to develop radical.

	Ideation	Market Potential	Technology Feasibility	Idea Selection	Project Execution	Market Introduction
Research & Development						
Innovation Center						
Business Units						
Headquarters						
External Partners						

Figure 10. Process for incremental and radical innovation.

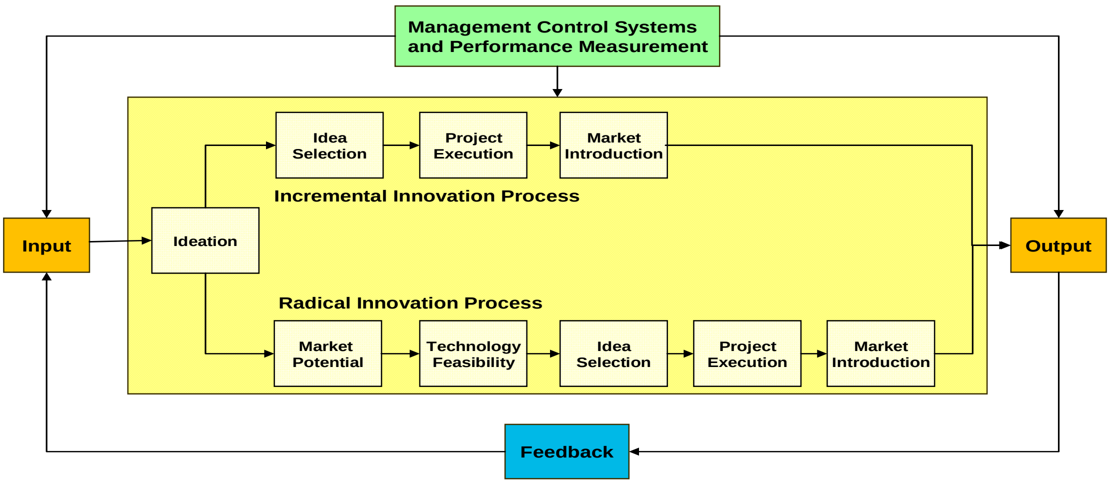


Table 1. Interviews, meetings, and conferences

	Round one	Round two	Round three
Time	March-September 2009	September 2010	May 2011
Interviewees	1 CEO Alcan EP Lausanne, Switzerland 1 Managing Director Innovation Cells Lausanne, Switzerland 1 Director Corporate Technology & Innovation Neuhausen, Switzerland 1 Director Corporate Technology & Innovation Voreppe, France 1 Director Composites Technology & Innovation Neuhausen, Switzerland 1 Director Strategy & Innovation Specialty Sheet Zurich, Switzerland 1 Director Innovation & Commercialization Specialty Sheet Singen, Germany 1 Project Manager Innovation Cells Lausanne, Switzerland 1 Sales Manager Innovation Cells Lausanne, Switzerland 1 Sales Manager Specialty Sheet Singen, Germany 10 interviews in total	1 Managing Director Innovation Cells Lausanne, Switzerland 1 Project Manager Innovation Cells Lausanne, Switzerland 1 Sales Manager Innovation Cells Lausanne, Switzerland 1 Sales Manager Specialty Sheet Singen, Germany 1 Senior Technology Transfer Officer EPFL Lausanne, Switzerland 5 interviews in total	1 Managing Director Innovation Cells Lausanne, Switzerland 1 Project Manager Innovation Cells Lausanne, Switzerland 1 Sales Manager Innovation Cells Lausanne, Switzerland 3 interviews in total

Table 2. Qualitative selection criteria for radical ideas

1. Idea is not an Environmental Health and Safety, social, and economic threat
2. Idea fits Alcan EP's strategy
3. Regulatory or legal issues manageable
4. Not purely a new market for existing product
5. Not incremental to existing product or process
6. Building on core competences
7. Proven technology at least at lab scale
8. Identified commercial application
9. Length of stay at Innovation Center not to exceed 6 months

Source: Alcan Innovation Cells 2009.

Table 3. Quantitative selection criteria for radical ideas

1. Market attractiveness (size, growth)
2. Investment
3. Time-to-market
4. Customer benefit / unmet need satisfaction
5. Commercial feasibility & risk
6. Technical feasibility & risk
7. Competitive intensity & entry barriers

Source: Alcan Innovation Cells 2009.

Appendix

Questionnaire – Management Systems and Organizational Structures for Radical Innovation[28]

Interview - Management Systems for Radical Innovation

Company __________ Interviewer __________
Person __________ Date __________
Title __________

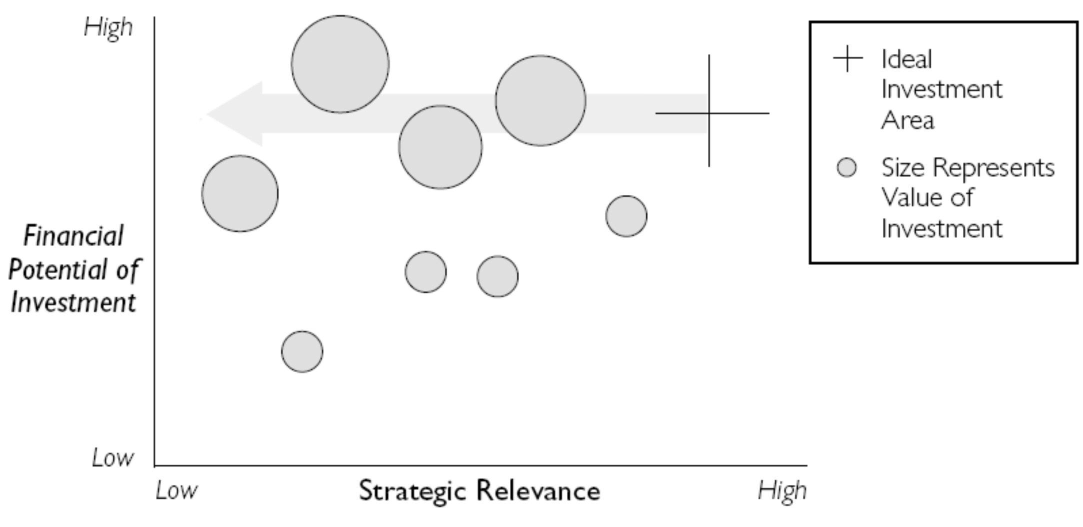
In this interview we want to better understand for each stage of the innovation process: idea generation (IG), idea selection (IS), project execution (PE) and commercialization (CO). The challenges that your company faces when developing incremental and radical innovation, we are interested in management systems and how these help to manage the innovation process.

Innovation Strategy

1. What are some examples of strategic objectives for radical innovation? And how would you rank them? E.g. window on technology, window on market, etc.

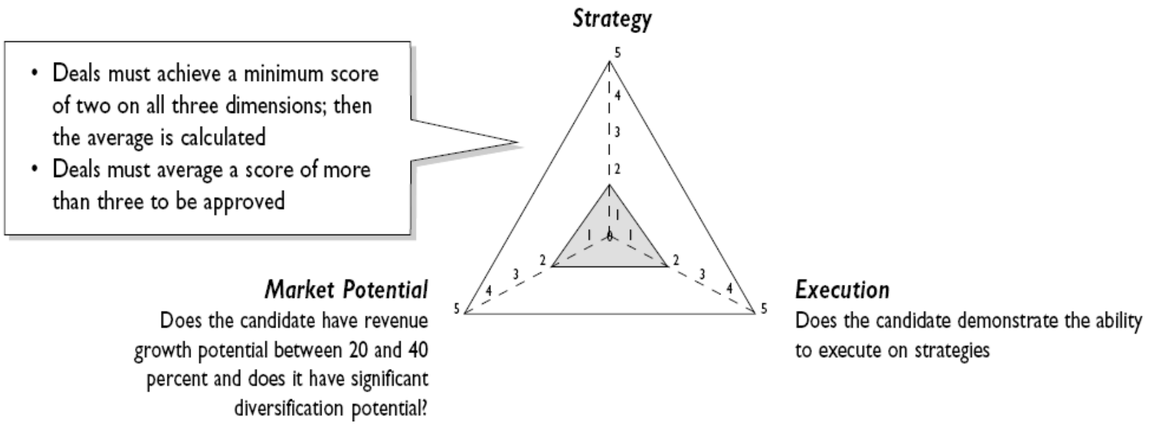
2. Do you have an innovation project portfolio, and if so how do you balance financially promising vs. strategic relevant projects? Has your organization specified an optimal balance?

Schematic Venture Investments Misaligned with Corporate Strategy



[28] Questionnaire adapted from Working Council for Chief Financial Officers. Corporate Venture Capital Managing for Strategic and Financial Returns. 2000 Corporate Executive Board.

3. Is there a minimum score that the project must meet on all three dimensions (Strategy, Execution, and Market potential)?



4. Is management tolerant to "failure" (innovation efforts that did not lead to value creation)? Is it different for incremental and radical projects?

5. Does management have tolerance for market and technological uncertainty? Is it different for incremental and radical projects?

Management Systems and Innovation Process

6. Do you have different organizational, technology and market risk control for radical and incremental innovation?

7. Do you have different budgets for radical and incremental innovation?

8. Are project failures systematically reviewed and analyzed for lessons, or buried and nobody talks about it? If so how often and who participates in the evaluation?

9. Is there a measurement that tracks the quality of ideas and the conversion rate into projects and value? -is it formalized and documented?

10. Is there a project execution system tracking the evolution of projects in dimensions such as time, and cost -is it formalized and documented?

11. Do you measure the number of ideas generated by R&D, sales, manufacturing, customers, and external partners?

12. Please indicate if your Innovation Center (IC) and/ or Business Unit (BU) review the following monitoring systems and how often - Is there a difference on these when developing incremental or radical innovation:

	Incr.|Month/Year|(IC/BU)	**Rad.|Month/Year | (IC/BU)**
Product profitability reports		
Customer profitability reports		
Reports comparing budget to actual performance		
Product quality monitoring systems		
Product development monitoring systems		
Sales force effectiveness (pipeline management)		
Partnership development reports		
External benchmarking reports		
Operational expenditure approval process		
Capital expenditure approval process		

13. What would you describe as the major differences between the management systems for incremental and radical innovation at your company? Why?

14. When transferring ownership "due diligence" of the project to the Business Unit, is there a management system to assure proper market and tech transfer? Is it specific to certain stages in the innovation process?

15. For each system below, please indicate for what type of innovation it is used and at what stage of the innovation process idea generation (IG), idea selection (IS), project execution (PE) and commercialization (CO) are evaluated.

	Incremental				Radical			
	IG	IS	PE	CO	IG	IS	PE	CO
Product profitability analysis								
Customer profitability analysis								
Customer acquisition costs								
Financial performance against budget								
Capital investment approval procedure								
Operational expense approval procedure								

16. What actors participate at each stage of the Innovation Process, and who has the most influential power "rank" to allocate resources, continue or discontinue a project. We are interested in their influence when developing incremental and radical innovation. Actors are: Innovation Center (IC), Business Unit (BU), Corporate (CR), Research & Development (RD), and Outsiders e.g. external experts, customers, suppliers, etc. (OS)?

Ranking	Incremental (Idea Generation)	Who participates in the decision e.g. Finance, Sales, Manufacturing, R&D, BU General Manager, etc.	Radical (Idea Generation)	Who participates in the decision e.g. Finance, Sales, Manufacturing, R&D, BU General Manager, etc.
1				
2				
3				
4				
5				
Ranking	Incremental (Idea Selection)	Who participates in the decision e.g. Finance, Sales, Manufacturing, R&D, BU General Manager, etc.	Radical (Idea Selection)	Who participates in the decision e.g. Finance, Sales, Manufacturing, R&D, BU General Manager, etc.
1				
2				
3				
4				
5				
Ranking	Incremental (Project Execution)	Who participates in the decision e.g. Finance, Sales, Manufacturing, R&D, BU General Manager, etc.	Radical (Project Execution)	Who participates in the decision e.g. Finance, Sales, Manufacturing, R&D, BU General Manager, etc.
1				
2				
3				
4				
5				
Ranking	Incremental (Commercialization)	Who participates in the decision e.g. Finance, Sales, Manufacturing, R&D, BU General Manager, etc.	Radical (Commercialization)	Who participates in the decision e.g. Finance, Sales, Manufacturing, R&D, BU General Manager, etc.
1				
2				
3				
4				
5				

17. What are the **three** most important financial measures that you use to evaluate progress at each of the stages of the Innovation Process, and where is it measured at the Innovation Center (IC) and/ or Business Unit (BU) (for example, ROI, sales growth, IRR or cash burn rate) as well as to determine if there is a difference between these when developing incremental or radical innovation?

Ranking	Financial measure for Idea Generation	Incr.|Month/Year | (IC/BU)	Rad.| Month/Year | (IC/BU)
1			
2			
3			
Ranking	Financial measure for Idea Selection	Incr.|Month/Year | (IC/BU)	Rad.| Month/Year | (IC/BU)
1			
2			
3			
Ranking	Financial measure for Project Execution	Incr.|Month/Year | (IC/BU)	Rad.| Month/Year | (IC/BU)
1			
2			
3			
Ranking	Financial measure for Commercialization	Incr.|Month/Year | (IC/BU)	Rad.| Month/Year | (IC/BU)
1			
2			
3			

18. Why do you consider these measures the most important financial measures? What are the challenges in measuring some of these variables?

19. Do you measure Return on Investment [(sales-cost)/investment] and / or Residual Income [(sales-cost)-(cost of capital*investment)] for incremental and radical?

20. What other reports do you use throughout the course of the projects? Are these different for incremental and radical projects? Are these reports formalized and documented?

21. What are the **three** most important non-financial measures that you use to evaluate the progress of innovation (for example, customer satisfaction or on-time delivery)?

Ranking	Non-financial evaluation measure for Idea Generation	Incr.|Month/Year | (IC/BU)	Rad.| Month/Year | (IC/BU)
1			
2			
3			
Ranking	Non-financial measure for Idea Selection	Incr.|Month/Year | (IC/BU)	Rad.| Month/Year | (IC/BU)
1			
2			
3			
Ranking	Non-financial measure for Project Execution	Incr.|Month/Year | (IC/BU)	Rad.| Month/Year | (IC/BU)
1			
2			
3			
Ranking	Non-financial measure for Commercialization	Incr.|Month/Year | (IC/BU)	Rad.| Month/Year | (IC/BU)
1			
2			
3			

22. Why do you consider these measures the most important non-financial measures? What are the challenges in measuring some of these variables?

23. What is the longest time horizon set for these projections (for example, "We project one year into the future.")?

	Incremental longest time horizon years	Radical longest time horizon years
Cash flow projections		
Sales projections		
Operating budget		

24. When developing incremental and radical innovation. At what stage of the innovation process idea generation (IG), idea selection (IS), project execution (PE) and commercialization (CO) is the following information generated and evaluated?

	Incremental				Radical			
	IG	IS	PE	CO	IG	IS	PE	CO
Financial projections								
Market forecasts								
Competitor analyses								
Customer analyses								
Technology forecast								
Product positioning								
Investment plans								
Marketing plans								
Assess project strengths and weaknesses								

25. How often does the project innovation committee meet to review the different stages of the innovation process? Please specify time frame e.g. weeks, months.

	Incremental				Radical			
	IG	IS	PE	CO	IG	IS	PE	CO
How often does the project innovation committee meet?								

Incentives

26. Please indicate how often your Innovation Center (IC) and/ or Business Unit (BU) reviews the following evaluation systems. Indicate whether there is a difference between these when developing incremental or radical innovation:

	Incr.| Month/Year | (IC/BU)	**Rad.| Month/Year | (IC/BU)**
Written performance objectives for managers		
Written performance evaluation reports		
Linking compensation to performance		
Individual incentive programs		

27. Is the process of awarding financial bonuses to employees for innovation performance formalized? Are these different for incremental and radical?

28. How often does your company pay out financial bonuses to managers (for example, every quarter)? Are these different for incremental and radical?

29. Is the process of awarding non-financial incentives to employees for innovation performance formalized? Are these different for incremental and radical?

30. How often does your company recognize employees with non-financial incentives (for example, every quarter)? Are these different for incremental and radical innovations?

31. Is the process of awarding financial or non-financial incentives to external "partners" for innovation performance formalized? Are these different for incremental and radical?

Organization

32. How is the company organized for incremental innovation (functional, business unit, matrix)? Who proposed or structured the organization?

33. How is the company organized for radical innovation (functional, business unit, matrix)? Who proposed or structured the organization?

Partnerships and alliances with "outsiders" for Innovation

34. How do you identify important alliance partners? Formal scouting system vs. informal network. Are these different for incremental and radical projects?

35. Which are the three main criteria your company uses to select its partners?

Ranking	Criteria
1	
2	
3	

36. What are the three main measures that top management uses to evaluate the progress of partnerships (in other words, what are the milestones of a partnership based upon)?

Ranking	Measure	How often does top management check it (weekly, monthly, quarterly)?
1		
2		
3		

Product development

37. How are incremental project ideas generated in your organization?

38. How are radical project ideas generated in your organization?

39. How do new product development projects get selected? Is there a distinction in the process if the project is of an incremental or radical innovation nature - Why? E.g. Technology vs. market driven—customers, competitors. Individual product decisions vs. portfolio decisions. Intuition vs. analysis of customer needs / technology possibilities.

40. Please indicate if your company, formalize each system below. "Formalized" is defined as having documented a process and / or periodically and purposefully executing and evaluating the process.

	Incr.|Month/Year| (IC/BU)	Rad.| Month/Year | (IC/BU)
Project milestones		
Budget for development projects		
Reports comparing actual progress to plan		
Project selection process		
Product portfolio roadmap		
Project team composition guidelines		
Product concept testing process		

Sales and marketing

41. How and at what stage of the innovation process (idea generation, idea selection, project execution and commercialization), do sales and marketing participate? What are the main challenges? Is Sales involvement different when developing incremental or radical innovation?

42. Please indicate at what stage of the process: idea generation (IG), idea selection (IS), project execution (PE) and commercialization (CO) does your company formalize each system below? "Formalized" is defined as having documented a process and / or periodically and purposefully executing the process.

	Incremental project	**Radical project**
Sales force training program		
Sales force hiring and firing policies		
Sales targets for salespeople		
Sales force compensation system		
Marketing collaboration policies		
Market research projects		
Reports on open sales processes		
Sales process manual		
Customer satisfaction feedback		
Customer Relationship Management (CRM) system		

43. What are the three most important measures that top management uses to evaluate the progress of the sales and marketing effort (for example, sales growth, customer satisfaction) for both incremental and radical innovation?

Ranking	Measure	How often does top management check it (weekly, monthly, quarterly)? Incremental	Radical
1			
2			
3			

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Thesis Conclusions

The aim of this dissertation is to study enablers such as MCS, processes, managerial practices, and organizational structures that can foster innovation. By studying these we also seek to provide evidence of their contribution to value creation.

The main research questions, summaries, and conclusions are:

I. What influences CVC activity?

This study was motivated by limitations from existing research on CVC and the effect that internal and external determinants have on CVC activity in different CVC expansion and contraction periods. This study addresses these limitations and makes the following contributions. The external financial market conditions analyzed in this study reveal that CVC activity is highly volatile as demonstrated by fluctuations in investment activity over the past decades. Moreover, when studying the 1985 - 2008 period, our econometric analysis indicates strong and significant positive associations between CVC activity and our independent variables R&D expenditure and NASDAQ index. There is also an existing negative significant association between CVC and sales growth. Free cash flow proves to have a significant and positive association with CVC activity only for the 1985 – 1993, 2001 – 2004, and 2005 - 2008 periods.

By focusing on the characteristics and conditions in which established firms operate as CVC investors, we complement the work by Dushnitsky and Lenox (2005a) as we also found a significant positive coefficient on R&D influencing CVC activity, suggesting that internal R&D expenditure and external CVC investment are complementary. This supports previous literature on complementarity between internal R&D expenditure and external CVC investment (Cassiman & Veugelers, 2002; Ennen & Richter, 2010; Mitchell & Singh, 1992; Sahaym et al., 2010). In essence, CVC seems to provide large firms with a flexible way to increase or decrease commitments to new technology depending on market and technology uncertainty and attractiveness (McGrath & Nerkar, 2004).

We also found evidence that supports Bruton and Ahlstrom (2003) arguments, suggesting that external financial conditions influence the behavior of CVC managers, which can increase or decrease investments to minimize or maximize the financial and strategic goals. Despite financial market volatility, several large firms seem to maintain their CVC activity as a window on technology (Chesbrough, 2002a).

II. What is the contribution of CVC and its interaction with R&D to value creation?

This article examines the impact of CVC, R&D, and their interaction, on value creation across six business sectors and different regions between 1985 and 2000. Our findings suggest that the effects of CVC and its interaction with R&D on value creation are positive and significant. However, this relationship is contingent upon business sectors and regions.

Some business sectors are more active in their use of CVC than others. CVC variance across business sectors suggests that the value of CVC depends on the sector context and its environment. Sahaym et al. (2010) found that business sectors with greater absorptive capacity developed by prior R&D investment display greater efforts towards pursuing innovations using CVC. These sectors include engineering & business services and ICT.

Regarding profitability value creation (i.e. ROS) CVC presents a significant positive effect on machinery & electronics, and ICT. Hence, we suggest, along with Qualls et al. (1981) and Eisenhardt and Martin (2000), that firms operating in certain business sectors characterized by rapid technological change, are motivated to develop new alternative external sources of innovation that can influence value creation.

In terms of geography, we observe a more potent significant effect of CVC vs. R&D in USA & Canada, while for Asia only CVC proves significant. However in Europe only R&D shows a significant positive effect on value creation.

Regarding the CVC and R&D interaction, when analyzing the whole sample, we noticed that the regression estimates indicate that R&D and CVC are complementary to value creation. When dissecting the sample in different business sectors and regions the results suggest that corporations operating in ICT, machinery & electronics, and engineering & business services, as well as North America and Europe, are better off engaging in R&D and CVC simultaneously. Hence, firms can combine CVC and R&D aiming to increase the probability of generating value creation.

III. How is radical innovation organized and managed?

Davila et al. (2009) developed arguments and new research opportunities on the relevance of MCS to foster innovation. Their view on such research opportunities is contrary to the traditional MCS paradigm, identifying MCS as detrimental to innovation. Our research takes the perspective that management of radical innovation constitutes a dynamic capability which fundamentally represents a firm's ability to exploit and develop resources and processes that create and capture value, while operating in rapidly changing technological environments (Eisenhardt & Martin, 2000; Teece et al., 1997; Zahra et al., 2006). Moreover, our case study at Alcan EP focuses on the development and utilization of management systems and organizational structures as a source of dynamic capabilities to generate radical innovation via internal knowledge exploitation and external knowledge exploration through an open innovation approach. The observed interaction between Alcan EP and EPFL reinforces the complementarity between internal R&D and external partnerships described by Cockburn and Henderson (1998), and Cassiman and Veugelers (2002).

We found that the organizational structure at Alcan EP is dynamic and adjustable depending on the nature of the innovation project as suggested by Chandler (1962) who stated that organizational structures evolve to fit company strategies. Additionally, in line with O'Reilly and Tushman (2011), Chandy and Tellis (1998), and Teece (1986), we observed that in order for Alcan EP to generate radical innovation, an adaptable organizational structure is required to cope with technology and market uncertainties.

The research findings are congruent with innovation management defined as the implementation of management practices, processes, structures, and techniques intended to generate inventions and reach organizational goals (Birkinshaw, Hamel, & Mol, 2008b). Our findings explain the different approaches of the innovation process, in which incremental and radical innovations need be managed through different processes, MCS, and organizational structures in order to optimize resource and outputs. Firms can almost guarantee a sub-optimization of certain systems and resources by processing incremental and radical innovation through a one-size-fits-all process (Davila et al., 2006).

More importantly, we observed that radical innovation can be generated in a systematic way through enablers such as processes, MCS, and organizational structures. Jelinek and Schoonhoven (1993) and Davila et al. (2007; 2006) found that innovative firms have institutionalized mechanisms for innovation, arguing that innovation cannot occur in an organic environment where flexibility and consensus are the main managerial mechanisms. We adhere to the notion that radical innovation requires a clear organizational structure and MCS, ensuring that both discipline and creativity are present when developing radical innovation.

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