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INTERORGANIZATIONAL KNOWLEDGE TRANSFER THROUGH
CORPORATE VENTURE INVESTMENT

By

TAEWAN KIM

A DISSERTATION

Presented to the Faculty of
The Graduate College at the University of Nebraska
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INTERORGANIZATIONAL KNOWLEDGE TRANSFER THROUGH
CORPORATE VENTURE INVESTMENT

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University of Nebraska, 2011

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Today established corporations seeking growth face an increasing need to pursue innovation. Historically, the innovation literature has focused on the role of internal R&D and related diversification for firm innovation. However, internal R&D plays only a partial role in firm innovation when the firm attempts to create an entirely new market.

In order to acquire the knowledge necessary to generate innovation, firms have increasingly chosen more radical transformation paths recently. Particularly in the information and communication technology sector, large firms have set up Corporate Venture Capital (CVC) to bring external ideas and technologies outside their existing business areas into their innovation arena.

A single research question motivated this dissertation: How does corporate venture capital investment by a parent firm affect knowledge transfer from the start-up? In answering this question I employed two theoretical foundations. First, drawing on the concept of distant search, I argue that search for external knowledge through CVC investment provides a parent firm with an

opportunity to source external knowledge from the start-up. Second, building upon literature on knowledge transfer, I suggest that types of CVC structure facilitate external knowledge transferred from the start-up to a parent firm. Finally, I posit that knowledge attribute of the parent firm improves the parent firm's ability to source external knowledge from the start-up. Three hypotheses are developed to test these relationships.

Longitudinal data on a panel of 29 large firms in the information communication technology industry covering the period from 1995 to 2005 are used to test these hypotheses. Patent citation is used to measure the level of knowledge transferred from an entrepreneurial firm to a parent firm. Taken together, statistical results of this research provide evidence that the number of CVC investments has an inverted U-shaped relationship with the level of knowledge transferred from the start-up. Both the CVC structure and technological diversity of the parent firm have moderating effects on the relationship between the number of CVC investments and the level of knowledge transferred from the start-up.

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TABLE OF CONTENTS

CHAPTER 1 INTRODUCTION.....	1
1.1 INTRODUCTION.....	1
1.2 CONCEPTUAL OVERVIEW.....	4
1.2.1 Theoretical perspectives.....	4
1.2.2 Motivation.....	5
1.3 RESEARCH DESIGN.....	8
1.4 STRUCTURE OF THE DISSERTATION.....	9
CHAPTER 2 LITERATURE REVIEW.....	12
2.1 ORGANIZATIONAL KNOWLEDGE	12
2.1.1 Positivist perspectives on organizational knowledge.....	13
2.1.2 Constructivist perspectives on organizational knowledge.....	14
2.1.3 Sourcing and transfer of external knowledge.....	15
2.2 CORPORATE VENTURE CAPITAL.....	16
2.2.1 Definition of corporate venture capital.....	16
2.2.2 Trend of corporate venture capital.....	18
2.2.3 Objectives of corporate venture capital.....	21
2.2.4 Structures of corporate venture capital.....	23
2.2.5 Corporate venture capital and performance.....	26
2.3 SUMMARY OF LITERATURE REVIEW.....	27

CHAPTER 3 LITERATURE ON THEORETICAL FOUNDATION.....	29
3.1 ORGANIZATIONAL KNOWELDGE SEARCH.....	29
3.1.1 Definition and general characteristics.....	29
3.1.2 Local search.....	32
3.1.3 Distant search.....	34
3.2 ORGANIZATIONAL KNOWELDGE TRANSFER.....	37
3.2.1 Definition and characteristics of knowledge transfer.....	37
3.2.2 Antecedents of organizational knowledge transfer.....	38
3.2.2.1 Knowledge characteristics.....	38
3.2.2.2 Organizational characteristics.....	40
3.2.2.3 Network characteristics.....	41
3.3 SUMMARY OF LITERATURE ON THEORETICAL FOUNDATION...	43
CHPATER 4 HYPOTHESES DEVELOPMENT.....	44
4.1 HYPOTHESIS 1.....	45
4.2 HYPOTHESIS 2.....	48
4.3 HYPOTHESIS 3.....	49
4.4 SUMMARY OF HYPOTHESES DEVELOPMEMNT.....	51
CHAPTER 5 METHODS AND MEASUREMENTS.....	52
5.1 SAMPLE AND DATA COLLECTION.....	52
5.2 VARIABLE DEFINITIONS AND MEASUREMENTS.....	54
5.2.1 Patent data.....	54

5.2.2 Dependent variable.....	55
5.2.3 Independent variables.....	56
5.2.3.1 The number of corporate venture capital investments.....	56
5.2.3.2 Structure of corporate venture capital.....	57
5.2.3.3 Technological diversity.....	57
5.2.4 Control variables.....	58
5.3 MODEL SPECIFICATION AND ESTIMATION.....	61
5.4 SUMMARY OF METHODS AND MEASUREMENTS.....	62
CHAPTER 6 RESULTS.....	63
6.1 DESCRIPTIVE STATISTICS.....	63
6.2 REGRESSION MODELS.....	66
6.2.1 Direct effects.....	67
6.2.2 Moderation effects.....	70
6.3 DISSCUSSION.....	72
6.4 SUMMARY OF RESULTS.....	74
CHAPTER 7 CONCLUSION.....	75
7.1 SUMMARY OF THE RESEARCH.....	75
7.2 CONTRIBUTION OF THE RESEARCH.....	77
7.2.1 Theoretical contribution.....	77
7.2.2 Managerial contribution.....	78
7.3 LIMITATIONS AND FUTHRE RESEARCH.....	79

REFERENCES.....81

LIST OF TABLES

TABLE 2.1 The industry sector distribution of CVC investments in 2009.....	21
TABLE 5.1 Model variables and measurements.....	60
TABLE 6.1 Correlations and descriptive statistics.....	68
TABLE 6.2 Poisson regression models.....	69

LIST OF FIGURES

FIGURES 1.1 Structure of the study.....	11
FIGURES 2.1 Terminology in CVC investment.....	18
FIGURES 2.2 Investment trends of CVC.....	20
FIGURES 2.3 Types of CVC Structure.....	25
FIGURES 4.1 A research model.....	45
FIGURES 6.1 Interaction effect of CVC structure.....	71
FIGURES 6.2 Interaction effect of technological diversity.....	72

CHAPTER 1

INTRODUCTION

1.1 INTRODUCTION

Established corporations seeking growth face an increasing need to innovate. In industries such as personal computers, multimedia, or telecommunications a constant stream of new technologies, together with changing regulatory environments, globalized markets, and fierce competition produces a competitive environment that is characterized by constant often dramatic change (Eisenhardt, 1989). Firms are faced with a transformation of existing markets and the emergence of completely new business opportunities. In this environment, innovation is the key to successful strategies.

Historically, the innovation literature has focused on the role of internal R&D (Griliches, 1979) and related diversification on firm innovation. For instance, they can develop new products for the markets they already compete in. Or they can try to capture new markets for their existing business and technologies. For the most of the twentieth century, companies pursuing closed innovation strategies performed well.

However, this traditional approach plays only a partial role in firm innovation and is eroding due to a number of factors (Chesbrough, 2003). One factor was the increased availability of highly experienced and skilled people. The supply of well-trained, educated people expanded tremendously during the

postwar period. The growth of this population indicated a large increase in the “raw material” able to create useful knowledge. A related erosion factor was growing mobility of these highly trained and educated people, spreading the knowledge that they possessed from internal R&D organizations to suppliers, customers, partners, universities, start-ups, consultants, and other third parties (Reference). With information more available and widespread, new firms could access useful knowledge that previously they could not.

Recently, Corporate Venture Capital (CVC) investment has gained attention as an instrument for incumbent firms to learn about new technologies and markets. CVC is equity investment by incumbent firms in independent entrepreneurial ventures that are generally not-publicly-traded and are seeking capital to continue operations (Gompers and Lerner, 1998). Typically, CVC makes a financial investment- just as independent venture capital does and receives a minority equity stake in the entrepreneurial company. CVC may also facilitate investment of in-kind and other resources into the portfolio company. As a result, the corporation gains a window on both new technologies and strategically complementary companies that may become strategic partners.

However, the link between such CVC investments and innovation outcomes has not been studied in detail. I want to investigate the conditions under which CVC investments affect knowledge transfer between corporate investors and start-ups. This study builds on two theoretical pillars. First, the knowledge necessary to generate innovations may likely reside outside the boundary of incumbent firms (Cohen and Levinthal, 1990). Second,

entrepreneurial startups may be a valuable source of such knowledge (Agfthon and Tirole, 1994; Kortum and Lerner, 2000; Shane, 2001).

Simply put, a single research question motivated this dissertation: How does CVC search the answer to this question, two theoretical foundations are employed. First, drawing on the concept of distant search, I argue that search for external knowledge through CVC investment provides a parent firm with an opportunity to source external knowledge from the start-up. Second, building upon literature on knowledge transfer, I suggest that types of CVC structure facilitate external knowledge transferred from the start-up to a parent firm. Finally, I posit that the knowledge attribute of the parent firm improves its ability to source external knowledge from the start-up.

Longitudinal data on a panel of 29 large firms in the Information Communication Technology (ICT) industry covering the period from 1995 to 2005 are used to test these predictions. Patent citation is used to measure the level of knowledge transferred from an entrepreneurial firm to a parent firm. Taken together, statistical results of this research should provide evidence that the number of CVC investments has an inverted U-shaped relationship with the level of knowledge transferred from the start-up. Both CVC structure and technological diversity of the parent firm have moderating effects on the relationship between the number of CVC investments and level of knowledge transferred from the start-ups.

1.2 CONCEPTUAL OVERVIEW

1.2.1 Theoretical perspectives

This research is based on two theoretical foundations. First, I draw heavily on insights from the innovation (or organizational) search literature. Search is defined as the attempts on the part of an actor to discover a solution to a problem. In this perspective, innovation refers to a problem-solving process where problems are recognized and then solved out through search activities (Dosi, 1988).

Of particular import to this research is the concept of distant search. Although many of scholars suggest the prevalence of local search with empirical evidence and theoretical argument, some studies argue that the development of new knowledge requires distant search where actors investigate and integrate unrelated and diverse knowledge domains (Grant, 1996; March, 1991). Additionally, other scholars suggest that such distant search can lead a firm to achieving more novel or “radical” knowledge-related outcomes than those that result from local search processes (Ahuja and Lmapert, 2001; Levinthal and March, 1981; Mezias and Glynn, 1993; Schumpeter, 1934). More importantly, distant search provides a firm with more opportunities to acquire such novel and external knowledge by providing firms access to a variety of knowledge domains (Levinthal and March, 1981; March, 1991; Mezias and Glynn, 1993).

Second, I build upon literature of knowledge transfer to understand how different mechanisms may facilitate external knowledge transferred from entrepreneurial ventures to a parent firm. Using the concept of social capital in the sociological literature, I examine how CVC structure may moderate the quadratic relationship between the number of CVC investments and the level of external knowledge transferred from entrepreneurial ventures. Social capital refers to the instrumentally valuable resources that exist in a network of social relationships (Coleman, 1988; Porters and Sensebrenner, 1993). Specifically, I draw on one dimension of social capital, relational capital, in relating CVC investments with knowledge transfer from the start-up.

Additionally, I also draw on literature of knowledge transfer to examine how knowledge diversity may lead the parent firm to facilitate knowledge transfer from the start-up. Using the concept of knowledge diversity (Van Wijk et al., 2001), I investigate the effect of knowledge diversity on the inverted U-shaped relationship between the number of CVC investment and the extent of knowledge transfer from the start-up.

1.2.2 Motivation

The study of the determinants of inter-organizational knowledge transfer through CVC investment is motivated by importance of organizational knowledge. In the field of strategic management, organizational knowledge has become a basis of competitive advantage of firms (Spender and Grant, 1996).

Traditional explanations of competitive advantage have relied largely on the positioning of organizations in an industry (Porter, 1980) or the development of firm assets through competitive interaction with competitors (Dixit, 1980; Shapiro, 1989). While this traditional approach shows that industry effects may be present (MaGahan and Porter, 1997), empirical research indicates that differences between firms may account for more variances in organizational performance than differences between industries (Rumelt, 1991). In other words, variances of firm performance are now attributed to differences in organizations over industry differences.

Although empirical research suggests firm resources as a basis of competitive advantage, theoretical arguments have been useful to identify the types of resources for competitive advantage. Based on Penrose's (1959) insight, Barney (1991) and Wernerfelt (1984) develop the resource based view (RBV) of the firm that internal knowledge, embodied within a firm's resources is an important source of competitive advantage. Barney (1991) notes that two assumptions are elemental to RBV: (1) resources are distributed heterogeneously across firms, and (2) these productive resources cannot be transferred from firms without cost. Given above described assumptions, Barney (1991) makes two fundamental arguments. First, resources that are both rare and valuable can produce competitive advantage. Second, when such resources are also simultaneously not imitable, substitutable, and transferable, those resources may produce a sustained competitive advantage.

Because of the emphasis on firm resources that are difficult to be copied by competitors, organizational knowledge becomes a principal source of competitive advantage (Spender and Grant, 1996; Teece, Pisano, and Shuen, 1997). The firm is often the source of much of knowledge used in innovation. However, few firms possess all the organizational knowledge required for successful and continuous innovation that leads a firm to sustain competitive advantage. Moreover, very few firms can independently develop a variety of knowledge and skills needed to compete in ever-changing environments (D'Aveni, 1994; Lane et al., 1998). As a result, most firms will develop a deficit within their boundaries regarding the critical knowledge required to prosper and grow (Coase, 1937; Dussauge et al., 1998). Although a firm's own research efforts play an important role in innovation, firms must search and source external knowledge to successfully maintain their innovative processes and competitive advantage.

Traditional mechanisms of sourcing external knowledge include strategic alliances, joint ventures, licensing agreements, and mergers and acquisitions. Recently, companies have become increasingly aware of other options such as CVC investments (Dushnitsky and Lenox, 2005). However, little is known about which factors facilitates external knowledge transfer from start-ups through CVC investment. Thus, this dissertation adds to the existing literature about inter-organizational knowledge transfer through CVC investment.

1.3 RESEARCH DESIGN

In this dissertation, hypotheses are tested using a longitudinal panel data set of 29 firms in the ICT Industry. The longitudinal design includes annual snapshots of CVC investment activities for the period from 1995 to 2005 and patent citing activity for the period 1995 to 2009, reflecting five year lag between CVC investment and knowledge transfer.

This dissertation focuses on the ICT industry, which has gone through restructuring because of intensive competition, and dramatic change in technology (Olley and Pakes, 1996). Rapid technological change in ICT industry and its convergence with other industries have resulted in some important trends. First, technological convergence has made the innovation process and nature of R&D in this industry much more systemic, and this has increased product complexity at the firm level (Pisano, Russo, and Teece, 1988). Second, the convergence with other industries has forced companies to participate in the demand as well as the supply side of CVC investments to keep abreast of changes, and to track and access external technologies. Finally, companies in this industry routinely and systematically patent their inventions to protect their intellectual property (Levin et al., 1987). Since this research uses patent data to measure various constructs, firms in this industry can provide an excellent context for this research.

Using Poisson regression modeling, I test three hypotheses regarding the impact of CVC investments on the level of knowledge transferred from the start-up and moderating effects of CVC structure and technological diversification on

the quadratic relationship between CVC investment and the extent of knowledge transfer.

1.4 STRUCTURE OF THE DISSERTATION

This dissertation consists of 7 chapters. The first chapter has presented the introduction, conceptual overview and research design. In the introduction part, I described the research question that motivated this dissertation. The conceptual overview presented two theoretical foundations which include knowledge search and transfer. This chapter has also described why search for external knowledge and transfer of organizational knowledge have become a basis for competitive advantage.

Chapter 2 examines relevant core concepts and literature that provide research foundations. A thorough review of research stream on organizational knowledge and CVC investment is presented.

Chapter 3 reviews literature on theoretical foundations for this dissertation. First, this chapter examines literature on knowledge search. Second, work on knowledge transfer is reviewed.

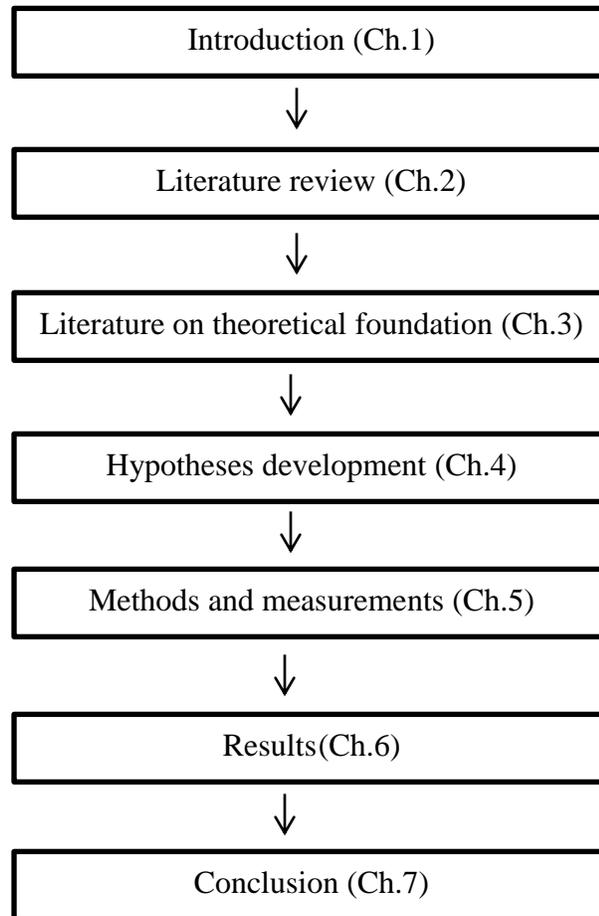
Chapter 4 presents hypotheses development to establish the causal relationship among CVC investment, CVC structure, technological diversity, and the level of knowledge transfer from the start-up. Building on literature of knowledge search and transfer, I develop three hypotheses regarding the impact

of CVC investments on the level of knowledge transfer from entrepreneurial firms and interaction effects of the CVC structure and technological diversity.

Chapter 5 describes essential methodological issues of variable definition and operationalization, model specification, and statistical models employed. This chapter also introduces and describes the empirical context of the study as well as the data sources.

Chapter 6 presents data analysis methods and empirical results. The results of direct effects and moderating effects are also presented. Chapter 7 summarizes results of the study and describes the theoretical and practical contributions of this dissertation. This chapter also shows research limitations, followed by possible directions for future research. The structure of the study is illustrated in Figure 1.1.

Figure 1.1 Structure of the study



Chapter 2

LITERATURE REVIEW

In this chapter, the relevant core concepts and literature that provide the empirical foundations for this dissertation is reviewed. This study builds upon and is motivated by two empirical streams of literature: organizational knowledge and CVC investment. First, I introduce the concept of organizational knowledge with diverse perspectives. Second, I examine literature on CVC investments which firms use as one of options to access external and novel technology.

2.1 ORGANIZATIONAL KNOWLEDGE

Organizational knowledge is an established theoretical construct and is examined by many scholars in the field of strategic management. Several authors suggest that the heterogeneous knowledge base and capabilities among firms are key sources of sustained competitive advantage and superior corporate performance (Ghoshal and Moran, 1996; Grant, 1996; Kogut and Zander, 1992). This argument is rooted in the resource-based view of the firm (Barney, 1991; Penrose, 1959).

Despite the intensive focus on organizational knowledge as a source of competitive advantage, however, it seems that there is a lack of conceptual clarity on the definition of organizational knowledge. Different philosophical

views and conceptual paradigms offer different perspectives about what knowledge is and how it can be utilized.

In this section, a review of diverse perspectives on organizational knowledge and assumptions that support them is presented. First, I introduce positivist perspectives on organizational knowledge. Then, constructivist views on organizational knowledge are examined. Finally, I review literature on governance modes to source external knowledge for competitive advantage and innovation.

2.1.1 Positivist perspectives on organizational knowledge

The field of organization and management has a long tradition of ‘epistemology,’ which is to examine theories of knowledge and ways of knowing, particularly in the context of the limits or validity of knowledge. In this view, knowledge is considered as ‘justified true belief,’ a concept developed by Plato. The focus of theories is on the explicit nature of knowledge (Nonaka and Takeuchi, 1995). In other words, knowledge is defined as an unambiguous, reducible and easily transferable construct, while knowing is associated with processing information (Eisenhardt and Santos, 2000). This positivist view is regarded as the predominant one in Western culture and a generally accepted assumption in organizational theory (Nonaka and Takeuchi, 1995).

This traditional approach to knowledge has developed several theories that suggest a machine-like functioning of organizations. Traditional microeconomic theory views knowledge as a quasi-public good. In this

perspective, knowledge is characterized by high level of indivisibility and non-excludability (Davis et al., 2005). Only the result of scientific research and general methodological procedures can generate knowledge. Moreover, knowledge transfer is largely easy and is thought of as a spontaneous aspect of the economic system (Davis et al., 2005). Scientific management theory also argues that the organization of work should be entirely controlled by codified knowledge, and that the knowledge of the firm is held by a few number of decision makers. Similarly, the information processing perspective describe organizations as machines that employ rules and routines to address the individual information processing requirements caused by interdependent work and environmental uncertainty (Santos, 1999).

2.1.2 Constructivist perspectives on organizational knowledge

In contrast with these traditional views on organizational knowledge, more constructivist perspectives posit that knowledge cannot be conceived independently from action. Constructivist perspectives are based on Polanyi's (1967) influential work which argues that knowledge is explicit and tacit. Tacit knowledge is defined as personal, context-specific, and is hard to formalize and communicate (Polanyi, 1967). It is possible to learn this type of knowledge only through observation and doing. Explicit knowledge refers to knowledge that is transmittable in formal, systematic language.

An alternative view has been championed by Nonaka (1991; 1994), among others. Nonaka explains processes of how firms create tacit knowledge

and transform knowledge from tacit to more explicit forms. These processes include socialization, externalization, combination, and internalization. This view also involves the creation of new knowledge by reconstructing existing perspectives, frameworks, or premise on an ongoing basis. Furthermore, Nonaka (1994) describes a model of knowledge expansion arising from the dynamic interaction between tacit and explicit knowledge by firm through four modes of knowledge conversion describe above.

2.1.3. Sourcing and transfer of external knowledge

The distinction between explicit and tacit knowledge has proven to be particularly important in the dominant knowledge-based approach to strategy (Kogut and Zander, 1992; Grant 1996). It also identifies tacit knowledge as the most strategic resource of firms. It also identifies tacit knowledge as the most strategic resource of firms. The argument is that, since tacit knowledge is difficult to imitate and relatively immobile, it can become the basis of sustainable competitive advantage (Grant, 1996; Gupta and Govindarajan, 2000).

However, recognizing the importance of external knowledge does not necessarily allow a firm to access and transfer it. It also does not explain which certain organizations access external knowledge more efficiently than others. To facilitate knowledge transfer across firm boundaries, organizations must create linkages to outside sources of knowledge that are used as a channel for knowledge transfer (Almedia, 1996; Dyer and Nobeoka, 2000; Gulati et al., 2000).

Prior research suggests that firms use a number of mechanisms that allow them to create conduits to external sources of useful knowledge. These mechanisms include strategic alliances, joint ventures, licensing agreements, and mergers and acquisitions. Besides traditional mechanisms, the hiring of scientist and engineers (Almedia and Kogut 1999; Zucker, 1998), and the appropriation of informal networks (Liebeskind et al., 1996; Rosenkopf and Tushman 1998) has been used extensively. Recently, companies have paid attention to other options such as CVC investment (Dushnitsky and Lenox, 2005). In the following subsection, works on CVC investment are reviewed.

2.2 CORPORATE VENTURE CAPITAL

In the previous section, different approaches on the concept of organizational knowledge were reviewed. In the following subsections, I examine a major stream of literature on corporate venture capital investment which many corporations utilize as another approach to access external and innovative knowledge.

2.2.1 Definition of corporate venture capital investment

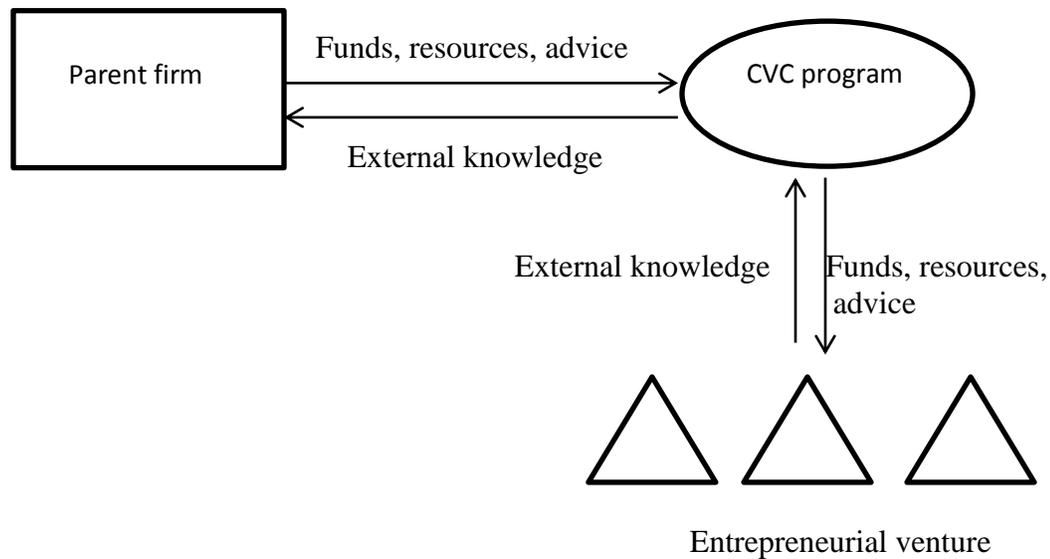
CVC investment is defined as an established industry incumbent's participation in the private equity market by providing start-ups with funding in return for a minority equity stake in these entrepreneurial firms (Gompers and Lerner, 2001). There are three factors which are common to all CVC investment (Dushnitsky, 2008). First, although financial returns are a critical consideration,

many CVC investments have strategic objectives as a major goal. Second, the funded start-ups are privately held and are independent from the parent firm. Third, the parent firm receives a minority equity stake in the venture.

The practice of corporate venture capital should be distinguished from other corporate activities that are intended to increase firm innovation. The definition of corporate venture capital does not include: (1) non-equity-based inter-organizational relationships; (2) other equity-based forms of inter-organizational relationships; and (3) spin-outs. Moreover, investments by financial corporations intending to diversify their financial portfolio, as well as investments by independent VC funds, are not considered as CVC activities.

Despite much attention on CVC investment in last decades, there is a lack of clarity on major terms to describe participants in CVC activities. To avoid confusion, I employ the terminology for CVC investment introduced by Dushnitsky (2008). Figure 2.1 describes main participants in CVC activities. These main actors include a parent firm that launches a CVC program, which in turn makes investment in entrepreneurial ventures.

Figure 2.1 Terminology in CVC investment



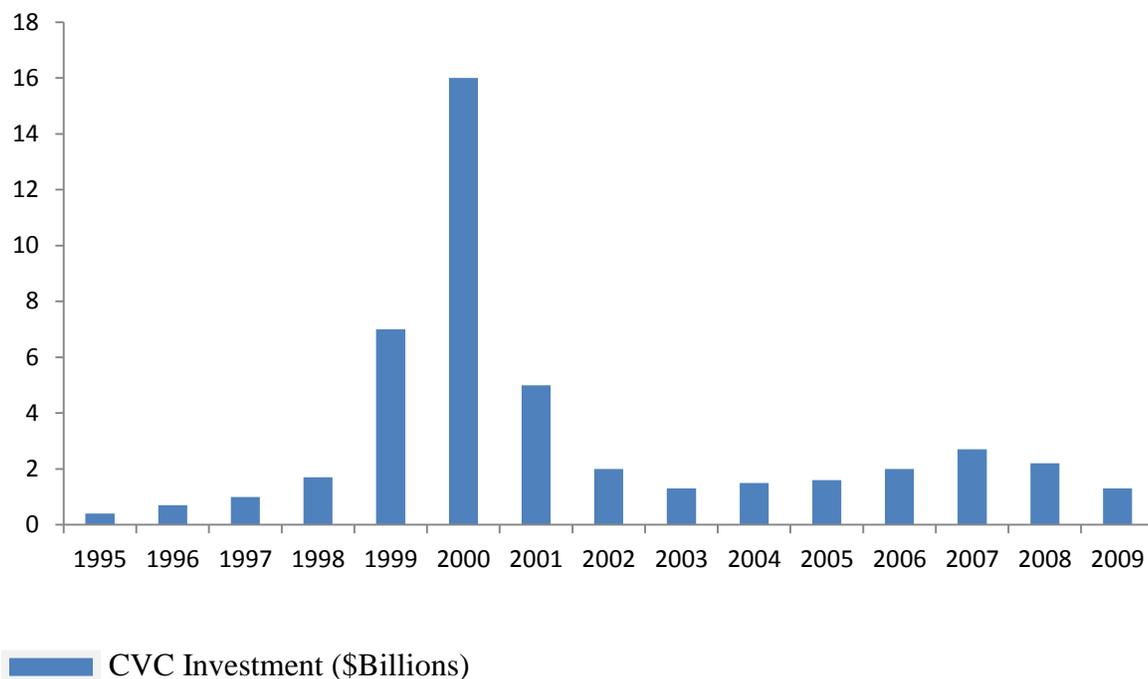
2.2.2 Trend of corporate venture capital

The history of CVC indicates three different ‘waves’ of CVC activity (Gompers and Lerner, 1998). First, in the late 1960s, firms participated in CVC to access “window on technology.” In the late 1960s and early 1970s, more than 25% of the Fortune 500 firms were engaged in CVC activities (Gompers and Lerner, 1998). The second wave took place in 1980s. Because of changes in legislation, significant growth in technology oriented opportunities, and favorable market encouraged CVC activities. Many firms used CVC as a diversification tool. Especially, many leading firms in the chemical, pharmaceutical, and ICT industries initiated CVC programs for that purpose. However, the stock market crash of 1987 led to a sharp decline in CVC investments.

The third wave in CVC took place during the 1990s. During the latter half of the 1990s, a large number of CVC investments emerged again. Figure 2.2 describes the overall CVC investment from 1995 to 2009. In this period, the “internet bubble” of 1999-2001 stands out as the latest and most extreme example of boom-and-bust cycles that have characterized CVC investment over the past several decades. In 2000, the number of CVC programs soared to more than 400, investing close to \$16 billion in entrepreneurship ventures (Venture Economics, 2001). However, after the peak in 2000, the economic crisis has resulted in a sharp decline in the number of CVC activities. In recent years, the total venture capital investment stabilized and remains well above historical levels.

The historical overview indicates a key reason for this renewed interest in CVC investment. The motivation for CVC activities in later waves has been to explore, identify, and invest in new technologies and business models (Mishra and Gobeli, 2000). Corporations have also seen highly entrepreneurial and innovative ventures as one of major sources for external knowledge. Hamel (1999) describes this process of exploring new idea and new enterprise formation within a parent firm as “bringing Silicon Valley inside.” CVC is currently pursued mainly by a parent firm in turbulent industries potentially as a response to Schumpeterian competition.

Figure 2.2 Investment trends of CVC



Source: National Venture Capital Association (2009)

Table 2.1 presents the industry sector distribution of venture capital and CVC investments in 2009. The top sectors for venture capital investment were biotechnology, software, and industrial/energy. For CVC investment in 2009, the top sectors were biotechnology, software, industrial/energy, telecommunications, semiconductors, and media/entertainment. Consistent with the historical review, firms in turbulent industry such as biotechnology and ICT are more likely to pursue CVC activities than ones in a stable industry.

Table 2.1 The industry sector distribution of CVC investment in 2009

Industry sector	% of CVC Investment \$	% of All US VC \$
Biotechnology	30.6%	20.1%
Software	14.3%	17.5%
Industrial/Energy	11.7%	13.1%
Medical devices and Equipment	8.1%	14.1%
Media and Entertainment	6.4%	6.6%
Semiconductors	5.0%	4.3%
Financial Services	5.0%	2.0%
IT Services	4.2%	6.1%
Networking and Equipment	4.2%	4.0%
Telecommunications	4.0%	3.1%
Computers and Peripherals	2.3%	1.9%
Electronics/Instrumentation	2.0%	1.7%
Business Product and Services	1.5%	1.4%
Retailing/Distribution	0.3%	1.0%
Consumer Products and Services	0.2%	2.1%
Healthcare Services	0.1%	0.6%
Other	0.0%	0.2%
Total	100%	100%

Source: National Venture Capital Association (2009)

2.2.3 Objectives of corporate venture capital

In the research on corporate venture capital, one of the most active topics has been objectives of corporations that invest in corporate venture capital.

Some previous studies have compared the relative importance of the various objectives that corporations have for their corporate venture capital operations

(Kann, 2000; Keil, 2000; McNally, 1997; Siegel et al., 1988; Silver, 1993; Sykes, 1990). The literature suggests that some firms pursue CVC to secure financial gains, while others seek strategic benefits. Yet, others pursue both (Block and MacMillan, 1993; Chesbrough, 2002).

Several studies examine financial goals of CVC which is to gain a financial return from the investment (Kann, 2000; Keil, 2000; McNally, 1997; Siegel et al., 1988; Silver, 1993; Sykes, 1990). For instance, Siegel et al. (1998) found that the return on investment is the most important objective, followed by exposure to new technology and markets. By investigating the objectives of corporate venture capitalists in the United Kingdom, McNally (1997) found that 36 percent of firms in his sample cited financial gain as the most important reason for their investment activity.

Some firms may make CVC investments exclusively for strategic benefits, without consideration of financial returns. Learning and monitoring of new markets and technology are generally recognized as the primary objective of this investment approach (Dushnitsky and Lenox, 2005; Wadhwa and Kotha, 2006) particularly in technology- intensive industries. In other words, firms focus on learning about new technologies and bringing new ideas into the parent company may choose to invest without regard to financial returns through CVC investment.

By using an archival research of 152 CVC programs, Kann (2000) distinguishes three classes of strategic objectives for corporations; external

R&D, accelerated market entry, and demand enhancement. Among three major strategic objectives, external R&D is the most 'aggressive' goal which is defined as the intent of corporations to enhance their internal R&D by acquiring resources and intellectual property from ventures. Accelerated market entry refers to firms which try to access and develop resources and competences needed to enter a new market. Enhancing demand refers to corporations which leverage their strong resources base and stimulate new demand for their technologies and products by sponsoring companies that use and apply those technologies and products.

Keil (2000; 2002) also identified four primary strategic objectives; monitoring of markets, learning of markets and new technologies, option building, market enactment. Monitoring of markets refers to a warning system for collecting weak signals on the future developments of markets. Learning about new markets and technologies refers to learning from the relationships in the venture. Options to expand refer to placing bets to be ready if certain markets prove important and valuable. Market enactment refers to a more proactive approach where CVC investment is used to shape markets to set standards and stimulate demand.

2.2.4 Structure of corporate venture capital

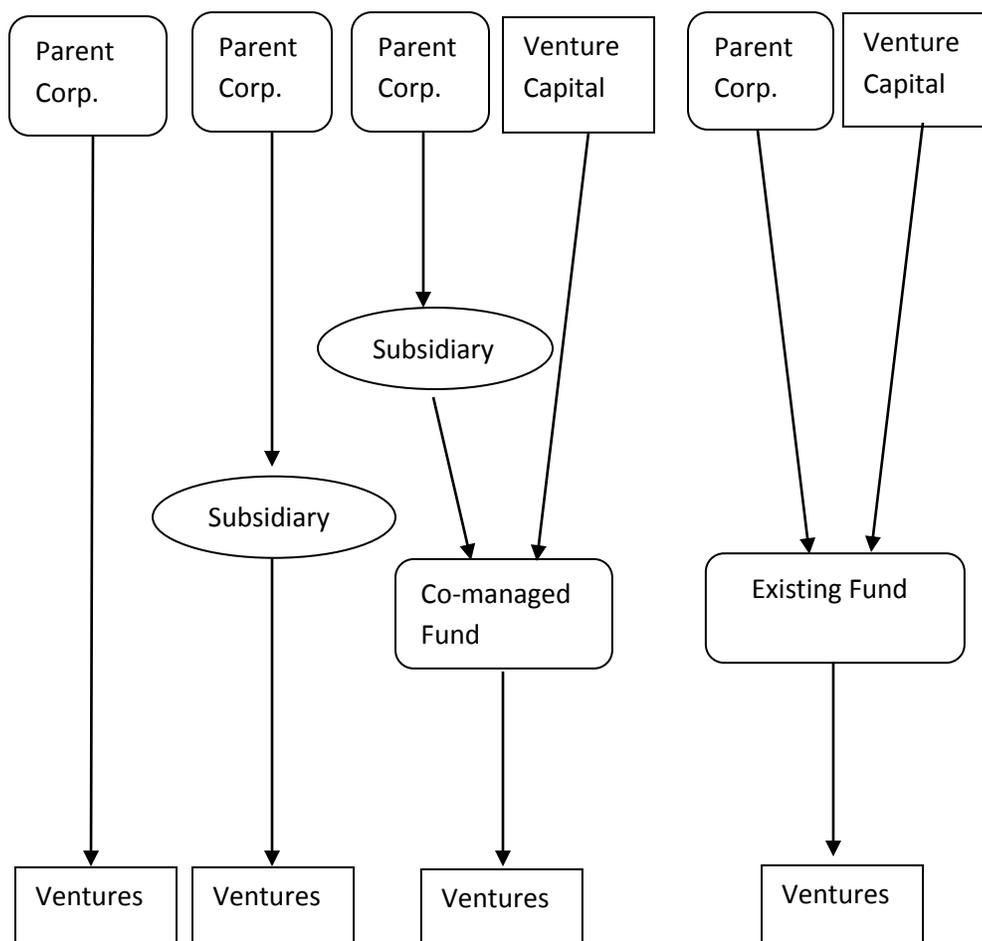
CVC can be organized through several structures that differ according to the degree of involvement of the corporation (Keil, 2002). Dushnitsky (2008)

found that generally, there are four types of structures of CVC. These range from tight structures to loose ones. First, some firms invest in ventures directly. This type of CVC structure is the most strongly tied to a parent firm, called a 'Direct Investment' structure. In such a case, company sets up programs where current operating business units are responsible for CVC activities. Second, a program is organized as 'Wholly-Owned Subsidiary.' This program has a separate organizational structure which is set up for the ultimate purpose of achieving corporate venture capital. Third, 'Dedicated Funds' is a structure where the firm and independent VC fund manage the investment activities together. Last, some firms invest in the start-ups indirectly by joining existing VC funds as limited partners. This structure is labeled as CVC as Limited Partners which is the most weakly tied to a parent firm. The classification of CVC structure is depicted in Figure 2.3.

Kann (2000) reported the vast majority of strategically-driven CVC programs are managed by their parent firms. She classified CVC governance modes into three types: 'CVC as LP', 'Dedicated Fund' and a third category of corporate-managed-programs which include both 'Direct Investment' and 'Wholly-owned Subsidiary.' Seventy-eight percent of the programs belonged to the last category, whereas each of the first two accounts for 11 percent. Further analysis shows that there is a significant correlation between CVC structure and objectives. The research suggests that firms seeking to support complementary ventures are more likely to pursue 'CVC as LP'. In contrast, firms that aim to

develop internal R&D capabilities by sourcing new technology are more likely to use 'Direct Investment' and 'Wholly-owned Subsidiary.'

Figure 2.3 Types of CVC structure



Direct Investment Wholly-Owned subsidiary Dedicated Fund CVC as LP

2.2.5 Corporate venture capital and innovation

The performance of CVC has gained attention as topics in research area of CVC during last several years (Chesbrough and Tucci, 2004; Dushnitsky and Lenox , 2006; Dushnitsky and Lenox, 2005a; Keil et al., 2003; Schildt et al., 2004). In contrast to earlier dominant perception of corporate venture capital resulting in poor financial performance, most of recent research focus on the effect on firm innovation rates, implicitly centering on the role of CVC as a mechanism to explore new technology.

By examining a large panel of public firms during the time period 1975 to 1995, Dushnitsky and Lenox (2005b) found that the number of CVC investment is positively related to subsequent increases in firm patenting. This result is consistent with the fact that parent firms currently use CVC as a window on new technologies. Moreover, they also found that CVC investments are more effective in weak intellectual property regime and when firms have a high level of absorptive capacity. Using a panel of US public firms during the period 1990 to 1999, Dushnitsky and Lenox (2006) also analyzed the effect of CVC investments on the value creation of parent firms. By investigating the impact of CVC on Tobin's q , they found evidence that CVC investments create greater firm value when parent firms pursue strategy oriented CVC rather than other goals.

Chesbrough and Tucci (2004) investigated the research activities by 270 US and foreign CVC investing firms, during the 1980 to 2000 period. They compared the level of corporate R&D expenses prior to the onset of the CVC

program to the one after employing the CVC program. Statistical results show that the existence of a CVC program is significantly related to increase in corporate R&D expense, even after controlling for both firm and industry factors. Based on these results, they argue that CVC provides parent firms with strategic value and may supplement other R&D efforts.

Using a large panel of US corporations in the information and telecommunication industry, Schildt et al. (2005) investigated the venturing activities. The authors examine which models of venturing activity such as CVC, strategic alliances, joint ventures, and acquisitions allow a parent firm to achieve either exploitative or explorative learning. They define explorative learning as parent firm patents citing portfolio companies, and exploitative learning as patents citing both parent firms' prior patents. The results of this study indicate that CVC is positively associated with explorative learning.

Keil et al. (2003) also investigated the impact of difference in governance models for venturing activity and venture relatedness on firm innovation. By using a large panel of companies in the information and technology industry from 1990 to 2000, authors found that CVC investment is positively related to patenting and that the relatedness between parent firms and venture firms moderates the impact of CVC investment on firm innovation.

2.3 SUMMARY OF LITERATURE REVIEW

This chapter has provided an overview of prior research on organizational knowledge and CVC investments. First, different perspectives on organizational

knowledge were reviewed to streamline the concepts of organizational knowledge and their fundamental assumptions that support unique views. While positivist perspectives focus on explicit knowledge to deal with elements of perception, skills, experience and history, constructivist perspectives underscore dynamic aspects of knowledge. Thus, when a static approach on organizational knowledge is replaced by dynamic one, scholars argue that research agenda should shift from managing knowledge assets to examining the knowledge process, such as creation, retention, and transfer (Argote and Ingram, 2000; Nonaka and Takeuchi, 1995; Pisano, 1994; Szulanski, 1996).

Second, this chapter has provided an overview of literature on CVC investments. While CVC has been highly cyclical with mixed success in companies, CVC investments remain an important mechanism in the corporate venturing activity. Established firms pursue CVC investments for various reasons. Some firms have participated in them to seek for financial returns. However, many other corporations have engaged in CVC investments for more strategic reasons.

CHAPTER 3

LITERATURE ON THEORETICAL FOUNDATION

In this chapter, the literature that provides the theoretical foundation for this dissertation is discussed. This study combines the concept of knowledge search and organizational knowledge transfer. First, I examine work on search for external knowledge. Second, I discuss the literature on factors to facilitate transfer of external knowledge.

3.1 ORGANIZATIONAL KNOWLEDGE SEARCH

In this section, the literature on innovation search is reviewed to provide theoretical insight into the relationship between knowledge search through CVC investment and the level of knowledge transfer from the start-up. I begin by defining the concept of search and discussing its general characteristics. I then discuss in more detail two types of search and review research on each related to knowledge transfer.

3.1.1 Definition and general characteristics of search

The behavioral theory of the firm, introduced by Cyert and March (1963) has fundamental assumptions. First, firms have some degree of control over their market environment. Second, they adapt to their habitat through learning process. Learning occurs after feedback loops bring new market knowledge to the firm, which deals with particular problems of corporations. Firms respond to

such problems through what is called “search” behavior, by which they seek for new or alternative ways of doing things (Huygens et al., 2001).

Search is defined as “an act of scrutiny, inquiry or examination in an attempt to find something, gain knowledge, etc” (Merriam-Webster, 1994). Simon (1978) stated, “problems of search arise when not all the alternatives of action are presented to the actor *ab initio* [emphasis in original], but must be sought through some kind of costly activity.” In the context of innovation studies, search is defined as the effort on the part of some actors to find an answer to a problem. In this way, innovation is described as problem-solving process in which solutions to problems are discovered through search and then problems are dissolved (Dosi, 1988).

This definition captures key characteristics of search. First, search is a costly activity (Cyert and March, 1963), especially when aimed to discover highly novel solutions (Levinthal and March, 1981). However, search costs may decrease with experience as actors develop more efficient search competences and routines (Levinthal and March, 1981; Nelson and Winter, 1982). Second, search is often planned and guided by routines and heuristics (Dosi, 1988; Nelson and Winter, 1982). Individuals and firms employ heuristics in their problem-solving processes, which often reside in organizational routines. The efficiency and effectiveness of similar and succeeding search behavior is increased by institutionalizing past search experience into organizational routines (Dosi, 1988; Nelson and Winter, 1982). Third, search is often encouraged by identifying a problem or recognizing a need for improvement in

the organization (Cyert and March, 1963; Levinthal and March, 1981). Finally, search often occurs under conditions of uncertainty and ambiguity (Dosi, 1988; Fleming, 2001; Nelson and Winter, 1982). Although search processes may be highly routinized, there exist wide variations of outcomes from search behaviors. Firms may not fully perceive the meaning of the problem or the possible domains of knowledge in which to seek for answers (Levinthal and March, 1993). Moreover, external environment in which answers are searched may be complicated and changing in unpredictable ways, increasing the level of uncertainty and ambiguous nature of search (March, 1991).

Prior research on organizational search has classified search into two types. The most widely recognized classification is the distinction between exploitation and exploration developed by March (1991). This distinction is based on two research. First one is the work of Cyert and March (1963), who contrasts problematic and innovation search. Second is the work of Levinthal and March (1981), who distinguished refinement from innovation search. As March (1991) later points out, problematic and refinement search indicates exploitation of existing knowledge whereas innovation search implies the exploration of relatively novel domains of knowledge. In the same vein, Nelson and Winter (1982) argue that firms are more likely to search locally in established domains of knowledge for technical solutions than in more distant domains where they have little or no prior knowledge.

3.1.2 Local search

The concept of local search, embedded in evolutionary theory (Dosi, 1988; Winter, 1987) indicates that a company will consider alternatives in the neighborhood of its current activities, thus making radical change less likely. Consistent with evolutionary approach, some scholars in the field of organizational learning (Cyert and March, 1963; March and Simon, 1958) also argue a similar point about the search for new knowledge. This literature suggests that decision makers who are boundedly rational depend on established organizational practices to drive the search for knowledge. Scholars in organizational theory view learning as a process that includes trial, feedback, and evaluation. If too many factors in the learning process are changed simultaneously, the ability of the firm to engage in meaningful learning decreases (Teece et al., 1997).

Furthermore, the evolutionary perspective suggests that routines guide organizational behavior. Nelson and Winter (1982) argues that these routines are relatively stable and greatly depends on the experience and history of firms and individuals. Corporations, therefore, recognize and source external knowledge which is closed to their existing knowledge domain (Cohen and Levinthal, 1990). In other words, the search for new knowledge is often restricted to a firm's current domains of expertise.

The concept of local search has been particularly important in innovation activities of the firm. Although firms face with a variety of research projects, they tend to the "neighborhood concept" to develop an optimal strategy to assign

innovative efforts into different technologies (Nelson and Winter, 1982). Technological learning is likely to be local and opportunities for learning will be “close in” to previous experience of the firm (Teece, 1988). Empirical evidence supports firm’s tendencies toward local search. Helfat (1994) demonstrates, for petroleum firms, how R&D expenses on various technologies vary little over years. Recently, Martin and Mitchell (1998) show that local search leads most established firms to develop designs that are similar to those incorporated in their existing products. Likewise, Stuart and Podolny (1996) show, for large semiconductor firms, how patenting activity tends to concentrate in the technological domains where the firm has previously patented.

Local search has proven to be beneficial to firms because it restricts the breadth or scope of search areas and thus allows firms to reduce the cost of the search process. Moreover, technologically proximate search leads firms to recognize and acquire valuable knowledge which are easily managed by the firm’s existing routines. By relying on closely related technological domains, thus, firms focus on similar technologies, develop incremental innovations, and become more competent in their current knowledge domains. This accumulated expertise is considered a distinctive competence if it leads firms to achieving competitive advantage.

However, local search restricts the possibilities for innovation, since it discourages firms to acquire novel and distant knowledge beyond currently familiar technological domains. The focus on local search can lead firms to developing core rigidities (Leonard-Barton, 1995) or falling into competency

traps (Levitt and March, 1988). For example, investigating firms in semiconductor and biotechnology industries, Sorenson and Stuart (2000) found that while heavy reliance on firms' prior knowledge leads firms to creating more patents, these patents are less innovative.

Recent studies in the field of strategic management argue that firms must move beyond local search to compete successfully over time since a constant stream of new technologies produces a competitive environment that is characterized by often dramatic change (Eisenhardt, 1989). For example, Kim and Kogut (1996) argue that the dynamic competition has encouraged firms in the semiconductor industry to diversify across technological sub-fields to maintain their competitive edge. Rosenkopf and Nerkar (2001) show that external exploration in distant technological domains creates innovations with more impact on a broader set of technological areas. March (1991) suggested that firms must keep balance between local search and more distant search.

3.1.2 Distant search

While empirical evidence and theoretical argument suggest the prevalence of local search, some scholars have argued that the development of new knowledge requires distant search where actors examine and integrate diverse and unrelated knowledge domains (Grant, 1996; March, 1991). Additionally, others suggest that such exploratory search can lead a firm to acquire more novel or "radical" knowledge-related outcomes than those that result from local

search processes (Ahuja and Lmapert, 2001; Levinthal and March, 1981; Mezias and Glynn, 1993; Schumpeter, 1934).

In contrast to the empirical evidence and theoretical arguments suggesting that actors tend to prefer their current domains of knowledge, distant search beyond boundary of a firm can stimulate the acquisition of novel knowledge through two mechanisms. First, an expanded search scope increases the number of knowledge elements that the firm can access (Fleming, 2001). The larger the set of knowledge elements searched, the greater the chance firms learn from search activities, *ceteris paribus*. Second, the search scope enhances the variety of knowledge elements examined and the variance in the outcomes to search (Fleming, 2001; March, 1991). An increase in the variance of search opportunities develops firms' current knowledge base (Levinthal and March, 1981). The "value of variance" (Mezias and Glynn, 1993) in search also increases the number of highly novel or radical solutions to be realized (Levinthal and March, 1981, March, 1991).

Several authors show empirical evidence that distant search leads a firm to source novel and external knowledge. Stuart and Podolny (1996) argue that Matsushita is able to reposition itself technologically by non-local search. They suggest that an extensive use of alliances with other firms allowed Matsushita to access to different technologies, resulting in its technological reposition. Likewise, Nagarajan and Mitchell (1998) show that firms seeking for technological change must rely on coordination among firms through strong

inter-relationships. Thus these studies suggest that spanning inter-firm boundaries naturally leads to spanning more technological boundaries.

Although distant search that is high in scope can enhance knowledge acquisition from the external environment, it has significant limitations. First, distant search which is high in scope is costly (Nelson and Winter, 1982). The cost of search is more likely to increase with its scope (Cyert and March, 1963; Kauffman et al., 2000; Nelson and Winter, 1982). While local search leads firms to reducing the scope of search areas, distant search increases the scope of search areas and is seeking for solutions in more diverse domains of knowledge. Thus, actors make efforts and expand resources to understand diverse knowledge. Second, a high scope in search areas is less successful on average because of the increase in cost of integrating diverse knowledge. As the level of search scope increases, the proportion of new knowledge to be integrated into a firm's knowledge base increases, which presents a challenge. Grant (1996) showed that the wider the scope of the knowledge integrated, the more complicated are the problems of controlling integration. Moreover, the organization's capacity to absorb new knowledge diminished due to the limited cognitive capacity (Fleming and Sorenson, 2001; Simon, 1978). As the number and variety of knowledge searched, therefore, firms face challenges in processing and implementing the outcomes of search activity (Kogut, 1998).

The results of this review have implications for this dissertation because they suggest a contingent relationship between search efforts and the outcome. Different types of search have differential effects on the outcome of search

(Katilia, 2000a). Particularly, distant search has indicated a significant impact on sourcing radical knowledge beyond the boundary of the firm. I argue that CVC investments provide firms with opportunities to search and access the diversity of technological knowledge, resulting in knowledge transfer from the start-ups to parent firms.

3.2 ORGANIZATIONAL KNOWLEDGE TRANSFER

In this section, literature on organizational knowledge transfer is reviewed to provide theoretical insight into moderating effects of CVC structure on the relationship between CVC investment and knowledge transfer from the start-up. A review of work on organizational knowledge transfer also provides theoretical insight into the influence of technological diversity on the relationship between CVC investments and knowledge transfer from the start-up. I begin by defining organizational knowledge transfer and discussing its general characteristics. I then examine the existing literature on factors that facilitate knowledge transfer across organizations.

3.2.1 Definition and characteristics of knowledge transfer

The increasing importance of organizational knowledge as a basis of creating competitive advantage has stimulated the research on antecedents of organizational knowledge transfer at the inter-organizational level. Organizational knowledge transfer refers to the process through which organizations exchange and receive the experience and knowledge of others. The long tradition of research in psychology has examined whether experience

with one task affects individual performance on a subsequent task. Recently, however, researchers have begun to investigate knowledge transfer at organizational levels. Following sections cover different mechanisms to facilitate organizational knowledge transfer.

3.2.2 Antecedents of organizational knowledge transfer

Knowledge can be transferred from the source to the recipient through a variety of mechanisms. Previous research has investigated a wide range of antecedents of organizational knowledge transfer. Consistent with prior literature, Wijk et al. (2008) classified different mechanisms of organizational knowledge transfer into three broad categories: knowledge, organizational and network characteristics.

3.2.2.1 Knowledge characteristics

Characteristics of knowledge affect how easily knowledge can be transferred across firm boundaries. Knowledge that is easily codified in documents or software is less difficult to be transferred than tacit knowledge (Nonaka, 1991). Similarly, previous empirical research indicates that high knowledge ambiguity is one of the most important predictors of organizational knowledge transfer (Szulanski et al., 2004). Knowledge ambiguity is defined as the inherent uncertainty about the underlying knowledge components and sources and how they interact.

The complexity of knowledge also affects the success of knowledge transfer. Galbraith (1990) found that attempts to transfer complex manufacturing technology are associated with higher initial losses in productivity at the recipient organization than attempts to transfer technology that is easily codified. Moreover, Ounjian and Carne (1987) found that increased complexity reduces the rate of diffusion of innovation. The observability of knowledge transferred is also likely to affect the ease of knowledge transfer. Meyer and Goes (1988) found that the ease of observing an innovation and seeing its effect can influence success of knowledge transfer within and across firm boundaries. Thus, knowledge observability is suggested to negatively affect organizational knowledge transfer.

Scholars have long recognized the roles of knowledge relatedness on the extent of organizational knowledge transfer. As Powell et al. (1996) point out, what can be learned is not always related to what is already known. By investigating pharmaceutical biotechnology R&D alliances, Lane and Lubatkin (1998) found that the similarity of the partners' basic knowledge bases supports organizational knowledge transfer. New information or knowledge in a familiar domain is generally easier to acquire than knowledge in an unfamiliar area. Thus, unrelated knowledge will challenge a firm to absorb limited value because a lack of common language becomes a barrier for understanding the knowledge.

3.2.2.2 Organizational characteristics

A second stream of research has investigated organizational characteristics as antecedents of organizational knowledge transfer. Many studies examine the roles of size. By including size of firms as a control variable, most studies show that the size of firms is positively related to knowledge transfer (Dhanaraj et al., 2004; Gupta and Govindarajan, 2000; Laursen and Salter, 2006). However, other research shows non-significant (Tsang, 2002) or negative (Makino and Delios, 1996) effects of organizational size on the extent of knowledge transferred. Thus, existing literature on the effect of organizational size on knowledge transfer indicates mixed results.

In addition to organizational size, prior research has considered the age of firms as an important factor of knowledge transfer. Cyert and March (1963) argue that aging organizations tend to become inert and to possess a limited capability to learn and adapt to changing circumstances (Cyert and March, 1963). Relatively younger organizations are supposed to be modified more easily. Previous research, thus, has argued that younger organizations tend to have learning advantages over older ones (Frost et al., 2002). Other empirical research suggests, however, that age has no effect on knowledge transfer (Gray and Meister, 2004). As such, prior studies have been inconclusive about the effect of age on the extent of knowledge transferred.

Cohen and Levinthal (1990) originally introduce the concept of absorptive capacity that has emerged as one of the most important factors to enhance organizational knowledge transfer. Absorptive capacity is defined as a firm's

ability to recognize, assimilate and apply new external knowledge (Cohen and Levinthal, 1990; Lane et al., 2006; Zahara and Geroge, 2002). Absorptive capacity is built on prior knowledge endowments. In other word, the more knowledge a firm owns in a certain domain of knowledge, the easier it is to acquire new knowledge in that domain (Cohen and Levinthal, 1990). Various empirical studies found that absorptive capacity lead firms to acquire external knowledge within and across firm boundaries (Gupta and Govindarajan, 2000; Szulanski, 1996).

3.2.2.3 Network characteristics

The last category of factors studied in prior literature includes network characteristics. Although knowledge has become a source of competitive advantage (Grant, 1996), knowledge required to innovate is not always readily available within a single firm. Previous research argues that social relations among actors lead the firm to gaining access to knowledge, to facilitate knowledge transfer (Alder and Kwon, 2002). The social context can be divided along three dimensions: the structural, relational and cognitive dimension (Inkpen and Tsang, 2005; Nahapiet and Ghoshal, 1998).

First, social network theorists have focused much attention on structural dimensions of social capital (Adler and Kwon, 2002), such as tie strength. Tie strength refers to the closeness of relationship between partners and range from weak to strong ties (Granovetter 1973, Hansen 1999). While more diverse

information is likely to drive from weak than strong ties (Granovetter, 1973), accumulated evidence suggests that strong ties lead to greater knowledge transfer (Reagans and McEvily, 2003; Rowley et al., 2000). Presumably, strong ties lead organizations to directing more efforts to ensure that knowledge seekers or receivers understand and exploit newly acquire knowledge (Hansen, 1999).

Second, research has focused much attention on the relational aspects of social networks. The relational dimension is defined as the nature of the relationships themselves such as trust between partners (Tsai and Ghoshal, 1998). Trust 'reflects the belief that a partner's word or promise is reliable and that a partner will fulfill its obligations in the relationship' (Inkpen, 2000). Trust enables the transfer of organizational knowledge since it enhances partners' willingness to share knowledge (Lane et al., 2001).

Last, the cognitive dimension of social capital refers to the resources within relationships that provide shared meaning and understanding (Nahapiet and Ghoshal, 1998). Tasi and Ghoshal (1998) argue that the cognitive dimension of social capital is embodied in collective goal and values which allow actors to have similar perceptions as to how they should interact with one another. Since shared goals and values promote mutual understanding and provide a crucial bonding mechanism, organizational knowledge transfer is argued to be facilitated across firm boundaries (Lane and Lubatkin, 1998; Mowery et al., 1996). Therefore, shared vision and systems tend to contribute to the extent of organizational knowledge transfer.

3.3 SUMMARY OF LITERATURE ON THEORETICAL FOUNDATION

This chapter provided underlying theoretical foundation for this dissertation. First, the literature on different types of organizational knowledge search was reviewed. The results of this review show that while firms tend to practice local search, distant search has proven to enhance the quality of innovation.

Second, this chapter presented an overview of prior work on antecedents of inter-organizational knowledge transfer. The literature indicates three broad categories of mechanisms to facilitate organizational knowledge transfer: knowledge, organization and network characteristics.

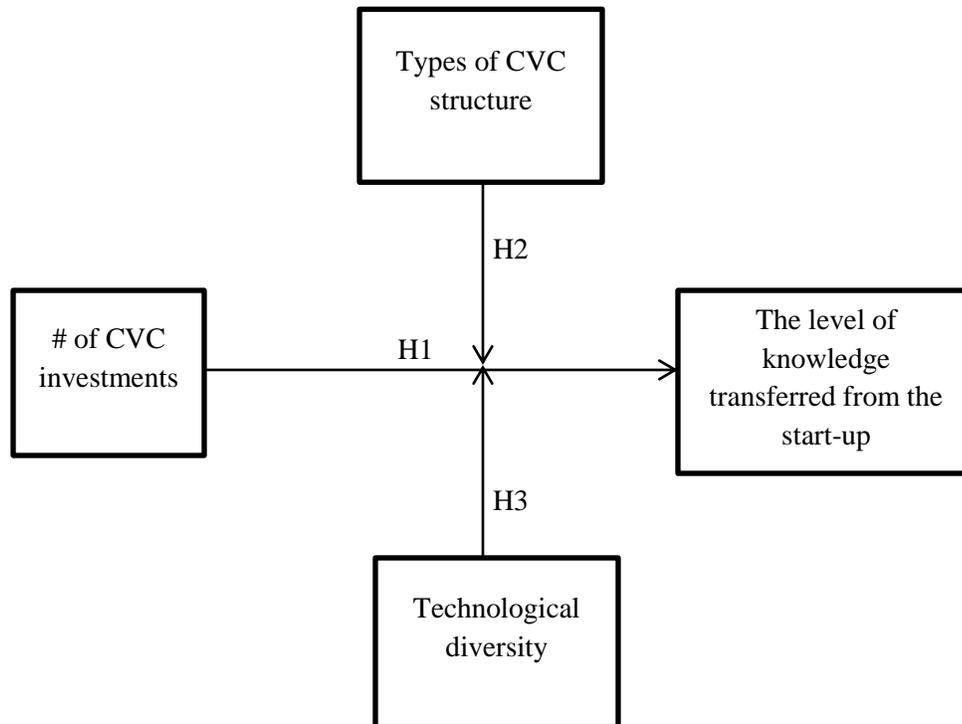
CHAPTER 4

HYPOTHESES DEVELOPMENT

In this chapter, I develop hypotheses that establish the causal relationships among CVC investment, CVC structure, technological diversity, and the level of knowledge transfer from the start-up. Building upon the review of knowledge search and transfer, I develop three hypotheses regarding the influence of a firm's ability to source external knowledge from entrepreneurial ventures.

Two central propositions concerning the effect of CVC investment on external knowledge transfer are inherent in my arguments. Drawing upon research emphasizing the roles of search in organizational knowledge transfer, first, I suggest that access to external knowledge through CVC investment provides the parent firm with opportunities to learn from the start-ups. Second, I note that CVC investment itself provides the parent firm only with opportunity to access diverse technical knowledge. For knowledge transfer to be facilitated, firms need mechanisms to accelerate knowledge transfer beyond firm boundaries. Building upon literature on organizational knowledge transfer, I propose that both CVC structure and technological diversity moderate the relationship between the number of CVC investment and the extent of knowledge transfer from entrepreneurial ventures as shown in Figure 3.1.

Figure 4.1 A research model



4.1 HYPOTHESIS ONE

Because of rapidly changing technology and competitive environments, established firms are under constant pressure to search knowledge beyond their boundaries. Rapid technological obsolescence has made it essential to access external sources of new and diverse knowledge to develop firms' internal operations and discoveries. A large number of search activities through relations with other firms facilitate access to potentially useful knowledge, ideas, or resources and thus increase the probability and amount of organizational knowledge transfer (Reagans and McEvily, 2003). Recently, firms view new

ventures as one of key sources of new knowledge that can be brought into the organization (Dushnitsky and Lenox, 2005) and use CVC investments to search for external knowledge in their external environment (Keil, 2004).

There are at least two channels through which CVC activity facilitates learning from entrepreneurial ventures. First, the due-diligence process provides the firm a unique opportunity to learn about entrepreneurial inventions even prior to committing capital (Dushnitsky and Lenox, 2005). Before investing, corporations generally conduct extensive due diligence activities related to the ventures under certain consideration. These activities include investigation on ventures' operations, business plan, market prospects, products, and technology. Following investment, investors may also learn about novel technologies through board membership in venture firms (Dushnitsky and Lenox, 2005; Zahra, Ireland, and Hitt, 2000). Since voting board members with observer rights can contact with the new venture's technical experts (Pisano, 1989), they provide corporate investors with an opportunity to access the technology of new ventures. Thus, access to new external knowledge residing in the start-ups through CVC investment gives an opportunity to acquire external knowledge.

Although CVC investments lead firms the access to external source of knowledge from the start-up, they have potential limitations regarding organizational knowledge transfer. Because managers of CVC programs are "boundedly rational" (March and Simon, 1958), they may eventually face challenges to gather and process a wide scope of knowledge from the start-up by simply increasing CVC investment. In addition, the organization's capacity to

absorb new knowledge may be diminished due to the low level of cognitive capacity (Fleming and Sorenson, 2001; Simon, 1978). More importantly, decision makers in CVC programs also operate under resource constraints, because CVC activities in corporations generally receive limited organizational support to manage the process (Kiel et al., 2004).

Taken together, these arguments suggest that, beyond a critical point, the relationship between the amount of CVC investment and the level of knowledge transfer from the start-up will either diminish or result in negative returns. Thus, I propose the following hypothesis:

H1: The level of knowledge transfer from the start-up to the parent firm has a curvilinear (inverted U-shaped) relationship with the number of corporate venture capital investments.

Although the search for and selection of portfolio firms to invest represent a firm's distant search activities, they provide corporate investors only with an opportunity to acquire new external knowledge. For the opportunity to be realized, corporate investors need proper mechanisms of knowledge transfer. Thus, this study considers the role of CVC structure and knowledge diversity of the parent firm to facilitate the extent of organizational knowledge transfer from the start-up.

4.2 HYPOTHESIS TWO

One of the important factors that may explain whether knowledge transfer across organizations is the relationship that exists between the organizations involved in knowledge transfer. While there is benefit of weak tie to facilitate organizational knowledge transfer, social network researchers have demonstrated that strong ties lead to greater knowledge transfer (Ghoshal et al., 1994; Hansen, 1999; Szulanski, 1996; Uzzi, 1996,1997).

Corporate venture capital can be organized through several structures that vary according to the degree of involvement of the corporation (Keil, 2002). These different structures range from a strongly tied to loosely tied ones. For instance, 'Direct Investment' is the structure where current operating business manages CVC activities directly and has the strongest tie and an embedded relationship with the parent firm (Dushnitsky, 2008). On the other hand, other types of CVC structure such as 'Wholly-Owned Subsidiary,' 'Dedicated Fund' and 'CVC as LP' have loosely tied relationships to the parent firm. For example, 'Wholly-Owned Subsidiary' is a structure which is independent from the parent firm with the sole purpose of pursuing CVC activity and then is loosely tied to a parent firm.

Some research show that a strongly tied relationship between organizations allows for more regular communication which is proposed as a mechanism of organizational knowledge transfer (Ghoshal & Bartlett, 1988,;Rothwell, 1978). Moreover, organizations in a strongly embedded relationship generally trust each other to a greater degree than those in less

embedded network relationships (Granovetter, 1985; Uzzi, 1996). When trust exists, actors are more willing to give useful knowledge (Andrew and Delahay, 2000) and are also more willing to listen to and absorb others' knowledge (Levin, 1999; Mayer et al., 1995). Because CVC programs operating within the parent company have greater geographic proximity and more meetings, they are likely to have more chances to have regular communication with the parent firm. Thus, I propose the following:

H2: The relationship between the number of corporate venture capital investments and the level of knowledge transfer from the start-up will be positively moderated in strongly tied corporate venture programs.

4.3 HYPOTHESIS THREE

The possession of valuable internal knowledge plays a critical role of facilitating organizational transfer knowledge across organizations. Von Hippel (1988) shows how possession of knowledge serves lead firms to knowledge sharing and transfer across firm boundaries. Thus, the extent of external knowledge transfer depends on the firm's ability to internalize knowledge existing in the external environment, and bring it within the scope of its own boundaries.

The scope and diversity of the firm's knowledge base contribute to developing its sourcing ability. When the knowledge stocks of actors in a network overlap, knowledge transfer is fostered. Van Wijk et al. (2001) found that broad knowledge facilitates the absorption of knowledge in a broad domain of knowledge, and help increase the chance that the knowledge of network actors overlaps. As the number of CVC investments by the parent firm increases, the parent firm is more likely to be exposed to different and possibly unrelated knowledge from entrepreneurial firms (Wadhwa and Kotha, 2006). In such a case, a broad scope of knowledge enhances the probability of the firm's ability to understand and source unconnected knowledge.

The above argument suggests that a more diverse technological knowledge base will enhance an already positive relationship between the number of CVC investments and the rate of knowledge transfer from the start-up. Even when this relationship turns negative, investor firms with more diverse technological bases are better able to evaluate and absorb incoming knowledge from their investments in venture firms. Thus, technological knowledge diversity of the parent firm plays an important role for maximizing the level of knowledge transfer from an entrepreneurial venture. I offer the following hypothesis:

H3: The relationship between the number of corporate venture capital investments and the level of knowledge transfer from the start-up will be positively moderated by the technological diversity of the parent firm.

4.4 SUMMARY OF HYPOTHESES DEVELOPMENT

This chapter developed a research model comprised of four variables derived from a review of literature. These research variables included the number of CVC investments, types of CVC structure, technological diversity, and the level of knowledge transfer. Based on these variables, three hypotheses were presented. The following chapter provides an overview of the methodology used to test these hypotheses, including the sample, measures, and model specification.

CHAPTER 5

METHODS, MEASURES, AND EMPIRICAL CONTEXT

In this chapter, I discuss statistical methods, definitions and operationalization of variables, and the empirical context of this dissertation. The chapter is divided into three sections. The first section describes the sample. The second section presents the definitions and operationalizations as well as the procedures and the sources used to collect the data. The final section presents statistical methods used to test hypotheses developed in the previous chapter.

5.1 SAMPLE

This dissertation focuses on the ICT industry, which has faced restructuring because of intensive competition and dramatic change in technology (Olley and Pakes, 1996). Rapid technological advances in the ICT industry and their convergence with different industries such as biotechnology, have resulted in some important trends. First, technological convergence has made the innovation process and nature of R&D in this industry much more systemic, and this has increased product complexity at the firm level (Pisano, Russo, and Teece, 1988). Second, the convergence with other industries have forced companies to participate in the demand as well as the supply side of CVC investments to keep abreast of changes and to track and access external technologies (Wadhwa and Kotha, 2006). Finally, companies in this industry routinely and systematically patent their inventions to protect intellectual

property (Levin et al., 1987). Since I use patent data to measure various constructs, firms in this industry can provide an excellent context for this research.

The research sample is drawn from large U.S. public firms operating in the ICT industries. ICT industries are defined by using Standard Industrial Classification (SIC) codes: 3571 (electronic computer), 3661 (telephone and telegraph apparatus), 3663 (radio and TV communications equipment), 3669 (communication equipment), 3674 (semiconductors and related devices), 4813 (telephone communications), 7371 (computer programming services), 7372 (packed software), and 7373 (computer integrated system design) to assemble the sample of firms.

To construct the sample of U.S. public firms that had invested in venture companies either directly or through their own venture funds, I drew on the VentureXpert, the official database of the National Venture Capital Association (NVCA). The VentureXpert maintains a list of corporate investors at the fund level and contains a comprehensive coverage of investment, exit, and performance activities in the private equity industry and provides the population of all private equity investments by established firms. Using this list of corporate funds, I searched extensively by fund name on Google and in other online databases like Lexis-Nexis to assign each corporate fund to its corporate parent. I then selected investor firms that were operating in the eight sectors of ICT industries: electronic computer, telephone and telegraph apparatus, radio and TV communications equipment, semiconductors and related devices, telephone

communications, computer programming services, packed software, and computer integrated design.

This research focused on the time period from 1995 to 2005. The final sample of this dissertation consisted of 29 investors firm that invested in entrepreneurial firms at least once during 1995-2005. The final panel consisted of 178 firm-year observations. For each observation, I compiled the corresponding investor firm characteristics, CVC characteristics, and details of their patents.

5.2 VARIABLE DEFINITIONS AND OPERATIONALIZATIONS

5.2.1 Patent data

Patent citations have been widely used in prior literature to measure knowledge flows between companies and geographical areas (Ahuja and Katila, 2001; Jaffe and Trajtenberg, 1993; Mowery, Oxley, and Silverman, 1996; Rosenkopf and Nerkar, 2001; Stuart and Podolny, 1996). Patent data have received so much attention because they are systematically compiled, have detailed information, and are available continuously across time. When the U.S Patent and Trademark Office grants a patent, for example, the granting officer includes a list of all previous patents on which the granted patent is based. The list of citation for each patent is arrived at through a uniform and rigorous process applied by the patent examiner as a representative of the patent office. The patent applicant and lawyer are obliged by law to specify in the application any and all of “the prior art” of which they are aware. In principle, a citation of

Firm_y's patent by Firm_x's patent indicates that Firm_x's patent builds upon previously knowledge embodied in Firm_y's patent. Thus, I used patent data extensively to measure knowledge-transfer patterns of corporations in the sample.

5.2.2 Dependent variable

The dependent variable, measured at the patent level, represents the extent of knowledge transferred from start-ups. The variable is operationalized as the number of citations the parent firm *i*'s patent refers to any patent of partners in year *t*. An increase in this measure indicates an increase in the degree to which a patent builds upon the knowledge of parent firm's partner.

To construct the measure of knowledge transfer from the start-up to the parent firm, I used the Derwent Innovations Index, which provides access to 54.5 million patent and literature citations found in 7.8 million patent families since 1963. Each record in the database presents the patent number, date of application, date of grant, company to whom the patent is assigned and references to prior patents for each granted patent. Thus, the Derwent Innovation Index is ideal for measure the level of knowledge transfer from the start-up to the parent firm.

This study makes a time limit regarding the period of patent citations in the sample. Alliances and joint ventures seldom last more than 5 years, and announcements related to termination of alliances are rarely given (Ahuja, 2000). Likewise, the effects from acquisition are likely to fade within 5 years,

since learning between the acquirer and target becomes an internal knowledge flow (Schildt et al., 2005). Since this research focused on the time period from 1995 to 2005, I collected U.S. patents of investor firms that cited a patent of start-ups using the Derwnet Innovation Index, covering patents filed during the 1995-2009 period. These patent citations form the basis of empirical analyses. This data collection procedure resulted in a sample containing patents filed by parent firms during the period, with one observation per patent.

5.2.3 Independent variables

5.2.3.1 The number of CVC investments

Primary independent variable of this dissertation is the number of CVC investments. I measured the number of CVC investments for each firm in the sample by counting the total number of unique start-ups invested in by firm i in year t . If a firm does not make any investments in a given year, a value of 0 is assigned.

To measure the number of CVC investments by the parent firm that had invested in the venture firm in the sample, I drew on the VentureXpert, the official database of the NVCA which contains a comprehensive coverage of CVC investments, exit, and performance activity.

5.2.3.2 Structure of CVC

I coded CVC programs to reflect types of CVC structure. A CVC program was coded as a direct structure when a CVC program operates as a group within the parent company. When a CVC program operates as an independent entity out of the parent company, a CVC program was coded as an indirect one. This study used information disclosed by the firm during the announcement of its venturing program to measure types of CVC structure. For each CVC firm in the sample in this study, I conducted an extensive search for announcements of CVC fund formation in hundreds of newspapers, trade magazines, newsletters and other sources available through Lexis-Nexis Academic Universe.

5.2.3.3 Technological diversity

I measured the technological diversity of a corporate investor by calculating the inverse concentration ratio of the distribution of the firm's patents over the primary technology classes to which they had been assigned (Nerka, 2003; Silverman, 1999). This measure reflects the distribution of the corporate investor's patents across technology classes over four years (t-1 to t-4) prior to observation of the dependent variable (Wadhwa and Kotha, 2006).

Specifically, the calculation is as followings:

$$\begin{aligned} &\text{Technological knowledge diversity } i \text{ (t-1 to t-4)} \\ &= \sum p_j \times \ln (1/p_j) \end{aligned}$$

where P_j indicates the ratio of patents filed in patent class j , and $1/P_j$ is the weight for patent class j . This approach is similar to measuring the entropy measure (Palepu, 1985), which has been widely used in prior research, and a larger value of this measure represents greater diversity. I used data from the Derwent Innovation Index that provides detailed information on patents.

5.2.4 Control variables

This study includes a range of control for firm and industry level factors that may influence a firm's level of knowledge transfer across organizations. I controlled for firm age because it exerts a systematic effect on organizational knowledge transfer (Frost et al., 2002). Firm age is operationalized as the number of years from the founding of a parent firm i to the year before the observation of CVC investment. Firm size can affect organizational knowledge transfer either positively (Gupta and Govindarajan, 2000; Laursen and Salter, 2006) or negatively (Makino and Delios, 1996). Firm size is measured as the natural logarithm of sales for firm i at time $t-1$. Because a firm's stock of patents has influenced organizational knowledge transfer (Cohen and Levinthal, 1990), I controlled for patent stock which is measured as the number of patents attributable to a firm in the four years prior to its CVC investment in venture firms. Data were obtained from the COMPUSTAT.

As R&D intensity influences a firm's ability to absorb external knowledge (Cohen and Levinthal, 1990), research using the number of patents as a dependent variable (Ahuja and Lampert, 2001; Benner and Tushman, 2002)

should control R&D intensity. R&D intensity is measured as the ratio of R&D expenditure to the parent firm's sales at time $t-1$. In addition, I controlled for industry relatedness between a parent firm and a portfolio firm since it is correlated with the level of knowledge transfer (Powell et al., 1996). I collected data from the COMPUSTAT.

The relatedness is measured as the basis of the SIC codes of parent firms and the Venture Xpert Classification Codes (VEIC) of venture firms. A portfolio firm is considered related to its corporate investor if any of the VEIC codes are found to match SIC codes at the three-digit level (Wadhwa and Kotha, 2006). This measure is the average count of venture firms belonging to the same three-digit SIC codes as a parent firm i in year $t-1$. Finally, dummy variables for years 1995-2005 are included to control for effects caused by economic cycles, using year 1995 as the default in the regression model. Table 5.1 summarizes model variables and their measurements.

Table 5.1 Model variables and measurements

Variables	Measurements	Databases
Independent variable		
# of CVC investments	# of unique investment in start-ups by parent firm i in t	VentureXpert
Dependent variable		
# of knowledge transferred through CVC investment	# of the start-ups' patents cited by parent firm i from $t \sim t+4$	Derwent Innovation Index
Moderating variables		
Types of CVC structure	Direct (0)/Indirect (1)	LexisNexis/ Google
Technological diversification	Scope over scale of parent firm i technology $t-1 \sim t-4$	Derwent Innovation Index
Control variables		
Age of parent firm	(CVC investment year-1) - founded year	COMPUSTAT
Size of parent firm	Log sales of parent firm i in $t-1$	COMPUSTAT
R&D intensity	R&D expenses over sales of parent firm i in $t-1$	COMPUSTAT
Industry relatedness	Three digits of SIC parent firm i in $t-1$ and VEIC in $t-1$	VentureXpert/ SIC
Economic cycles	Dummy variables from 1995 to 2005	LexisNexis
Parent firm's stock of patents	# of patents of parent firm i in the four years prior to its entry into the sample	Derwent Innovation Index

5.2 MODEL SPECIFICATION AND ESTIMATION

The Poisson distribution is often used to model information on counts of various kinds, particularly in situations where there is no natural “denominator,” and thus no upper bound or limit on how large an observed count can be. Counts refer to the number of events that occur on the same observation unit during a temporal or spatial interval (Lindsey, 1997). Counts are quite common in research in social and health sciences (Byers, Allore, Grill, and Peduzzi, 2003; Gardner, Mulvey, and Shaw, 1995; Vives, Losilla and Rodrigo, 2006). Possible examples of count data where a Poisson model is useful include the number of patents.

When a Poisson model is appropriate for an outcome Y , the probabilities of observing any specific count, y , are given by the formula:

$$\Pr(Y=y) = \lambda^y e^{-\lambda} / y!$$

where λ is known as the population rate parameter, and $y! = y \times (y-1) \times \dots \times 2 \times 1$.

One of the characteristic properties of the Poisson distribution is the identity relationship between mean and variance:

$$\text{Variance}(Y) = \mu$$

However, count data rarely fit the restrictive assumptions of the Poisson distribution (Chambers, 1998). The violation of much of such assumptions commonly results in overdispersion invalidating the Poisson distribution (Winkelmann, 2000). As a result, undetected overdispersion may entail

important misleading inference, so its detection is essential. Among different overdispersion diagnostic tests, Goodness-of-fit test is most widely used (McCullagh and Nelder, 1989). This test assesses any departure from the Poisson distribution by means of the relationship between the Pearson chi-square and degrees of freedom.

In this research, Goodness-of-fit test show that the Pearson chi-square/df is closer to 1.0, suggesting that there is no overdispersion. I also tested research model with negative binomial model, showing that there is no significant difference in Goodness-of-fit test results between the Poisson and Negative binomial models. Therefore, I chose the Poisson model to test research hypotheses.

5.4 SUMMARY OF METHODS AND MEASUREMENTS

The methodology for the dissertation has been outlined in this chapter. The selection procedure of U.S. public firms in the ICT industries as the research sample was discussed, along with the definition and measures for research variables. The Poisson regression model was reviewed to test hypotheses developed in the previous chapter. The next chapter provides an overview of the results of the hypothesis test.

CHAPTER 6

RESULTS

In this chapter, the results of statistical analysis and hypotheses tests will be presented. First, descriptive statistics for the variables are presented. This is followed by the results of regression models which test direct effects of CVC investments on the level of knowledge transfer and moderating effects of CVC structure as well as technological diversity.

6.1 DESCRIPTIVE STATISTICS

Table 6.1 reports summary statistics and the correlation matrix for all the variables of interest. The number of CVC investments, patent stocks, firm age, R&D expenditure, and industry relatedness are transformed because they are highly skewed. The average number of citations that the parent firm refers to any patent of partners was 6.49. The number of knowledge transfer varied from 0.00 to 104. However, this number is skewed by the high number of firms who did not cite the patents of start-ups. On average, firms invested 9.33 times per year in entrepreneurial ventures. This number is also skewed by the relatively few firms who invested in entrepreneurial firms in great numbers. The number of firms which invested in entrepreneurial firms directly was 102 out of 178. In other words, 42 numbers of firms in the sample invested in start-ups through their own funds. The average of Technological diversity of parent firms was 9.51, ranging from 0.00 to 26.03.

The bivariate correlations between variables are also presented in Table 6.1. The results of correlations show that the number of CVC investments was positively and strongly correlated with the number of knowledge transfer ($r=.595$, $p < .05$). In addition, the relationship between technological diversity and the level of knowledge transfer is significantly positive ($r=.195$, $p < .05$), suggesting that higher level of technological diversity is associated with higher level of knowledge transfer from the venture firm to the parent firm. The level of knowledge transfer was found to be negatively and significantly correlated with a dichotomous variable to identify types of CVC structure ($r=-.271$, $p < .05$), suggesting that the level of knowledge sourced from a start-up is higher when the parent firm invested in an entrepreneurial firm directly than indirectly.

As for the control variables, age, size and patent stock displayed significant correlations with the dependent variable in expected directions. Older organizations were associated with higher level of knowledge transfer ($r=.235$, $p < .05$). In addition, the bigger size of firms was found to be positively associated with the number of knowledge transferred from the start-up to the parent firm ($r=.275$, $p < .05$). Patent stock also displayed a significant and positive association with the level of knowledge transfer ($r=.225$, $p < .05$). Finally, the level of knowledge transfer was not significantly related with both R&D intensity ($r=-.047$, $p < .10$) and industry relatedness ($r=.020$, $p < .10$).

Since the linear terms of variables are highly correlated with their higher order terms (squared terms and the linear and quadratic interactions used to test hypotheses), I centered all predictors prior to creating the quartic and interaction

terms. I follow the procedure introduced by Cohen, Cohen, West, and Aiken (2003).

The procedure introduced by Aiken and West (1991) suggests that lower order coefficients in higher order regression equations can only have meaningful interpretations if variables in the research have a meaningful zero. There is a simple solution to making the value zero meaningful on any quantitative scale. I center the linear predictor as follows:

$$\text{Centered linear predictor } x: x = (X - M_x)$$

With centered variables, the mean M_x is, of course, zero. Thus, the regression of Y on x at $x=0$ becomes meaningful. It is the linear regression of Y on Z at the mean of the variable X . Once I have centered the linear predictor, I then form the higher order predictors from centered x :

$$\text{Centered quadratic predictor } x^2: x^2 = (X - M_x)^2$$

I used these predictors in the polynomial regression equations. Thus, the quadratic equation in this study becomes:

$$\begin{aligned} Y = & B_1(\text{CVC investment} - M_{\text{CVC inv}}) + B_2(\text{CVC investment} - M_{\text{CVC inv}})^2 + B_3 \text{ Structure of} \\ & \text{CVC} + B_4 \text{ Structure of CVC} * (\text{CVC investment} - M_{\text{CVC inv}}) + B_5 (\text{CVC investment} - M_{\text{CVC} \\ & \text{inv}})^2 * \text{Structure of CVC} + B_6 (\text{Techdiversity} - M_{\text{Techdiversity}}) + B_7 (\text{Techdiversity} - \\ & M_{\text{Techdiversity}}) * (\text{CVC investment} - M_{\text{CVC inv}}) + B_8 (\text{CVC investment} - M_{\text{CVC inv}})^2 \\ & * (\text{Techdiversity} - M_{\text{Techdiversity}}) + B_0 \end{aligned}$$

To gain the benefits of interpretation of lower order terms, I did not center the criterion Y; I leave in raw scores from so that predicted scores will be in the metric of the observed criterion. This procedure reduces nonessential ill-conditioning between independent variables and their higher-order terms and facilitates better interpretation of coefficients (Cohen, Cohen, West, and Aiken, 2003).

6.2 REGRESSION MODELS

Using Poisson regressions, I tested three hypotheses regarding the impact of CVC investments on the level of knowledge transferred from start-ups and moderator effects of CVC structures and technological diversification on the relationship between CVC investments and the number of knowledge transfer from venture companies. Table 6.2 summarizes the statistical findings from the Poisson regressions. Model 1 is the unconstrained control only model. Model 2 introduces the number of CVC investments as linear and quadratic terms to test Hypothesis 1. Model 3 includes two additional independent variables: types of CVC program structure and technological diversity. Model 4 incorporates the interaction effects to test Hypotheses 2 and 3: interactions of CVC program structures and technological diversity with the linear term, the number of CVC investments, and interactions of involvement and technological diversity with the squared term, the number of CVC investment squared. Thus, model 4 represents the fully specified model. Although not reported, all models include time dummies to control for unobserved heterogeneity and time-varying factor.

6.2.1 Direct effects

Hypothesis 1 posits an inverted U-shaped relationship between the number of CVC investments and patent citation, proxy for knowledge transfer. The results in model 2 indicate that the linear term, number of CVC investment, is positive and significant ($\beta = .503$, $p < .001$), and the number of CVC investment squared is negative and significant ($\beta = -.602$, $P < .01$), thus supporting Hypothesis 1.

The insignificant of the linear term number of CVC investments in model 4 is perhaps the result of the collinearity introduced by the numerous interaction terms involving this linear term. Multicollinearity is common when interactions are entered together with their component terms in regression equation (Jaccard and Turrisi, 2003). Although multicollinearity affects the standard errors and coefficients of simple component terms, it does not influence the efficiency of estimates of higher-order terms.

Table 6.1 Correlations and Descriptive Statistics

Variable	Mean	s.d.	Mini	Max	1	2	3	4	5	6	7	8
1. Number of Knowledge transferred $i(t \text{ to } t+4)$	2.90	4.45	.00	12.50								
2. Number of portfolio firms it	2.10	1.18	.00	2.24	.595**							
3. Types of CVC structure it	.57	.50	0	1	-.271**	-.261**						
4. Technological diversity $i(t-1 \text{ to } t-4)$	9.51	7.32	.00	26.03	.195**	.115	-0.88					
5. Age $it-1$	5.03	1.80	1.41	7.97	.235**	.194**	-.216	.612**				
6. Size $it-1^b$	9.66	.81	5.86	10.98	.275**	.298**	-.270	.619**	.631**			
7. R&D intensity $it-1$.36	.12	.00	.77	-.047	-.112	.187	-.329**	-.359**	-.592**		
8. Industry relatedness	.38	.39	.00	1.12	.020	-.009	-.061	-.159*	-.095	-.098	.073	
9. Patent stock $i t-1$	23.31	21.01	1.00	61.36	.225**	.167*	-.057	.896**	.595**	.658**	-.329**	-.140

n=178

*P<.10, ** P<.05, *** P<.01

Table 6.2 Poisson regression models

Variables	Model 1	Model 2	Model 3	Model 4
Constant	1.512***(.000)	1.250***(.000)	1.517***(.000)	.559(.122)
Independent				
1. Number of portfolio firms <i>it</i>		.503***(.000)	.464***(.000)	.063(.603)
2. Number of portfolio firms <i>it</i> squared		-.602**(.008)	-.656**(.004)	-1.707***(.000)
3. Types of CVC structure <i>it</i>			-.432***(.000)	1.156(.042)
4. Technological diversity <i>i</i> (t-1 to t-4)			.031*(.048)	.014(.453)
Moderating				
1. Types of CVC structure <i>it</i> x Number of portfolio firms <i>it</i>				.821(.326)
2. Technological diversity <i>i</i> (t-1 to t-4) x Number of portfolio firms <i>it</i>				-.038(.464)
3. Types of CVC structure <i>it</i> x Number of portfolio firms <i>it</i> squared				-1.136*(.032)
4. Technological diversity <i>i</i> (t-1 to t-4) x Number of portfolio firms <i>it</i> squared				.050**(.006)
Control				
1. Age <i>it</i> -1	.044(.202)	.067*(.044)	.012(.755)	.010(.797)
2. Size <i>it</i> -1	1.173***(.000)	.384***(.001)	.433***(.000)	.435***(.001)
3. R&D intensity <i>it</i> -1	4.926***(.000)	2.775***(.000)	3.600***(.000)	3.741***(.000)
4. Industry relatedness	.203†(.096)	.180(.240)	.189(.228)	.164(.309)
5. Patent stock	-.001(.695)	.005*(.043)	.000(.940)	.003(.598)
<i>df</i>	6	8	10	16
Log-Likelihood	-583.656	-452.286	-441.752	-425.856
Log-Likelihood ratio	199.326***	462.066***	483.134*	514.928***
Wald χ^2				

n=178

*P<.10, ** P<.05, *** P<.01

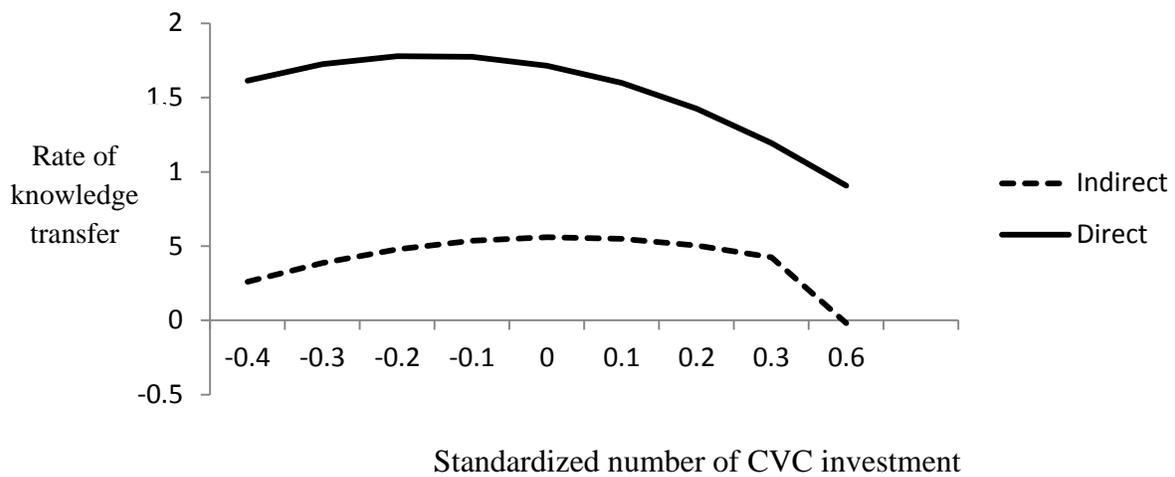
6.2.2 Moderation effects

To test for moderating effects on the curvilinear relationship, I created linear interaction terms composed of the number of CVC investments and each of the two moderating variables and quadratic interaction terms. I entered the moderator together as a block to account for their simultaneous effect on the dependent variable (Golden and Viega, 2005). Evidence of moderation is found when the quadratic interactions are significant in the hypothesized direction and the model fit improves (Golden and Viega, 2005).

Hypothesis 2 posits that strongly tied program moderates the relationship between number of CVC investments and knowledge transfer positively higher than weakly tied CVC one. In model 4, a fully specified model, the interaction term is negative and significant ($\beta = -1.136, p < .05$), and a log-likelihood test shows that inclusion of the quadratic interaction further improves model fit.

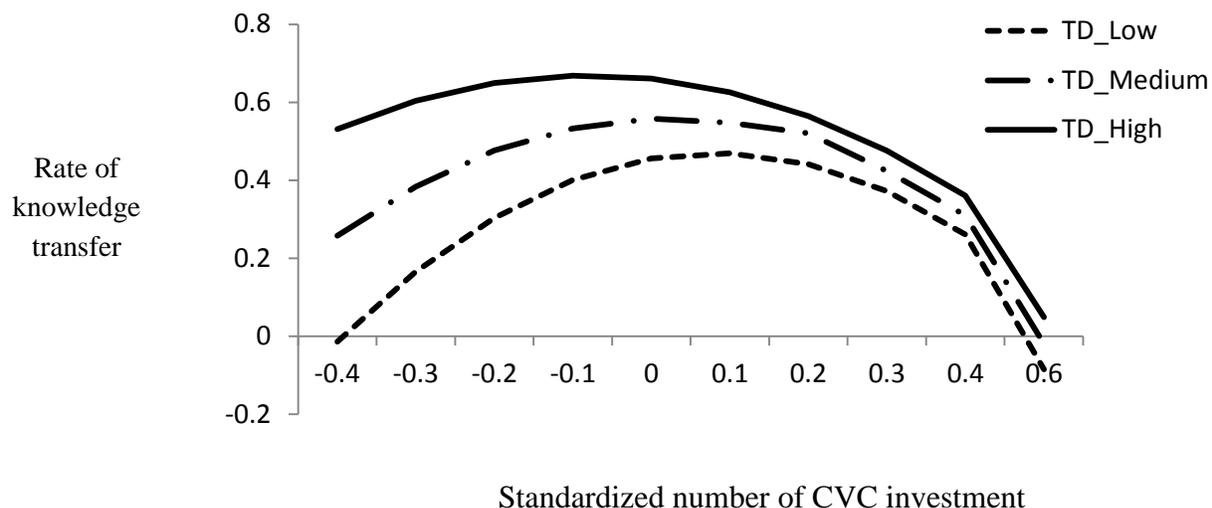
To better interpret the interaction terms, I graphed the quadratic-by-linear effect using procedure outlined in Cohen et al. (2003). Figure 6.1 shows that for a parent firm with strongly tied CVC structure, the rate of knowledge transfer is higher than it is for a parent firm with weakly tied CVC structure.

Figure 6.1 Interaction effect of CVC structure



Hypothesis 3 argues that technological diversity moderates the relationship between the number of CVC investments and the dependent variable. The quadratic interaction term, technological diversity by number of CVC investments squared, is positive and statistically significant ($\beta=.050$, $p<.001$), and a log-likelihood test shows that inclusion of the quadratic interaction further improves model fit. Thus, Hypothesis 3 is supported. Figure 6.2 shows that for a parent firm with low technological diversity, the rate of knowledge transfer is lower than it is for a parent firm with medium technological diversity and with high technological diversity.

Figure 6.2 Interaction effect of technological diversity



6.3 DISCUSSION

This study conceptualized CVC investments as an exploratory process whereby firms use these investments to source external knowledge in their environments. By launching CVC programs and using their technological knowledge diversity, parent firms can use their access to entrepreneurial firms to source knowledge through CVC investments. Findings of this research focused on contextual factors in overcoming the limitations inherent in exploratory activities (Levinthal and March, 1993).

This dissertation posited that the level of knowledge transfer from the start-up to the parent firm has an inverted U-shaped relationship with the number of CVC investments. The curvilinear relationship between the number of CVC investments and the level of knowledge transfer found in this study suggests that this relationship may be more complicated than previously thought.

For instance, this finding differs from the positive relationship found by Schldt et al. (2005). They did not test for a nonlinear relationship between CVC investments and the level of knowledge transfer from the start-up. In this dissertation, it was found that, beyond a critical point, the relationship between the amount of CVC investment and the level of knowledge transfer either diminishes or results in negative returns.

This dissertation argued that both types of CVC structure and technological diversity of the parent firm moderate the curvilinear relationship between the number of CVC investments and the level of knowledge transfer. Both types of CVC structure and technological diversity were viewed as necessary for facilitating knowledge flow from the start-up to the parent firm. I argued that the level of knowledge sourced from the start-up would be lower when the parent firm invests directly in entrepreneurial firms rather than indirectly. I found the effect to be strong enough to moderate the relationship between the number of CVC investments and the level of knowledge sourced from venture firms. As seen in Figure 6.1, for a parent firm with strongly tied CVC structure, the level of knowledge transfer from the start-up is higher than it is for a parent firm with weakly tied CVC one.

Technological diversity was argued to moderate the inverted U-shaped relationship between the number of CVC investments and the level of knowledge transfer from the venture firm. As shown in Figure 6.2, I found that for a parent firm with high technological diversity, the rate of knowledge

transfer is higher than it is for a parent firm with medium and low technological diversity.

6.4 SUMMARY OF RESULTS

In summary, all of the hypothesized relationships suggested in this research were supported by findings. The number of CVC investments had a quadratic relationship with the level of knowledge transfer from the start-up to the parent firm. In addition, the relationship between the number of CVC investments and the level of knowledge transfer from the start-up was significantly moderated in strongly tied corporate venture programs. Finally, the relationship between the number of CVC investments and the level of knowledge transfer from the start-up was significantly moderated by the technological diversity of the parent firm.

CHAPTER 7

CONCLUSION

This chapter describes summary of the research, identifies potential implications of the results, and provides limitations of this dissertation and possible directions that could be taken by future research.

7.1 SUMMARY OF THE RESEARCH

This dissertation was motivated to investigate a single question: How does CVC investment by a parent firm affect knowledge transfer from the start-up? In order to answer this question, I employed two theoretical foundations: the concept of distant search and inter-organizational knowledge transfer.

First, based on the concept of distant search, I posited that search for external knowledge through CVC investments lead a parent firm to accessing and sourcing knowledge from the start-up. The results showed that there is an inverted U-shaped relationship between the number of CVC investment and the level of knowledge transferred from the start-up. In other words, as the number of CVC investments grows beyond a certain level, the impact of CVC investments on knowledge transfer diminishes. One explanation for this could be that managers of CVC programs are “bounded rational” (March and Simon, 1958). They may eventually face challenges to collect and process a wide scope of external knowledge from the start-up through CVC investments. In addition

to this, decision makers in CVC programs also operate under resource conflicts because there is limited organizational support to manage CVC activities.

Second, building on literature on inter-organizational knowledge transfer, this study argued that CVC structure and technological diversity moderate the curvilinear relationship between the number of CVC investment and knowledge transfer. I posited that strongly tied CVC structure would facilitate knowledge transfer more positively than weakly tied one. The results provided empirical evidence that for a parent firm with strongly tied CVC structure, the rate of knowledge transfer is higher than it is for a parent firm with weakly tied CVC structure. An explanation for this effect may be that a strong relationship between a CVC program and the parent firm provides the parent firm more opportunities for regular communication. In addition, a CVC program in a strongly embedded relationship with the parent has greater degree of trust to increase the level of knowledge transfer between organizations.

Finally, the present research also found that the U- shaped relationship between the number of CVC investments and knowledge transfer is moderated by technology diversity which is second potential moderator. In other words, a diverse technological knowledge base enhances the curvilinear relationship between the number of CVC investments and the rate of knowledge transfer.

7.2 CONTRIBUTION OF THE RESEARCH

This study makes several theoretical and empirical contributions to the literature on corporate venture capital and organizational knowledge transfer in general. In the following sections, these contributions are briefly discussed.

7.1.1 Theoretical contribution

One of contributions of the present research is to add understanding of corporate venture capital with rigorous empirical research focusing on the relationship between corporate investors and their portfolio firms. There has been the research gap in the rigorous empirical studies focusing on this relationship. Limited research on corporate venture capital has primarily relied on secondary data (Gompers and Lerner, 1998; Kelley and Spinelli, 2001, and Maula and Murray, 2000a). As a result, there is a lack of knowledge to understand the dynamics of these relationships. By using various theoretical perspectives and longitudinal data on a panel of 29 large firms in the ICT industries covering the period from 1995 to 2005, this current research contributed to a deeper understanding of the relationship between corporate investors and venture firms.

In addition to contributing to the scarce literature on CVC, the current research contributes to the literature on inter-organizational relationships. Although different theories such as learning theories, absorptive capacity and dynamic capabilities have been applied to the analysis of CVC activity, few studies in this research area have paid attention to network theories (Maula et al.,

2003b). By arguing theoretically and demonstrating empirically the importance of tie strength of CVC structure on organizational knowledge transfer, this current study extends the previous understanding and applicability of social capital to understand CVC activity.

This study also contributes to the search literature by conceptualizing CVC investment as distant search process to source external knowledge from the start-ups. The research showed that the effects of CVC investment on obtaining organizational knowledge across firm boundaries diminish beyond a certain point. This finding is consistent with the fact that organizations face the dilemma to balance between exploitation and exploration modes of learning (Levinthal and March, 1993). This finding also indicates that learning takes places only between organizations that are linked through knowledge transfer relationships and not between firms without those links (Ingram, 2002).

7.1.2 Managerial contribution

The findings of this research should be of interest to those who manage CVC programs, because the results provide important insights into management of CVC activities. For corporate investors to successfully source external knowledge through CVC investments, they need to understand which factors effectively facilitate knowledge flow from the start-ups. The results of this dissertation illustrate two factors to moderate the direct relationship between the number of CVC investments and the level of knowledge transfer from the start-up to the parent firm.

First, it is important for managers in CVC programs to understand which governance modes of CVC lead firms to more effectively source knowledge beyond the boundary of a firm. One of the key findings in this research is that the number of CVC investments which lead the parent firm to source external knowledge from the entrepreneurial organization is low, and increase in the number of CVC investments has it's a downward trend. This dissertation shows that the strongly tied CVC structure to a parent firm is more effective to facilitate knowledge transfer from entrepreneurial firms than the loosely tied one.

Second, the present study examines the role of technology diversity on the quadratic relationship between the number of CVC investment and the level of knowledge transfer from the start-ups. The results of this research empirically demonstrate that the level of technological diversity positively moderates the main relationship between the amount of CVC investments and the level of knowledge transfer from the start-up to the parent firm. Thus, managers should be advised to develop the scope of organizational knowledge for successful CVC activity.

7.3 LIMITATIONS AND FUTURE RESEARCH

This study has certain limitations which require future research. First, archival data used in this research may not be representative of the population of CVC investments. This study focused on U.S. public firms operating in the ICT industry. While the ICT industry is one of the top sectors for CVC investment,

the biotechnology industry itself accounts for more than 30% of total CVC investments in U.S. Thus, future studies need to gather data from a wide population and then examine where differences among various industry exist.

Second, this research on CVC investments only used US companies. This is a weakness of this research in terms of generalizability of the study result. Although most of CVC focused on US firms, some recent studies have also investigated CVC activities in other regions, for instance, Germany (Weber and Weber, 2005; Reichardt and Weber, 2006), Korea (Lim and Lee, 2006) or taking more global view (Birkinshaw et al., 2002). Therefore, by collecting data from different regions, the future study could focus on different cultural setting that influence the design or CVC programs and their effects on the rate of knowledge transfer from the start-up to the parent firm.

Third, the sample in this research only includes corporate investors from 1995 to 2005. Given the exceptional development in CVC investment during 1995-2005, there is always a concern for generalizing the results over other period of time. Thus, much wider range of periods is required to examine the effect of CVC investment on external knowledge transfer across firms.

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