The Effect of Alliance Portfolio Configuration on Innovative Performance of Entrepreneurial Firms:

A Study of Dedicated Biotechnology Firms

By

John Jen-wei, Liu

A thesis in fulfilment of the requirements for the degree of Doctor of Philosophy in Management

School of Management

UNSW Business School

January 2015

Table of Contents

List of Tables

List of Figures

List of Appendices

Originality Statement

I hereby declare that this submission is my own work and to the best of my knowledge it contains no materials previously published or written by another person, or substantial proportions of material which have been accepted for the award of any other degree or diploma at UNSW or any other educational institution, except where due acknowledgement is made in the thesis. Any contribution made to the research by others, with whom I have worked at UNSW or elsewhere, is explicitly acknowledged in the thesis. I also declare that the intellectual content of this thesis is the product of my own work, except to the extent that assistance from others in the project's design and conception or in style, presentation and linguistic expression is acknowledged.

Signed.....

Date.....Apr 2015

Copyright statement

Signed .....

Date ..... Apr 2015

Authenticity statement

Signed .....

Date ..... Apr 2015

Abstract

Alliance portfolio is the full set of alliances that a firm undertakes with different partners. Previous research has shifted the focus from the drivers and outcomes of individual alliances to the effects of alliance portfolio on firm-level outcomes. However, current research on alliance portfolio is inadequate in several aspects. First, different dimensions of alliance portfolio have been randomly chosen and inconclusively studied. Second, it is unclear whether alliance portfolio exerts its effect on innovation through tangible or intangible resources, or both. Third, it is unclear whether external resources obtained from alliances complement or are a substitute for the internal resources of the top management team. To address these gaps, I identified three key dimensions – size, diversity and intensity – of an alliance portfolio, and developed a theoretical model based on the resource-based view and firm capability perspective to examine the interactive relationships among various dimensions of portfolio on the innovative outputs of an entrepreneurial firm. I hypothesized a mediating role of alliance capital and a moderating role of the top management team's capability in the relationships between alliance portfolio and innovative outputs. The proposed theoretical model was tested on the archival data of 238 U.S. biotechnology firms who undertook 2501 alliances from their inception until 2009. Results based on negative binomial regressions showed that (1) portfolio size was positively related to innovative outputs, (2) portfolio diversity and portfolio intensity strengthened the positive relationship between portfolio size and innovative outputs, (3) the top management team's capability strengthened the moderating effect of portfolio intensity, and (4) portfolio size had both direct and indirect effects through alliance capital on innovative outputs. This thesis contributes to the literature on alliance portfolio by examining whether different

dimensions of alliance portfolio interactively affect innovation, whether alliance portfolio affects innovation both directly and indirectly through financial resources generated from the portfolio, and whether external portfolio resources complement internal top management team resources on innovation. The findings suggest that managers of entrepreneurial firms should actively manage their portfolio of alliances for diversity and intensity, and they should be aware of the complementarity of alliance and internal resources. (348 words)

Acknowledgements

Finally I produced a PhD thesis. My experience differed fundamentally from that of Christopher Columbus. Christopher Columbus did not know where he was going before he took off, did not know where he was when he arrived, and did not know where he had been after his return to Spain. Thanks to my sole supervisor, Professor Steve Lui, I now know where I have been in terms of writing a PhD thesis. At the risk of being a sycophant, I would like to thank Steve for his invaluable comments and support. Steve always made himself available to answer my questions, no matter how trivial! His detailed reading and comments are the sole factor leading to my producing a thesis that is acceptable for PhD.

I would also like to thank two external examiners for their comments. Thank you for taking time out from your busy schedule to examine my PhD thesis. Your helpful comments would make this a much more thorough and rigorous thesis.

The infrastructure support of Graduate Research School and School of Management allowed me to complete the thesis without unnecessary troubles. I am grateful for the support of staff from both organizations.

I wold like to thank Veronica Lin, who kindly provide technical helps and selflessly share her knowledge with me. She exemplifies what an aspiring academic should be, and is the best neighbour one can ask for. I thank professional editor, Dr Alison Basden, who provided copyediting and proofreading services, according to the guidelines laid out in the university-endorsed national *Guidelines for editing research theses*.

I would also like to acknowledge the financial support from Ms. Kao, R. C. and Mr. Liu, M.C. Although the findings from this thesis will probably not be much use for you two, but your generous financial support allowed me to complete this degree in a level of material comfort that few in my circumstances can afford. Thank you mom and dad. Finally, it goes without saying, all errors found in this thesis are mine alone.

Chapter 1: Introduction

1.1 Introduction

Recent alliance research has conceptualized the alliance network possessed by a firm as its alliance portfolio, and argues that the attributes of a given portfolio can have a significant effect on firm performance. Building on this line of research, this thesis examines how the configuration of the alliance portfolio affects the innovative output of entrepreneurial firms. Entrepreneurial firms are profit-seeking enterprises that are nascent in their given field or industry and therefore have fewer resources than their industry peers (Street & Cameron, 2007). Most studies have categorized entrepreneurial firms as firms less than 10 years old, and with annual revenue less than U.S. $100 million dollars (Park et al., 2002). Entrepreneurial firms face two distinct liabilities not faced by incumbent firms: young age (Stinchcombe, 1965) and small size (Baum & Oliver, 1996).

Given these two liabilities, forging external business alliances to obtain much needed resources and information becomes an indispensable strategic tool for entrepreneurial firms (Arora & Gambardella, 1990; Barley et al., 1992; Jarillo, 1989; Shan, 1990). Studies have shown alliances play a vital role in many firms' value-creation activities: obtaining resources that were previously unavailable (Eisenhardt & Schoonoven, 1996), reducing coordination costs (Jarillo, 1988) and integrating value chains (Larson, 1992; Uzzi, 1997). All these activities, in turn, enhance the financial performance (Stuart et al., 1999), rate of innovation (Stuart, 2000) and survival rate of entrepreneurial firms (Hoffmann & Schlosser, 2001). Both the industry phenomenon and empirical findings

demonstrate the prevalent use of alliances by entrepreneurial firms to enhance both survival rate and success, despite the limitations imposed by being new and small. For instance, newly established companies in knowledge-intensive industries, such as biotechnology, tend to form multiple alliances with various research-oriented universities and large pharmaceutical companies during the initial stage of product development (Pisano, 2006). Baum et al. (2000) showed that an alliance network configured at the founding of a firm has a positive effect on the firm's financial and innovative performance. In short, a major theme that has emerged from prior alliance research is that effective deployment of alliances is a critical determinant of entrepreneurial firms' success.

Recent research has conceptualized collections of inter-firm alliances as a holistic portfolio, referred to as the alliance portfolio (Wassmer, 2010). Focus on the alliance portfolio differs from other studies of alliance networks. An alliance portfolio approach concentrates only on the focal firm that initiates and manages a collection of alliances (Lorenzoni & Baden-Fuller, 1995; Parise & Casher, 2003). These studies show that the deliberately constructed alliance portfolio often enhances the focal firm's performance (Ozcan & Eisenhardt, 2009; Stuart, 2000). For example, Hoffmann (2005, 2007) found the amount of external resources made available to a focal firm depends largely on the size of its alliance portfolio. Bruyaka and Durand (2012) found the likelihood of a firm's successful exit from the market hinges on its diversified alliance portfolio, which signals to potential buyers the presence of complementary and resourceful business partners.

A common challenge among entrepreneurial firms is the need to simultaneously deal with the dual challenges of internal resources constraints and a high rate of external

technological discontinuities (Brown & Eisenhardt, 1995; Tushman & Anderson, 1986). Previous alliance portfolio research has shown that an alliance portfolio is instrumental in helping firms overcome these internal and external challenges. This study addresses these challenges in three ways. First, it focuses on the effect of the alliance portfolio on the entrepreneurial firm's innovativeness, and argues that a well-constructed alliance portfolio is particularly important to entrepreneurial firms whose survival depends on being the first to introduce innovative products onto the market (Schoonhoven et al., 1990). Second, this study argues that a well-constructed portfolio can provide access to various types of external partners, from whom the entrepreneurial firm can procure different types of essential resources (Rothaermel, 2001). These external resources could be proprietary know-how that allows the firm to adopt more radical innovative strategies (Faems et al., 2010; Wuyts et al., 2004), financial capital that provides for product developments and commercialization (Gopalakrishnan et al., 2008), or marketing networks that facilitate product distribution (Rothaermel & Deeds, 2004). The combination of these resources enables the entrepreneurial firm to develop new products and subsequent innovations. Third, this study expands on previous research that has highlighted the important role of the alliance portfolio, and examines how the interactions among different dimensions of the alliance portfolio affect the entrepreneurial firm's innovative outputs. This differs from previous research, which has tended to focus randomly on just one or two portfolio dimensions. The distinct focus of this study generates three research questions, presented in Section 1.3.

1.2 Research problem

Previous research findings show that the alliance portfolio contributes positively to an entrepreneurial firm's innovation effort, through providing access to new markets (García-Canal et al., 2002), complementary assets and capabilities (Deeds & Hill, 1996; George et al., 2001) and specialized knowledge (Powell et al., 1996), and by enhancing the firm's fundraising activities (Gulati & Higgins, 2003). While our knowledge of alliance portfolio and firm innovative performance has increased, most studies have examined just one or two random dimensions of the alliance portfolio, focusing, for instance, on either the portfolio's structural characteristics, such as size, or relational attributes of partnerships, such as the number of upstream research-oriented alliances (Baum et al., 2000; Powell et al., 1996; Rothaermetl & Deeds, 2004). This shortcoming has led to the first research gap identified here: that current research has not systematically considered how interactions among various alliance portfolio dimensions can affect the innovative outputs of the focal firm.

Moreover, previous studies have implicitly assumed that the larger and more diverse the firm's alliance portfolio, the higher the firm's innovative outputs, without addressing the mechanism of how the alliance portfolio enhances the firm's innovativeness (Cui & O'Connor, 2012). The need to clarify the mechanism of alliance resources is especially relevant to the acquisition of tangible financial resources that entrepreneurial firms need for their development. The second research gap, therefore, is that previous research has not examined the mechanism of how an alliance portfolio is converted into performance.

Lastly, while previous studies have examined the direct effect of the alliance portfolio on the innovative performance of entrepreneurial firms, few has yet considered

the internal resources of a firm simultaneously (Faems et al., 2010; George et al., 2001). In particular, this study argues that the role of a firm's senior management is critical, as it often has an overwhelming influence on the firm's strategic choices and portfolio management. The third research gap is, therefore, how senior management's capability interacts with the different dimensions of the alliance portfolio, and how it can affect an entrepreneurial firm's innovativeness. Section 1.3 below presents the three research questions developed to address these gaps in knowledge and Section 1.5 discusses the importance of addressing these gaps.

1.3 Objectives of the study

The objective of this study is to develop a theoretical framework that explains how different dimensions and contingent factors of the alliance portfolio affect the innovativeness of entrepreneurial firms. In light of this objective, this study proposes three specific research questions:

(1) How do different dimensions of an alliance portfolio interact to generate innovative outputs by an entrepreneurial firm?

(2) How do tangible financial resources procured externally from the firm's alliance partners mediate the effect of alliance portfolio on the innovative outputs of an entrepreneurial firm?

(3) How do top management team's capabilities interact with the firm's alliance portfolio to affect the innovative outputs of an entrepreneurial firm?

Altogether, nine hypotheses were tested to investigate these three research questions. Hypotheses 1–3 are concerned with the direct effect of portfolio size on firm's innovative outputs (H1), and the moderating effect of portfolio diversity (H2) and portfolio intensity (H3) on the direct relationship between portfolio size and innovative

outputs. Hypotheses 4–6 are concerned with the mediating role of tangible financial resources on the direct relationship of portfolio size and a firm's innovative outputs (H4), and whether this mediating relationship is enhanced with higher portfolio diversity (H5) and higher portfolio intensity (H6). Hypotheses 7–9 are concerned with the effect of senior management's capability on the alliance portfolio and innovative outputs: whether senior management's capability has a direct effect on innovative outputs (H7), whether there is a positive 3-way interaction among portfolio size, portfolio diversity and senior management's capability on the firm's innovative outputs (H8), and whether this is a positive three-way interaction among portfolio size, portfolio intensity and senior management's capability on the firm's innovative outputs (H9).

1.4 Research design

These nine hypotheses were empirically tested using 238 entrepreneurial firms operating in the biopharmaceutical industry in the United States. I examined the alliance portfolios initiated and managed by these 238 firms, which consisted of 2501 direct ties that were formed during the 19 years from 1990 to 2009. The biopharmaceutical industry was chosen as the empirical setting for three main reasons. First, the product outputs from the sector often involve major scientific and technological breakthroughs, and hence the products are considered highly innovative. Second, knowledge complexity underpins the biotech industry, and firms are often engaged in a network of alliances with institutions and organizations that offer compatible and complementary capabilities (Powell et al., 1996; Powell, 1998). Third, the industry itself is relatively young, emerging only in the 1980s, and hence it comprises a large number of entrepreneurial firms.

The selection of firms was limited exclusively to dedicated biotechnology firms, which are considered to be entrepreneurial firms engaged in producing knowledge-intensive products. The study focused exclusively on the innovative outputs of the human therapeutic products of dedicated biotechnology firms because, among all segments of the biopharmaceutical industry, such firms engaged have been recognized for their frequency of inter-firm alliances. These alliances result from the long development cycles and high demands for resources that are beyond the internal capacity of young and small entrepreneurial firms (Hagedoorn, 1993; Rothaermel, 2001; Shan, 1990). The number of new products under development by each firm was chosen as the independent variable, and was measured in 2010 to allow for a time lag between dependent variable and independent variable. Since the dependent variable (i.e., innovative outputs) is a positive integer, negative binomial regression was used for testing the hypotheses.

1.5 Potential contributions of the study

This thesis aims to contribute to alliance portfolio research in three ways. First, this study provides a more holistic understanding of an alliance portfolio by conceptualizing alliance portfolio as a multi-dimensional construct that consists of size, diversity and intensity. The multi-dimensional construct of the alliance portfolio allows for a more thorough investigation of how different dimensions of an entrepreneurial firm's alliance portfolio interact to generate innovative outputs. Such an approach offers a more comprehensive conceptualization of the alliance portfolio than previous research, which randomly chose just one or two portfolio dimensions to examine how the portfolio would affect firms' performance (Lin et al., 2009; McGill & Santoro, 2009).

Second, this study aims to delineate the mechanism by which alliance portfolio generates innovative outputs by considering the mediating role of tangible financial resources, procured externally from the firm's alliance partners. Examining the mechanism of how external resources are procured delineates different types of external resources that entrepreneurial firms can obtain from the alliance portfolio they configure. Such an approach provides empirical evidence for the positive contribution of alliance portfolio on a firm's innovative outputs through procuring tangible resources and, furthermore, highlights the utility of forming a large, diversified alliance portfolio.

Third, this study aims to address the synergetic effect of external resources from alliances and internal resources based on senior management by considering how top management teams' capabilities interact with their firm's alliance portfolio to jointly affect the innovative outputs of the firm. Specifically, this study examines the capability of senior managers to attract, recruit and select appropriate alliance partners that can complement the focal firm. Such an approach provides an extension to prior studies that have concentrated mostly on senior management personnel's background and social networks (Casper & Murray, 2005; Higgins & Gulati, 2006).

1.6 Organization of the thesis

This thesis comprises eight chapters and is divided into two major parts. The first part focuses on developing a new theoretical model to illustrate the relationship between alliance portfolio and the innovative outputs of entrepreneurial firms. Chapter 1 introduces the research topic and discusses the context of this research. Chapter 2, the literature review, discusses three dominant theories that are frequently employed in

inter-firm alliance research: transaction cost economics, resource-based view and social network theory. The chapter also identifies relevant research gaps and the three research questions. Chapter 3 summarizes current research on alliance portfolio, and proposes three related dimensions of the alliance portfolio – size, diversity and intensity – to be considered for alliance portfolio configuration. Chapter 4 develops a new theoretical model that relates alliance portfolio to innovative outputs of a firm, and proposes nine hypotheses based on the three research questions identified in Chapter 2.

The second part of the thesis describes the empirical testing of the theoretical model, and discusses the results. Chapter 5 describes the research context that this study employed for empirical testing. Chapter 6 presents the measurement of variables and the results from the analysis. Chapter 7 discusses the findings from the empirical testing. Chapter 8 presents the conclusions, highlights both the limitations and implications of this study and proposes possible future research directions.

Chapter 2: Literature Review

2.1 Introduction

The literature on the outcome of inter-firm alliances is dominated by three prevalent theoretical perspectives: Transaction Cost Economics (TCE), Resource-based View (RBV) and Social Network Theory (SNT). Prior research has identified many positive outcomes of inter-firm alliances based on these three perspectives, including reduced communication costs, acquisition of new resources, better coordination of value chain activities and increased rate of knowledge exchange (e.g., Eisenhardt & Schoonoven, 1996; Hoffmann & Schlosser, 2001; Jarillo, 1988; Staurt, 2000; Uzzi, 1997). Each of these three perspectives focuses on a distinct feature of inter-firm alliance: the transaction of the alliance, particularly in order to understand the governance aspect of the partnership (TCE), the characteristics of alliance partners, by examining the resources obtained from external partnerships (RBV), and the overall structure of alliance network and how it affects a firm's performance (SNT).

This review selected empirical studies that examined the effect of inter-firm alliance network on performance of entrepreneurial firms. I conducted the search using the general keywords *entrepreneurial firm alliance*, *small firm alliance*, *network of entrepreneurial firm*, and specific keywords relevant to the three proposed theoretical perspectives: *governance*, *transaction costs, resource acquisition, social network, social capital, network position*. The search was carried out in top-ranked management and strategic journals, including *Academy Management Journal, Academy Management Review, Administrative Science Quarterly, Long Range Planning, Journal of Law*

Economics and Organization, Organization Science, Research Policy, and *Strategic Management Journal*. I also included academic journals that are likely to be the outlets for entrepreneurial firms, such as *Entrepreneurship Theory & Practice, Journal of Business Venturing, Journal of High Technology Management Research, Journal of Small Business Management, Journal of World Business, Strategic Entrepreneurship Journal, Small Business Economics,* and *Strategic Organization.*

I focused only on empirical studies that discussed the role of inter-firm alliances from one of the three perspectives in the entrepreneurial firm setting, and selected studies that have been frequently cited. Once I identified a relevant paper, I first reviewed the theoretical section, including the stated hypothesis, to determine whether the paper was relevant to one of the three nominated perspectives. I then reviewed the research context to ascertain that the given study indeed focused on either small- and medium-sized companies or newly established firms, which would indicate the likely entrepreneurial behaviours by firms. Fifty-six papers were collected for this review, as summarized in Table 2.1.

The next three sections discuss the literature relevant to the three perspectives: TCE-based studies (Section 2.2), RBV-based studies (Section 2.3) and SNT-based studies (Section 2.4). Section 2.5 then summarizes the three perspectives, and Section 2.6 discusses the gaps in the current literature and presents the three research questions that inform this study. Finally, Section 2.7 presents a summary of the chapter.

Table 2.1: Review on inter-firm alliances of entrepreneurial firms

Journal article	Year	Theory	Research Setting	Independent Variable(s)	Dependent Variable(s)	Main Findings
Pisano, G. P. (1989) Using Equity Participation to Support Exchange: Evidence from the Biotechnology Industry. *Journal of Law, Economics, and Organization, 5*(1): 109-126.	1989	TCE	195 collaborations from biotech firms in California.	Presence of partial equity relationship between the entrepreneurial firm and the incumbent firm (1/0)	Performance of collaboration projects (R&D; Joint development; technology transfer agreements, marketing collaboration)	Using equity modes of collaboration would reduce potential transactional problems often associated with pure contractual mode of collaborations, since it align interests of entrepreneurial firms to the incumbent firm.
Jarillo, J. C. (1989) Entrepreneurship and growth: the strategic use of external resources. *Journal of Business Venturing*, *4*(2): 133-147.	1989	SNT	1902 SME firms in manufacturing-based industry.	Number of equity-based alliance with the alliance partner.	Annual sales growth rate	SME can acquire resources from the external network that the entrepreneur has tapped into.
Shan, W. (1990) An empirical analysis of organizational strategies by entrepreneurial high-technology firms. *Stategic Management Journal*, *11*(2), 129-139.	1990	TCE	278 biotech firms from PaineWebber Biotech Industry 86.	The existence of cooperative arrangement for the purpose of product commercialization.	Product diversity (Number of biotech products being commercialized).	Higher product diversity is influenced by the existence of cooperative arrangements.
Dubini, P. & Aldrich, H. (1991) Personal and extended networks are central to the entrepreneurial process. *Journal of Business Venturing*, *6*(5), 305-313.	1991	SNT	433 SME with less than 500 employees.	Diversity and density of the start-up's network	Effectiveness of start-up in planning and monitoring.	Understanding start-up's network must go beyond simple transaction view, and take into account its social context.
Larson, A. (1991) Partner networks: Leveraging external ties to improve entrepreneurial performance. *Journal of Business Venturing*, *6*(3): 173-188.	1991	TCE	Dyadic partnerships in 4 entrepreneurial firms with total 7 alliances.	Existence of mutual trust between partners	Network performance (occurrences of entrepreneurial firm's network moving from transactional to transformational relationship).	The dyadic alliances benefit both sides through 3 areas: product advances, administrative process improvements, and rapid response time
Larson, A. (1992) Network Dyads in Entrepreneurial Settings: A Study of the Governance of Exchange Relationships. *Administrative Science Quarterly*, *37*(1): 76-104.	1992	SNT	Dyadic relations between 7 entrepreneurial firms.	Perception of trust, reputation of the firm, presence of reciprocal relationship, mutual dependency	Evolution of dyadic econ exchanges to integration and control.	Long term oriented network rest on factors includes: trust, obligation, honesty, and reputation
Shan, W., Walker, G., Kogut, B. (1994) Inter-firm cooperation and start-up innovation in the biotechnology industry. *Strategic Management Journal*, *15*(2), 387 – 394.	1994	RBV, SNT.	85 start-up firms from *BioScan* 1989 that have 'research agreements' with established firms.	Start-up's position within the network (Number of inter-firm cooperation between start-up and established firms).	Innovation output (Number of patents grants by US PTO 1990)	The innovation output is impacted by number of cooperation as well as start-up's own position within the network.
Donckels, R. & Lambrecht, J. (1995) Networks and small business growth: An explanatory model. *Small Business Economics*, 7: 273-289.	1995	SNT	900 entrepreneurs in Belgium.	Attendance of various events at different level: regional trade fairs, national seminars, and international conferences	Growth of the firm (measured by sales figure)	Entrepreneurs with regional connections will be found significantly less frequently in the growth league than those with national and international contacts.
Deeds, D. L. & Hill, C. (1996) Strategic alliances and the rate of new product development: An empirical study of entrepreneurial biotechnology firms. *Journal of Business Venturing*, *11*(1): 41-55.	1996	RBV	714 alliances from 132 firms from *BioScan* in 1991.	Alliance of entrepreneurial firms with firms that have 'complementary' assets.	Rate of new product development for entrepreneurial firm.	The alliance of complementary firm exhibits 'U' shape performance curve, implying too many alliances will diminish and produce negative returns for the entrepreneurial firms.

Journal article	Year	Theory	Research Setting	Independent Variable(s)	Dependent Variable(s)	Main Findings
Human, S. E. & Provan, K. G. (1997) An Emergent Theory of Structure and Outcomes in Small-Firm Strategic Manufacturing Networks. *Academy of Management Journal*, *40*(2): 368-403.	1997	SNT	Comparative case study of two industry networks in the same industry	Structure of the network	Performance of the network	The formation and participation of SME network led to the information exchanges, organization credibility, financial performance.
Walker, G., Kogut, B. & Shan, W. (1997) Social capital, structural holes and the formation of an industry network. *Organization Science*, *8*(2): 109-125.	1997	SNT	101 biotech start-ups from *BioScan*.	Number of links with external parties	Dispersion of inter-group density	The formation of inter-org network is determined by social capital, not by the opportunities present from the network.
Uzzi, B. (1997) Social structure and competition in inter-firm networks: The paradox of embeddedness. *Administrative Science Quarterly*, *42*(1): 35-67.	1997	SNT	23 apparel firms with sales between USD $500,000 to USD $1,000,000,000.	Integration of the sourcing and production activities between the focal firm and its upstream and downstream partners.	Social relations of the firm: define by the degree of interaction between the firm and its customer and supplier.	Embedded ties based on trust offer several competitive advantaged to all involved firms: 1.Sharing of proprietary information; 2. Promotes econ of time
Deeds, D. & Hill, C. (1998) An examination of opportunistic action within research alliances: Evidence from the biotechnology industry. *Journal of Business Venturing*, 14: 141-163.	1998	TCE, SNT	132 small biotech firms from *BioScan*	Structural safeguard (presence of equity investment in the network)	Rate of new product development	The reduction of opportunistic behaviours in R&D alliances is most conductive via presence of strong social relations, rather than having complex contracts.
Weaver, K. M & Dickson, P. H. (1998) Outcome quality of small- to medium- sized enterprise–based alliances: The role of perceived partner behaviours. *Journal of Business Venturing, 13*(6): 505-522.	1998	TCE	2626 Norwegian manufacturing firms cross 10 industries.	Total number of alliances Existence of contractual relations (1/0)	Alliance outcome quality – measure by 5 point scale Financial performance – measure by 5 point scale	The performance of alliances in SME context is dependent upon the range of relationships, rather than on the firm size, financial strength and type of industries.
Lane, P. & Lubatkin, M. (1998) Relative absorptive capacity and inter-organizational learning. *Strategic Management Journal*, *19*(5), 461-477.	1998	RBV	69 alliances from 22 new biotech firms & 48 pharmaceutical firms	Participation rates of each firm in the same project – weighted participation rate measured by 5-point scale	New knowledge creation: measured by number of jointly published researches	This article argues that the choice of the teacher firm should be dependent upon the possibility of interactive learning of both teacher and student.
Stuart, T. E., Hoang, H., & Hybels, R. C. (1999) Inter-organizational Endorsements and the Performance of Entrepreneurial Ventures. *Administrative Science Quarterly, 44* (2): 315-349.	1999	SNT	301 small biotech firms back by venture capital	Technology partners represent by number of *patents* it jointly publish. Commercial partners represents by the existence of *equity* investments	The time it takes to go public Market capitalization of the firm	The survival and performance of SME depends upon the prominence of its partner. Having strong relationships with prominent firms give SME a vote of confidence to the outside world.
Baum, C. & Calabrese, T. (2000) Don't go it alone: Alliance network composition and start-ups' performance in Canadian biotechnology industry. *Strategic Management Journal*, *21*(3), 267-294.	2000	RBV	Survey of 142 biotech firms in Canada from 1991 to 1996	Initial configuration of the network including: Horizontal alliance, vertical-upstream alliance, and vertical-downstream alliance.	Performance of the firm (Revenue; R&D spending growth; number of patents gained).	How start-ups configure different types of alliance network can have an effect on overcoming its intrinsic characteristics of smallness and newness, and enhance its performance

Journal article	Year	Theory	Research Setting	Independent Variable(s)	Dependent Variable(s)	Main Findings
Human, S. & Provan, K. G. (2000) Legitimacy Building in the Evolution of Small-Firm Multilateral Networks: A Comparative Study of Success and Demise *Administrative Science Quarterly*, *45*(2), 327-365.	2000	SNT	Comparative case study of 2 SME networks in the same industry	Distinct administrative entity (Powerful lead firm; large pre-existing firm; broker firm).	Multilateral network – cooperation & integration of activities across multiple orgs. Orientation of the network: Internally focus V.S. externally focuses	The study examines how multilateral networks evolve to build its legitimacy.
George, G., Zahra, S. A., Wheatley, K. K. & Khan, R. (2001) The effects of alliance portfolio characteristics and absorptive capacity on performance: A study of biotechnology firms. *Journal of High Technology Management Research, 12*(2), 205 – 226.	2001	SNT	2456 alliances formed by 143 small biopharmaceutical firms.	Characteristic of the portfolio 1. structure - horizontal linkage - vertical linkage 2. Knowledge flow -knowledge generating alliance -knowledge access alliance	Financial performance-revenue Innovation performance-Products on the market rate	By viewing a firm's aggregate alliances as a 'portfolio of strategic agreements', the paper shows that firm's alliances would have different role and objective that impact its performance. The performance would also be 'modified' by its own capacity.
Hoffmann, W. H. & Schlosser, R. (2001) Success Factors of Strategic Alliances in Small and Medium-sized Enterprises--An Empirical Survey. *Long Range Planning*, *34*(3), 357-381.	2001	TCE, RBV	Survey of 164 of Austrian SMEs	Content-oriented variables: Asset-specificity, resources, partner resources. Process-oriented variables: Agreement among partners, support from top management, intent for partners to learn.	Success of the alliance	SME's success in its alliance effort is dependent upon trust, and compatibility to its partner.
Lee, C., Lee, K. & Pennings, J. (2001) Internal capabilities, external networks, and performance: a study on technology-based ventures. *Strategic Management Journal*, 22: 615-640.	2001	RBV, SNT	137 Korean start-ups in technology industries.	Internal resource conditions: entrepreneurial orientation, technological capabilities, financial resources. External network: Dyadic linkages to other types of organizations; Unilateral linkage to its sponsor.	Organizational performances: measured by growth in employment	Integrating both the internal resource conditions and external network of the start-up demonstrates that it is not wholly the prominence of the partner that matters, but the commitment of the partners as well.
Kelly, D. & Rice, M. (2001) Technology-Based Strategic Actions in New Firms: The Influence of Founding Technology Resources. *Entrepreneurship: Theory & Practice*, *26*(1), 55-73.	2001	RBV	67 public firms founded between 1984 and 1988 in computer and telecom industry.	Patent portfolio: No of patent counts & patent citations. Alliance formation: 1 if yes, 0 if no.	Innovativeness of technology resources at the firms founding: measured by expert rating	The more innovative the founding technological resources, the more likely the start-up will build patent portfolio and form alliances (particularly in R&D alliances) with other firms.
Rothaermel, F. T. (2001) Complementary assets, strategic alliances, and the incumbent's advantage: an empirical study of industry and firm effects in the biopharmaceutical industry. *Research Policy*, *30*(8), 1235- 1251.	2001	RBV	889 dyadic alliances by 324 DBFs from *BioScan*, cross referencing with SIC dataset.	Number of exploration alliance and number of exploitation alliance	New product development: New biotech products on the market	Incumbent firms that ally with start-up firms have better result in new product development. The alliance format tends to be exploitative in nature, than exploration.

Journal article	Year	Theory	Research Setting	Independent Variable(s)	Dependent Variable(s)	Main Findings
Park, S. H., Chen, R. & Gallagher, S. (2002) Firm Resources as Moderators of the Relationship between Market Growth and Strategic Alliances in Semiconductor Start-ups. *Academy of Management Journal, 45*(3), 527-545.	2002	RBV	171 US start-ups in semiconductor industry. Start-up is defined by its size and age: less than 10 years with annual revenue less than $100 million.	Perceived technology uncertainties within the industry. Type of alliances: exploration *vis-a-vie* exploitation	Alliance activities: Presence of alliance (1 or 0); diversity of alliance (types of alliances)	While firm's orientation to form alliances is dependent upon the perceived change in the market, it is contingent upon its internal resources conditions.
Davidson, P. & Honing, B. (2003) The role of social and human capital among nascent entrepreneurs. *Journal of Business Venturing*, *18*(3), 301-331.	2003	SNT, RBV	Interview of individual Sweden between ages of 25 to 44.	Human capital (background of the founder): credential, experience. Social capital: Bridging social capital (weak tie); Bonding social capital (strong tie).	Performance at of the firm at the emerging phase: First sales and profitability.	Human capital does not have strong impact comparing to social capital. In terms of social capital bridging capital has strong effect to bonding capital as the development progressed.
Soh, P. K. (2003) The role of networking alliances in information acquisition and its implications for new product performance. *Journal of Business Venturing*, 18: 727-744.	2003	SNT	Longitudinal studies of 48 computer network maker from 91 – 96.	Number of repeated partnership (represents relational embeddedness) Centrality position of the entrepreneurial firm (represents structural embeddedness)	Knowledge acquisition and subsequent new product development.	Dense ties foster by the firm's central position and trust among partners would lead to better collaboration among firms, and hence better produce performance.
Simsek, Z., Lubatkin, M. H. & Floyd, S. W. (2003) Inter-Firm Networks and Entrepreneurial Behaviour: A Structural Embeddedness Perspective. *Journal of Management*, 29(3), 427-442.	2003	SNT, RBV	Conceptual paper, no research setting provided	Relations of start-up firms with the network: structural, relational, cognitive	Behaviour of the start-up firm: firm's innovation, venturing, and strategic activities.	Entrepreneurial behaviour is shaped by the ongoing changes of firm's inter-firm relations.
Batjargal, B. N. & Liu, M. (2004) Entrepreneurs' access to private equity in China: The role of social capital. *Organization Science*, *15*(2), 159-172.	2004	SNT	160 venture capital firms in China	Social capital of the new venture: prior relations; 3rd party referral; strong tie. Technology product, business plan and quality of the team.	Decision to invest by venture capitalist. (1 if yes).	The start-up's social capital has significant impact to VC's decision to invest.
Rothaermel, F. T., & Deeds, D. L. (2004) Exploration and exploitation alliances in biotechnology: A system of new product development. *Strategic Management Journal*, *25*(3), 201-221.	2004	RBV	325 biotechnology firms that entered 2565 alliances over a 25-year period	Explorative alliances between firms: count variable that focuses on upstream activity of research Exploitative alliance between firms: count variable that focuses on downstream activity of marketing	Product in development: count variable of product being examine by regulatory agency. Product in the market: count variable of product available in the market.	New product development is the result of interaction between exploration and exploitative alliances.
Jack, S. (2005) The Role, Use and Activation of Strong and Weak Network Ties: A Qualitative Analysis. *Journal of Management Studies*, *42*(6), 1233-1259.	2005	SNT	Interviews with 14 entrepreneurs located at rural area of Scotland	Strong tie from immediate networks, weak tie from the extension of strong ties	Business generations and discovery of new opportunities	The study *extent* the 'strong & weak tie concept' and argues that it is how the tie is used rather than the frequency of interactions that sustain and grow the small business.

Journal article	Year	Theory	Research Setting	Independent Variable(s)	Dependent Variable(s)	Main Findings
Dickson, P. H., Weaver, K. M. & Hoy, F. (2006) Opportunism in the R&D alliances of SMES: The roles of the institutional environment and SME size. *Journal of Business Venturing*, *21*(4), 487-513.	2006	TCE, RBV	456 SMEs in manufacturing from 8 countries	Perceived opportunity behaviour of the partner: 5 item measure Institutional environment: 5yr national R&D expenditures	Type of R&D alliance the focal start-up is engaging. (Research VS Product development)	Firm's resource base (perceived in firm size) provides an significant moderating role in the R&D alliance.
Rothaermel, F.T. & Deeds, D. L. (2006) Alliance type, alliance experience and alliance management capability in high-technology ventures. *Journal of Business Venturing*, 21: 429 – 460.	2006	SNT	2226 R&D alliances from 325 biotech firms.	Alliance types- Define it by the type (upstream, horizontal and downstream) Alliance experience- Cumulative sum of total alliance duration	New Product development – total number of new products at 1997	The performance of the entrepreneurial firm's alliance portfolio is dependent upon its 'alliance management capability' and the capability is shaped by both the accrued experiences of the focal firm, and the different alliance types the focal firm has.
Maurer, I. & Ebers, M. (2006) Dynamics of social capital and their performance implications: Lessons from biotechnology start-ups. *Administrative Science Quarterly*, 51: 262-292.	2006	SNT	6 biotech firms in German	Different dimension of social capital: relational, structural, and cognitive relationship between start-up firm and its partners.	Start-up firm performance: measured by feedbacks of the industry firms.	Firms must continue to reconfigure, and manage its own social capital to utilize it to its fullest potential or else it becomes a liability.
Arend, R. J (2006) SME–supplier alliance activity in manufacturing: contingent benefits and perceptions. *Strategic Management Journal*, *27*(8), 741-763.	2006	RBV	200 SMEs from US that has less than 500 employees.	Existence of Upstream Vertical Alliance (1/0). UVA defined as linkage the entrepreneurial has to the larger incumbent firm within the same industry.	Market share gain by the SME.	SME can use 'upstream vertical alliance' to improve its performance.
Lechner, C., Dowling, M. & Welpe, I. (2006) Firm networks and firm development: The role of the relational mix. *Journal of Business Venturing, 21*(4), 514-540.	2006	SNT	60 start-ups, all less than 10 years old in German, Austria region across industries, but all are founded by VCs.	Network size- total no of important relationships Social network – total number of strong individual relations Reputational network – total nos of reputable partners Cooperative network – total no of tech alliance	Time for firms to reach break-even	It is the type of network (total 5 types offered) an entrepreneurial firm possess, rather than its size of network that would determine the success of entrepreneurial firms.
Reuer, J.J., Arino, A. & Mellewigt, T. (2006) Entrepreneurial alliances as contractual forms. *Journal of Business Venturing, 21*(3), 306-325.	2006	TCE, SNT	Survey of 257 German telecom firms	Asset specificity Relational capital Search cost (all measure with 5 point scales)	Contract complexity: Number of legal provision within the contract	The paper focuses on what determines contract complexity and choice of equity VS non-equity-based alliance. Contract complexity is dependent on search costs of new partner; while equity-base alliance is determinant upon asset-specificity.
Heimeriks, K. H., Duysters, G., Canhaverbeke, W. (2007) Learning mechanisms and differential performance in alliance portfolio. *Strategic Organization*, *5*(4), 373-408.	2007	RBV	Survey of 192 VP and alliance managers from IT and other industries.	Alliance experience – Number of alliance 'Integration' prior experience at individual level 'Institutionalize' prior experience at firm level.	Performance of the alliance: measured by achieving number of goals.	The study find experience and integrating prior experience produce positive effect, while institutionalizing prior experience 'might' not.

Journal article	Year	Theory	Research Setting	Independent Variable(s)	Dependent Variable(s)	Main Findings
Hallen, B. L. (2008) The Causes and Consequences of the Initial Network Positions of New Organizations: From Whom Do Entrepreneurs Receive Investments? *Administrative Science Quarterly*, *53*(4), 685-718.	2008	SNT	107 ties between internet security ventures and professional VCs.	Founder's initial tie & organization's previous accomplishment	Funding of the new venture (measured by amount of investment received by the start-up firms).	The cause of initial network formation can be determined by 2 factors: The ties the founder possess and the accomplishment of the organization itself.
Sarkar, M. B., Aulakh, P. S. & Madhok, A. (2009) Process capabilities and value generation in alliance portfolios. *Organization Science*, *20*(3), 583-600.	2009	RBV	Survey of 237 firms from industries drawn from *CorpTech Directory of Technology Companies*	Five-item Likert scale on: Partnering proactiveness, Relational governance, and Portfolio coordination	Performance of firm (ROA, ROE, ROI)	The paper argues that the firm's 'alliance portfolio management capability' is dependent upon the following 3 criteria: 1. proactively pursue alliance formation opportunities (Alliance proactiveness) 2. Engage in relational governance (relational orientation) and 3. coordinate knowledge and strategies across the portfolio (portfolio coordination)
Tsai, K.H. (2009) Collaborative networks and product innovation performance: Toward con a contingency perspective. *Research Policy*, *38*(5), 765-778.	2009	RBV	753 firms from 8 industries based on Taiwan Technological Innovation Survey	Four types of collaborations with supplier, customer, competitor, and university (dummy variables). '*Absorptive capacity*' as moderator variables- total R&D expenditures for the past 3 years / total no of employees this year	Product innovation- sales generated from 'new' products (define as introduce to the market in the past 3 years)	The study shows that firm's own absorptive capacity is a contingent factor that affect how different relations impact firm's product performances.
Zheng, Y., Liu, J. & George, G. (2009) The dynamic impact of innovative capability and inter-firm network on firm valuation: A longitudinal study of biotechnology start-ups. *Journal of Business Venturing*, *25*(6), 593-609.	2009	RBV, SNT	170 biotech start-ups for over 15 years. (1983 – 1994)	Innovation capability- number of patents granted to the start-up Inter-firm network- number of agreements with 'prestigious' partners.	Valuation of the firm- Total market value of the firm	Both the internal resources (innovation capability) and external resources (inter firm network) have impact on firm's valuation. As firms age, internal innovative capability play an increasingly important role than the firm network.
Manolova, T. S., Manev, I. M. & Gyoshev, B. S. (2010) In good company: The role of personal and inter-firm networks for new-venture internationalization in a transition economy. *Journal of World Business*, *45*(3), 257-265.	2010	RBV	Survey of 204 German SMEs in chemical, machinery, and auto that engage in R&D alliances	Alliance management capability: Coordination; Learning; Proactiveness; Transformation (all measures in 7 point Likert scale)	Alliance performance (4 point Likert scale)	Focus on defining the measurement for alliance management capability. Positive link between management capability and performance
Vanneste, B. & Puranam, P. (2010) Repeated Interactions and Contractual Detail: Identifying the Learning Effect. *Organization Science*, *21*(1), 186 – 201.	2010	RBV	Survey to 788 Dutch SME.	Prior interactions between the focal SME and its partner Number of repeated interactions	Contractual complexity: Technical details of the contract and legal details of the contract.	Repeated learning allows firms to develop technical details for its contract, hence enhance or protect itself on the technical side (more than legal)

Journal article	Year	Theory	Research Setting	Independent Variable(s)	Dependent Variable(s)	Main Findings
Zhang, J., Soh, P.H. & Wong, P.K. (2010) Entrepreneurial resource acquisition through indirect ties: Compensatory effects of prior knowledge. *Journal of Management*, *36*(2), 511-536.	2010	RBV	378 Individual-level interviews of entrepreneurs involved in high-tech firms less than 8 years old.	Tie strength -measured by duration & frequency Prior knowledge – knowledge and status of resource owner	1 if resource seeking is successful; 0 if failed	The success for entrepreneurs to gain needed resources not only depend on its own social ties, but also depend on the knowledge the resource owner has to its product / technology.
Adegbesan, J. A. & Higgins, M. J. (2011) The intra-alliance division of value created through collaboration. *Strategic Management Journal*, *32*(2), 187-211.	2011	TCE	200 R&D alliances by biotech firms that took place between 1991 and 2000.	Number of R&D alliances in which pharmaceutical firm is concurrently involved in early stage of R&D Number of R&D alliances in which pharmaceutical firm is concurrently involved in late stage of R&D.	Share of valuable pool of rights: the percentage of PS control rights won by the firm.	The amount of value an individual firm appropriates from an R&D alliance relative to its alliance partners depends on how the perceived value of the R&D, and how great its bargaining ability relative to its alliance partner.
Higgins, M. J., Stephan, P. E., & Thursby, J. G. (2011). Conveying quality and value in emerging industries: Star scientists and the role of signals in biotechnology. *Research Policy*, *40*(4), 605-617.	2011	SNT	89 small biotech firms conducting human or diagnostic research, with 44 for the first period (1990–1992) and 45 for the second period (1996–2000).	Presence of a Nobel Prize winner as a founder or member of the scientific advisory board Number of initial alliance with a pharmaceutical firm	Amount of proceeds raised from IPO	The number of initial alliances with pharmaceutical companies and the presence of Nobel Prized winner are complementary to the success of biotech firm's IPO activity.
Yu, J., Gilbert, B. A. & Oviatt, B. M. (2011) Effects of alliances, time, and network cohesion on the initiation of foreign sales by new ventures. *Strategic Management Journal*, *32*(4), 424-446.	2011	RBV, SNT	118 biotech ventures that have undertook IPO during the period 1990–2000.	Technology expertise of technological alliance partners: aggregate number of patents obtained by partners during the five years preceding each observation year. Marketing alliances with foreign firms: count of the number of marketing alliances with partnering firms	International sale of the firm	Resource derived from ventures' technology and marketing alliances increases the likelihood of firm's international sales.
Fuller, A. W. & Rothaermel, F. T. (2012) When stars shine: the effects of faculty founders on new technology ventures. *Strategic Entrepreneurship Journal*, *6*(3), 220-235.	2012	SNT	238 university research-related technology ventures	Presence of star scientists in the new university-technology ventures: defined by number of patents and citation received	Outcome for new technology venture: measured by one of four possible outcomes (IPO, Acquired, Remain private, and Failure).	The presence of star scientists is likely to facilitate new university-technology ventures to achieve an IPO than the lack of star scientist presence.
Haeussler, C., Patzelt, H. & Zahra, S. A. (2012) Strategic alliances and product development in high technology new firms: The moderating effect of technological capabilities. *Journal of Business Venturing*, *27*(2), 217-233.	2012	TCE, RBV	Survey of 343 British and 346 German biotechnology firms	Count of upstream, horizontal and downstream alliance Firm's technological capabilities(no. of techniques the firm employed for product development)	Number of new product development by the firm.	The benefits accrued to the firm from its alliance activities and the associated risks depend on the degree of internal technological capabilities the entrepreneurial firm possessed. The interaction is positive when the firm has strong internal technological capabilities.

Journal article	Year	Theory	Research Setting	Independent Variable(s)	Dependent Variable(s)	Main Findings
Lee, H., Kelley, D., Lee, J. & Lee, S. (2012) SME survival: The impact of internationalization, technology resources, and alliances. *Journal of Small Business Management*, *50*(1), 1-19.	2012	RBV, SNT	1,612 independent high-technology SMEs based in Korea	Firm's internal technology resources (measured by number of R&D employees to the firm). External R&D Alliances (measured by the number of R&D engagements with universities, government organizations, and private companies).	Survival rate: Measured by lack of occurrence of formal bankruptcy proceedings, or the discontinuance of the business for any reason when undertake export activities.	External R&D alliances have positive effect to survival rate, and the amount of export activities is moderated by the accumulation of technology resources within the firm.
Eberhard, M. & Craig, J. (2013). The evolving role of organisational and personal networks in international market venturing. *Journal of World Business*, *48*(3), 385-397.	2013	SNT	1304 Australian SME in manufacturing industry.	Inter-personal network (measured by the size of the manager's advice network). Inter-organisational network (measured by number of the link the SME has that led to either new business or a formal agreement).	Export intensity: ratio of exports to total sales	Both inter-personal networking and inter-organisational networking positively influence SME's export intensity.
Li, D. (2013) Multilateral R&D alliances by new ventures. *Journal of Business Venturing*, *28*(2), 241-260.	2013	SNT	173 new ventures involved in multilateral R&D alliances in high-technology industries	Multilateral R&D alliances measured in two ways: 1 when the multilateral R&D alliance is net-based and 0 when it is chain-based 1 when the R&D alliance is equity-based governance, and 0 when it was contract based	Market value of the firm	There exists a curvilinear relationship between the formation of multilateral R&D alliances by new ventures and the market value.
Pangarkar, N. & Wu, J. (2013) Alliance formation, partner diversity, and performance of Singapore start-ups. *Asia Pacific Journal of Management*, *30*(3), 791-807.	2013	RBV	Survey of 392 Singapore-based Internet companies.	Partner diversity (Number of different categories the firm has alliance). Categories: 1) universities/ research centres, 2) VCs/angel investors, 3) incubator canters, 4) entrepreneurial/networking organizations, 5) major customers, 6) government/ statutory boards	Firm Performance: 7-point Likert scale survey to measure perception of firm's performance in sales growth, profit growth, and market share	Start-up firms with a diverse set of alliance partner exhibits better performance than start-up firms that do not have a diverse set of partners.
Brouthers, K. D., Nakos, G., & Dimitratos, P. (2014) SME Entrepreneurial Orientation, International Performance, and the Moderating Role of Strategic Alliances. *Entrepreneurship Theory and Practice*, *38*(2), 341–363.	2014	RBV	700 privately held companies originating in the United States and the United Kingdom that had a maximum of 250 employee	Firm's joint research alliances and joint marketing alliances with local firms in its best performing foreign market.	Firm's international performance in a particular foreign market captured through three 7-point Likert-type questions.	The result indicate that privately held SMEs have higher international performance when the type of alliance (research or marketing) used is aligned with the resources possessed by the partnering firm.

Journal article	Year	Theory	Research Setting	Independent Variable(s)	Dependent Variable(s)	Main Findings
Milanov, H., & Fernhaber, S. A. (2014) When do domestic alliances help ventures abroad? Direct and moderating effects from a learning perspective. *Journal of Business Venturing*, *29*(3), 377-391.	2014	SNT	194 U.S. new ventures in computer equipment and communication industries that underwent an initial public offering (IPO) from 1995 through 2000.	Number of domestic alliance partners with international experience TMT international experience (measured in number of years)	New venture international intensity (Calculated by the percentage of foreign over total sales in the year following its IPO).	New ventures' international intensity is positively influenced by its previous alliance domestic experience, and alternatively is influenced by the new ventures' top management teams' international experience.
Vandaie, R., & Zaheer, A. (2014) Surviving bear hugs: Firm capability, large partner alliances, and growth. *Strategic Management Journal*, *35*(4), 566-577.	2014	RBV	150 small, independent studios in the U.S. motion picture industry during 1990–2010.	firm's capability which incorporate the heterogeneity of firm capabilities	Revenue growth of the firm	alliance partners may have negative influence to the internal processes of the focal firm, and therefore small firm’s growth diminished with higher the number of large partners

2.2 Transaction cost economics

Transaction Cost Economics (TCE) addresses the fundamental question of why firms exist. TCE considers a firm as a hierarchy that can allocate resources by command, and understands the existence of firms as a viable alternative in the market to minimize the transaction costs associated with economic activity (Coase, 1937; Williamson, 1975). From the perspective of TCE, how firms choose to organize their activities has paramount implications for their organizational boundaries. Firms usually make the decision to internalize (make) or procure externally (buy) the given economic activity based on three determinants: asset-specificity, frequency of transaction, and uncertainties (Williamson, 1985, 1991). In general, firms are more likely to source from the market if both the asset's specificity and market uncertainty are low. Conversely, a firm is more likely to internalize and take ownership of an asset if both the asset's specificity and the frequency of transactions are high. In the context of inter-firm alliances, TCE focuses on the governance choice for a given transaction, and places a different governance mode on the continuum between the parameter of make-and-buy decision.

Of the 56 papers reviewed, 19 adopted TCE perspective to examined governance choices for firms' inter-firm alliances. Most of these studies focused on how asset specificity, partner uncertainties and market uncertainties affect the choice of governance mode in a given alliance. The frequency of transaction has received relatively little empirical attention (Geyskens et al., 2006). The dependent variable that has received the most empirical attention is whether a firm should undertake a more integrative governance mode for its alliances (e.g., Folta, 1998; McGill, 2007; Santoro & McGill, 2005). The choice to make-or-buy is often a tenuous proposition for

entrepreneurial firms, since many of them possess insufficient means and resources to either undertake vertical integration or source directly from the market by themselves. Therefore entrepreneurial firms have to rely on varying levels of governance with their alliance partners as an alternative venue to carry out their make-or-buy decisions (Hoffmann & Schaper-Rinkel, 2001; Steensma et al., 2000). The decision for firms to opt for a more integrative governance mode in their alliances is seen as a formal safeguard for entrepreneurial firms to protect their valuable assets (Folta, 1998), because they take into account the complexity and difficulty for small and newly established firms to enforce their rights in a contractual relationship (Reuer et al., 2006). In addition, a more integrative governance mode is highly effective in aligning the interests of the firm and its alliance partners, and therefore it reduces incentives for alliance partners to misappropriate resources or behave opportunistically (Oxley, 1997).

From the literature review, I identified the four most frequently studied determinants to whether a firm should take a more integrative governance mode for its alliance. These were asset specificity, partner uncertainty, task uncertainty and technology uncertainty. Asset specificity refers to both tangible physical assets, such as plant, machinery and human resources, and intangible assets, such as brand name (Williamson, 1975). Most research focuses on theorizing how alliance-specific assets affect governance choice, arguing that as firms increase their investments in transaction-specific resources, the likelihood of opportunistic behaviour also increases, which generates appropriation hazards for the firm (Oxley, 1997). As a remedy, firms tend to opt for more integrated governance forms, where both firms have to make commitments and share mutual ownership of the transaction-specific assets (David & Han, 2004). In the context of inter-firm alliances of entrepreneurial firms, empirical research has found support for a positive relationship between the level of transaction-specific investment

and the adoption of more integrated governance form. For instance, Hoetker and Mellewigt (2009) have argued that an integrated governance form is better at safeguarding assets that can easily be codified and transmitted than is knowledge that cannot be specified.

Partner uncertainty refers to alliance partners' lack of familiarity of each other (Santoro & McGill, 2005). Partner uncertainty occurs because the two parties do not have prior ties that can generate partner-specific experiences (Goerzen, 2007; Stuart & Podolny, 1996). Studies have shown that repeated partnerships foster mutual trust and interdependence, which serve as an extra-contractual safeguard and are frequently utilized as a substitute to a more hierarchical governance mode (Gulati, 1998; Uzzi, 1997). Inversely, partners that are unfamiliar with each other face a high degree of uncertainty about both the intention and the likelihood of opportunistic behaviour by alliance partners, and therefore they resort to a more hierarchical governance to safeguard their own interests (Li et al., 2008; Santoro & McGill, 2005). For example, using alliances of biotech companies as the research context, Santoro and McGill (2005) found that the likelihood of adopting a more hierarchical governance mode increases when firms are more uncertain of their partners. Li et al. (2008) explicated the benefit of prior interactions in providing insight and information about a partner's behaviour, and argued that familiarity with one's alliance partner is negatively related to the choice of equity joint venture.

Task uncertainty refers to the complexity of monitoring and evaluating alliance partners' capabilities to coordinate and complete the required task (Santoro & McGill, 2005). Task uncertainty occurs because the alliance-specific task involves the exchange of tacit know-how and knowledge that cannot be easily codified (Casciaro, 2003).

Unlike partner uncertainty, where the firm is concerned with the likelihood of opportunistic behaviour by its partners, task uncertainty involves the difficulty of monitoring and evaluating a partner's contribution towards completing the task of increasing the complexity of the contract (Reuer et al., 2006). This is especially common in explorative-oriented alliances where the contractual complexity increases with task uncertainty, and therefore a hierarchical governance form, such as equity-based ties, is perceived to be more efficient in mitigating the negative effect of task uncertainty (Gulati, 1995).

Technological uncertainty refers to the pace of technological change and the effect it has on the rate of product obsolescence (Covin & Slevin, 1989; Steensm et al., 2000). When uncertainty increases, firms are compelled to increase the complexity of the contract in order to ensure efficient appropriation of their final outputs (Folta, 1998); however, with high technological uncertainty, where the rate of technological change is high and a new product can become obsolete quickly, increases in contractual complexity are found to be overly rigid and highly inefficient (Leiblein et al., 2002). In addition, entrepreneurial firms often lack the means of enforcing complex contracts (Reuer et al., 2006). To remedy this problem, entrepreneurial firms often respond to the increased technological uncertainty by opting to share the ownership of the transaction-specific assets with their alliance partners (McGill, 2007; Okamuro, 2007). Joint ownership of assets is particularly common for firms in knowledge-intensive industries. Here the pace of technology changes is extremely fast, which makes it difficult to specify all possible knowledge that needs to be shared in advance between the alliance partners (De Bettignies, 2008; Higgins & Rodriguez, 2006). The use of more hierarchical forms of governance resolves the problem of enforcing complex contracts

for firms; indeed, firms that enter into such alliances in times of high technological uncertainty are more likely to adopt a more hierarchical governance form.

Recent TCE literature has focused on the advantage of hierarchical governance forms in appropriating legal claims (Diestre & Rajagopalan, 2012; Kloyer, 2011; Kloyer & Scholderer, 2012). These studies have investigated the allocation of control rights, arguing that firms that possess more internal transaction-specific assets are likely to have more bargaining power *vis-a-vie* their alliance partners (Adegbesan & Higgins, 2011; Haeussler & Higgins, 2012; Haeussler et al., 2012). It argued that firms with a large number of patents pertinent to the alliance are likely to adopt a hierarchical governance form, not only to safeguard their assets from potential appropriation hazards and opportunistic behaviour, but also to claim a larger share of the economic profits generated by the alliance (Haeussler & Higgins, 2012). For instance, Kloyer (2011) found many research-oriented firms in the pharmaceutical industry often adopt the strategy of commercializing their research findings by forming joint ventures with alliance partners. These ventures can provide funding to produce and distribute the finished products, while retaining the right to sub-license research to third parties and the right for litigation of patent infringement. Such a strategy allows the relatively smaller research-oriented firms to maximize the economic value they can procure from their own assets.

In conclusion, TCE suggests that entrepreneurial firms that employ inter-firm alliances are likely to opt for a more hierarchical governance mode for their alliances when asset specificity, partner uncertainty, task uncertainty and technological uncertainty are all high. The choice of a hierarchical governance form allows the

entrepreneurial firm to protect its own proprietary assets while undertaking collaborative activities with its alliance partners.

2.3 Resource-based view

The resource-based view (RBV) focuses on resources possessed by the firm. From this perspective, firms within the same industry are able to differentiate themselves through possessing resources that are rare and difficult to replicate (Pfeffer & Salancik, 1978; Wernefelt, 1984). These resources can be both tangible, such as machinery, equipment and financial capital, and intangible, such as trademarks and brand recognition (Prahalad & Hamel, 1990). Firms that are able to combine their tangible and intangible resources, and utilize them more effectively than their competitors, are able to attain a sustainable competitive advantage (Barney, 1991, 2001). In the context of inter-firm alliances, RBV focuses on why and with whom firms form alliances, based on the resources the firms obtain from the alliances (Das & Teng, 2000).

Of the 56 papers reviewed, 17 adopted an RBV perspective to address motivations for inter-firm alliances. A common theme in these studies is that firms use inter-firm alliances as a strategic tool to gain additional resources from external sources that allow entrepreneurial firms to pursue opportunities that they could not otherwise do (Dubini & Aldrich, 1991). These studies argue that acquiring additional new resources from alliance partners allows entrepreneurial firms to enhance their survival rate (Brush et al., 2001; Cooper et al., 1994) and strengthen their competitive position (Eisenhardt & Schoonhoven, 1996). Some studies use TCE in conjunction with RBV to provide a complementary perspective in explaining entrepreneurial firms' mechanism and

motivation for the pattern of inter-firm alliances (e.g., Hoffmann & Schlosser, 2001; Street & Cameron, 2007).

The dependent variable that has received most empirical attention is the likelihood of alliance formation (e.g., Eisenhardt & Schoonhoven, 1996; Mowery et al., 1998; Park et al., 2002). Entrepreneurial firms enter into alliances because these firms often face a tenuous demand to be highly innovative and to be the first to introduce a new product to the market, yet they often lack sufficient internal resources (Schoonhoven et al., 1990; Teece, 1992). Therefore entrepreneurial firms have to rely on inter-firm alliances to provide access to resources from external sources (Baum et al., 2000; Powell et al., 2005). Even for firms that are relatively well endowed, the use of inter-firm alliances can ease the firm's resource burden by reducing the firm's resource commitment to a specific project, and allowing the firm to retain flexibility to react to the changing environment (Eisenhardt & Schoonhoven, 1996).

Inter-firm alliances allow entrepreneurial firms access to both tangible and intangible resources (Batjargal et al., 2004; Davidsson & Honig, 2003; Shane & Cable, 2002). The most common tangible resource that entrepreneurial firms seek is financial capital (De Carolis et al., 2009; Deeds et al., 1997), because many firms have insufficient internal financial resources to commercialize their discoveries (Shan, 1990). Firms also seek tangible technical knowledge, such as patents, and firms can frequently generate new technical knowledge by combining their existing knowledge with new knowledge from alliance partners (Phelps, 2010; Wuyts & Dutta, 2012). Entrepreneurial firms often use their experience from developing their own technical knowledge as the basis to identify, absorb and process new technological knowledge from their alliance partners, thereby

making appropriation of new knowledge much more effective than it would be otherwise (Wuyts & Dutta, 2012).

In addition, firms are likely to form partnerships with organizations if the alliance enhances the firm's legitimacy (Kelly & Rice, 2001). Entrepreneurial firms need to strengthen their legitimacy in order to overcome the liability of being new and small, and to develop their reputation, which eventually becomes an intangible resource (Stuart, 1999). These firms frequently use alliances with reputable organizations to validate their legitimacy (Zhang et al., 2009). Very often the acquisition of these three different resources (financial capital, patents and legitimacy) via inter-firm alliances is not mutually exclusive: firms are likely to seek financial capital from a reputable institution that can bestow legitimacy to the firm, such as venture capitalists or investment banks, prior to seeking any partners (Higgins & Gulati, 2006; Stuart et al., 1999).

While early research focused on procuring tangible and intangible resources from alliance partners, more recent studies have found the likelihood of the entrepreneurial firm forming an alliance with a specific partner depends largely on the fit of new resources with the entrepreneurial firm's pre-existing resources. This is because the firm's existing resource base and prior experiences form the basis of the firm's appropriation capability (e.g., Brouthers et al., 2014; Vandaie & Zaheer, 2014; Villanueva et al., 2012). For example, Brouthers et al. (2014) focused on the firm's capability, showing that firms with marketing experience are more likely to efficiently leverage their ties with foreign partners and overcome the liability of being a foreign organization seeking to enter new foreign market. Other studies found that pre-existing resources play a critical role in shaping a firm's strategic orientation, which determines

who the firm would select as its partners (Vandaie & Zaheer, 2014; Villanueva et al., 2012). In short, existing resource base and prior experiences are instrumental to the entrepreneurial firm's capacity to appropriate external resources.

In summary, RBV focuses on the motivation of firms forming inter-firm alliances, the primary motivation for which is to acquire complementary resources from external sources to supplement their existing internal resources. RBV focuses on the different type of resources that a firm can acquire externally through its alliance partners, and examines how these resources enhance the long-term competitiveness of the firm.

2.4 Social network theory

Social network theory (SNT) focuses on the alliance network's effect on the firm's performance. From the SNT perspective, firm performance is the result of the firm's position within its social network (Burt, 1987, 2000; Shan et al., 1994). Indeed, accepting certain positions within the network can be an advantage because it provides superior social capital to the firm (Burt, 2000). Although social capital has various definitions (Adler & Kwon 2002), the general consensus is that it consists of resources inherently embedded within networks of relationships at both organizational and individual levels (Davidsson & Honig, 2003; Stam & Elfring, 2008; Yli-Renko et al., 2001), and this social capital can be converted for the benefit of its owners (Coleman 1988; Nahapiet & Ghoshal, 1998). In the context of inter-firm alliances, SNT focuses on how firms leverage their alliance networks to generate social capital (Chung et al., 2000; Koka & Prescott, 2002).

Of the 56 papers reviewed, 20 adopted an SNT perspective to address how an entrepreneurial firm's social network affects its performance. These studies focused on how social capital contributes to identifying new opportunities and obtaining resources from external sources so the firm can then exploit new opportunities (Batjargal, 2003; Shane & Cable, 2002). These studies often employ SNT in conjunction with either TCE or RBV to develop their theoretical arguments. SNT complements both TCE and RBV. While TCE focuses on the formal mechanisms governing an alliance between two actors in the network, and sees the alliance as a purely market-based transaction with the intention of reducing transaction costs, SNT sees the alliance as reflecting the social relationship and being governed by socially accepted norms. While RBV argues that firms differentiate with their rare and valuable resources, SNT focuses on how firms can utilize their inter-firm alliances to enhance their social capital, which facilitates the firm's acquisition of rare and valuable resources.

According to SNT, social capital possessed by the firm and the entrepreneur come from two generic types of ties: strong ties that are direct, bonding relationships between the firm and its partner (Davidsson & Honing, 2003), and weak ties that are indirect, bridging relationships between the firm and its partner through an intermediary (Zhang et al., 2009). Both types of ties have been shown to serve a distinct function for entrepreneurial firms, yet they are not mutually exclusive (Shane & Cable, 2002; Jack, 2005). Since strong ties allow for better integration of activities between partnering firms (Ruef, 2002), firms with a larger number of strong ties are often found to have a denser and more centralized social network. On the other hand, since weak ties often lead to wider exposure of external environment (Granovetter, 1973), firms with a larger number of weak ties are often found to have a more decentralized network that contains

more structural holes (Uzzi, 1997; Walker et al., 1997) that allow for the introduction of novel concepts to the firm (Reagans & McEvily, 2008; Tiwana, 2008).

The dependent variable that has received the most empirical attention is firm performance (e.g., Florin et al., 2003; Hallen, 2008; Maurer & Ebers, 2006; Stam & Elfring, 2008). Studies have found firms with more direct strong ties are more likely to generate social capital that would provide the firm with better access to information and resources than its competitors (Burt, 2000; Coleman, 1990); however, the positive contribution of direct strong ties occurs only up to a threshold, after which the redundant ties generate a diminishing effect for the firm (Deeds & Hill, 1996; Lu & Beamish, 2006). The most productive social capital for entrepreneurial firms is generated when the firm is able to effectively combine its strong and weak ties, and leverage them as a whole (Chung et al., 2000; Inkpen & Tsang, 2005). Such social capital has a positive effect on firm performance, including higher survival rate (Batjargal 2003; Jarillo, 1989; Maurer & Ebers, 2006), higher rate of growth during early stages of development (Larson, 1991; Hite & Hesterly, 2001), higher likelihood of forming a technology cluster (Casper, 2007), higher likelihood of attracting new alliance partners (Walker et al., 1997; Gulati, 1995; Zhang et al., 2007), increased rate of filing patents (Ahuja, 2000; Chesbrough, 2003; Zahra, 1996) and more new product developments (Tasi, 2009; Tsai & Ghoshal 1998; Zheng et al., 2009). Social capital generated from an optimal combination of strong and weak ties also plays a positive moderating role in legitimizing new start-up ventures (Shane & Cable, 2002; Steier & Greenwood, 2000). Batjargal and Liu (2004) found entrepreneurial firms that have accumulated social capital with venture capitalists from prior interactions are more likely to have fewer contractual covenants when they receive investments. Stuart (1999) found entrepreneurial firms that have received endorsements from a reputable

intermediary, such as large investment banks or law firms, prior to their initial public offering are more likely to attract higher demand for their stocks than firms that do not.

A related stream of research focuses on how social capital at the inter-personal level affects the performance of entrepreneurial firms (Stam & Elfring, 2008; Wu et al., 2008). Such studies focus on the contributions of an entrepreneur's social capital to the early development and subsequent growth of a start-up (Dubini & Aldrich, 1991; Hite & Hesterly, 2001). Echoing the same theoretical logic at the firm level, the social capital of the founder entrepreneur sourced from the combination of weak and strong ties can provide the nascent firm with access to information (Birley, 1985), seed capital (Batjargal, 2003), recruitment of talent (Casper & Murray, 2005) and international growth (Prashantham & Dhanaraj, 2010). Recent studies examining the interaction of social capital at both organizational and personal levels have found the interaction dictates the entrepreneurial firms' rate of growth (Eberhard & Craig, 2013; Lee et al., 2012; Manolova et al., 2010; Yu et al., 2011). For instance, when an entrepreneurial firm seeks to enter new markets, of which the firm has neither prior experience nor knowledge, it often relies on senior executives' social capital to achieve its initial sales (Manolova et al., 2010; Milanov & Fernhaber, 2014).

The interaction between the individual and the firm's social capital is most pronounced in the recruitment of talent for entrepreneurial firms. Often, an entrepreneurial firm is a new start-up firm that attracts talent by having highly regarded individuals in its upper echelon (Gulati & Higgins, 2003). In such instances, the individuals' social capital acts as the *de facto* social network of the firm (Fuller & Rothaermel, 2012; Higgins et al., 2011). In other instances, the social capital of upper echelon personnel is used to facilitate collaboration between the entrepreneurial firm

and large industry incumbents, who can bestow resources and recognition to their smaller partners (Higgins et al., 2011; Ozcan & Eisenhardt, 2009).

In summary, SNT focuses on the effect of social capital to the survival, growth and performance of firms. It notes that the generation of social capital comes from the combination of strong and weak ties, with each type of tie providing a distinct contribution.

2.5 Summary and evaluation of the literature

The previous three sections have reviewed the contribution of inter-firm alliances to entrepreneurial firms via TCE, RBV and SNT. In summary, TCE addresses the issue of appropriation hazard and alliance governance, RBV addresses tangible and intangible resources that a firm procures from external sources through its alliances, and SNT addresses how the social capital of a firm affects its subsequent performance. Each of these three perspectives addresses a distinct aspect of entrepreneurial endeavour, which consists of identifying profitable opportunities, obtaining necessary resources and applying these resources to exploit these opportunities (Shane & Venkataraman, 2000). TCE explains how entrepreneurial firms can effectively safeguard their obtained resources by suggesting that firms can employ equity-based ties to minimize appropriation hazards from their alliance partners. RBV explains how entrepreneurial firms can obtain necessary resources by noting that firms often acquire necessary resources externally by forming multiple collaborative relationships with different owners of the resources. SNT explains how entrepreneurial firms can identify profitable

opportunities by noting that firms come across new opportunities through the relationships they possess with their industry counterparties.

The review of relevant studies highlights that entrepreneurial firms are more likely to expand the scope of their activities through inter-firm alliances than through internal expansion. This is because alliance networks allow entrepreneurial firms to remain flexible and react promptly to changes in the industry landscape (Ozcan & Eisenhardt, 2009). In addition to the strategic flexibility offered by the alliance, studies on the effect of inter-firm networks have increasingly found that most of the advanced knowledge that is crucial for innovation exists not within one single firm, but within a network of firms (Powell et al., 1996; Powell et al., 2005). Such insight suggests that entrepreneurial firms that operate in high-tech industries or aim to generate innovative outputs are more likely to successfully carry out their product development activities by formulating their own proprietary alliance networks, rather than relying solely on internal resources.

2.6 Research gap and questions

This section identifies the research gaps and the three research questions that form the focus of this study.

2.6.1 First research gap and Research Question 1

One of the common themes from reviewing the three different perspectives of TCE, RBV and SNT is their focus on the dyadic level of inter-firm alliances. The dyadic level

can be considered as a bilateral approach, since it focuses on individual transactions between a firm and its partner. A bilateral approach could be restrictive when a firm has multiple alliances and is embedded in a complex inter-organizational network (Das & Teng, 2002; Kenis & Knoke, 2002; Hoffmann, 2007). Limiting an analysis to individual transactions at the exclusion of all other transactions overlooks the full effect of a portfolio of alliances (Hakansson & Ford, 2002; Oliver, 2001). A portfolio approach is more appropriate than a restrictive bilateral approach, because it simultaneously takes into account the whole alliance network, focusing on a single firm that initiates and manages all these inter-firm alliances (Bamford & Ernst, 2002; Parise & Casher, 2003). A portfolio-level approach of inter-firm alliances has led researchers to focus on the configuration, management and performance of the alliance portfolio (Wasser, 2010).

This study employs a portfolio level of analysis to understand how an entrepreneurial firm can utilize its inter-firm alliances to overcome the 'liability of newness' and 'liability of smallness' when it attempts to innovate. The portfolio level of analysis is encapsulated with the conceptualization of 'alliance portfolio' that is discussed in the following chapter. This study builds on previous research of alliance portfolios (see Jiang et al., 2010; Wasser, 2010), and goes a step further to recognize different portfolio dimensions. Such recognition is informed by TCE, which distinguishes between more hierarchical and less hierarchical forms of governance in the presence of equity-based ties. As a result, the alliance portfolio of each firm differs because the firms have different types of partners within their portfolios and different proportions of strong ties within each portfolio, depending on the number of equity-based ties present.

No previous research has systematically examined the interaction among these different dimensions. This study addresses this research gap by examining inter-firm

alliances at the portfolio level and investigating how different dimensions of the alliance portfolio interact with each other to generate innovative outputs for entrepreneurial firms. Based on such reasoning, the first research question focuses on the systematic interactions among different portfolio dimensions, and how such interactions affect the innovative outputs of entrepreneurial firms.

Research Question 1: How do different dimensions of an alliance portfolio interact to generate innovative outputs by an entrepreneurial firm?

2.6.2 Second research gap and Research Question 2

The literature review of RBV has demonstrated that one of the driving motivations for entrepreneurial firms to form inter-firm alliances is the ability to procure external resources from alliance partners. More specifically, entrepreneurial firms seek to procure both tangible and intangible resources which the firm can then utilize to enhance its performance. Firms most commonly seek tangible financial resources, yet few previous studies have examined the mechanism by which entrepreneurial firms utilize their alliance portfolio to enhance their innovative outputs.

This study addresses this gap in understanding by examining the mediating role of tangible financial capital that firms procure externally from their alliance portfolio, known as alliance capital (Coombs & Deeds, 2000). Furthermore, this focus on alliance capital also confirms the effect of alliance capital on entrepreneurial firms' innovative outputs. Previous studies have largely focused on identifying attributes of the alliance that would lead to the generation of alliance capital (Deeds & Decarolis, 1999; Gopalakrishnan et al., 2008); however, empirical evidence remains inconclusive about

the relationship between alliance capital and a firm's innovative outputs (Baum & Silverman, 2004; Schilling & Phelps, 2007). This study examines the mediating role of alliance capital between the alliance portfolio and innovative outputs, in order to provide empirical evidence of the effect of alliance capital. Lastly, a direct examination of tangible financial resources illuminates the indirect role of intangible resources on enhancing an entrepreneurial firm's innovative outputs.

Research Question 2: How do tangible financial resources procured externally from the firm's alliance partners mediate the effect of alliance portfolio on the innovative outputs of an entrepreneurial firm?

2.6.3 Third research gap and Research Question 3

The literature review of SNT affirms the critical role of social capital in strengthening a firm's competitive position within the industry. Social capital provides important contacts that help newly established entrepreneurial firms gain access to the critical resources it needs to increase its innovative output (Maurer & Ebers, 2006). What remains unanswered from previous research is how internal resources, such as capability at the firm's upper echelon, interact with the alliance resources that the firm has procured. Capability at the firm's upper echelon is critical to an entrepreneurial firm's success: while the social capital of the upper echelon helps to facilitate alliances with well-known institutions on the firm's behalf (Baum et al., 2000; Fuller & Rothaermel, 2012), it is the knowledge of upper echelon personnel that dictates the selection of appropriate partners on behalf of the entrepreneurial firm. This study addresses the shortcoming in previous research by focusing on the upper echelon's

capability. By also incorporating the external resources from alliances, this study hypothesizes that the capability of the upper echelon is likely to interact positively with external resources procured from the firm's alliances, to jointly enhance the entrepreneurial firm's innovative outputs.

Research Question 3: How do top management team's capabilities interact with the firm's alliance portfolio to affect the innovative outputs of an entrepreneurial firm?

2.7 Chapter summary

This chapter has reviewed three theoretical perspectives –TCE, RBV and SNT – to understand why small and young entrepreneurial firms form inter-firm alliances, how they benefit from their alliance partners and how they govern their multiple alliances. Based on the review, I have argued that each perspective understands inter-firm alliances from a dyadic level, with a singular focus on individual transactions, and that such approach is overly restrictive when considering the cumulative effect of inter-firm alliances on entrepreneurial firms.

The chapter has identified the portfolio level as a more appropriate level of analysis and argues for the need to systematically examine different dimensions of alliance portfolio. Moreover, this chapter has highlighted the lack of clear understanding about what type of external resources firms procure, and how the alliance portfolio interacts with the firm's upper echelon to shape the entrepreneurial firm's innovative outputs. Finally, the chapter has presented the three research questions that enabled this study to address the current gaps in knowledge identified from the literature review.

Chapter 3: Theoretical Conceptualization of Alliance Portfolio

3.1 Introduction

An inter-firm alliance, in its broadest scope, is a collaborative arrangement for a specific objective of the parties involved (Das & Teng, 1996). These collaborative arrangements encompass a variety of formats, such as contractual alliances, customer and supplier agreements, R&D collaboration, joint ventures and various other types of collaborations (Grant & Baden-Fuller, 1995). The previous chapter discussed these collaborative arrangements from a dyadic level, and described how TCE focuses on the governance structure of alliances, RBV focuses on the different types of tangible and intangible resources that could be procured externally, and SNT focuses on how interactions within the network affect the firm's performance. This chapter shifts the level of analysis to the portfolio by incorporating the concept of alliance portfolio (Wassmer, 2010), which allows for a systematic examination on how entrepreneurial firms utilize all their inter-firm alliances to obtain resources and enhance performance.

Alliance portfolio has been widely employed across different industries, and studies have found that the configuration of alliance portfolio has a significant effect on the performance of the focal firm (e.g., Dyer & Nobeoka, 2000; George et al., 2001; Powell et al., 1996). In the context of a capital-intensive industry, such as automobiles, firms that can take advantage of their alliance portfolio are found to retain their incumbent status and produce higher returns on investments (Dittrich et al., 2007). In contrast, in an innovation-oriented industry, such as software, firms that consistently reconfigure

their alliance portfolio in line with changing industry conditions have a high survival rate (Lavie, 2007). In both contexts, the presence of an alliance portfolio provides advantages to the firm, such as gaining speedy access to new markets through targeted partnerships (Garcia-Camel et al., 2002), acquiring assets and capabilities which specifically complement the focal firm's existing resource endowments (Deeds & Hill, 1999; Rothaermel, 2001), and absorbing specialized knowledge (Powell et al., 1996).

The concept of alliance portfolio is especially relevant to understanding how the aggregation of collaborative arrangements affects the performance of entrepreneurial firms. Entrepreneurial firms are constrained by their small size and insufficient internal resources, yet they often need to meet multiple strategic objectives in order to succeed (Hoffmann, 2005; Lavie, 2007). What distinguishes the alliance portfolio of the entrepreneurial firm from that formed by well-established incumbents is that the entrepreneurial firm's alliance portfolio needs to serve multiple objectives simultaneously in order to increase the firm's survival rate (Ozcan & Eisenhardt, 2009), while incumbents often configure their alliance portfolio as a response to technological shifts in the industry (Vassalo et al., 2004). For example, small biotech firms in the biopharmaceutical industry often adopt the strategy of simultaneously forming research-oriented and production-oriented alliances in order to ensure that their innovations in the lab can be successfully commercialized. On the other hand, large pharmaceutical firms, by the virtue of their pre-existing distribution networks, often form only research-oriented alliances with external parties to take advantage of new research emanating from universities and small biotech firms (Baum et al., 2000; Stuart et al., 2007). In short, the underlying aim of inter-firm alliances for entrepreneurial firms is to overcome their inferior strategic position *vis-a-vie* competitors. Therefore, by taking into account both synergetic potentials and countervailing effects that can occur from a portfolio of

alliance partners (Lavie, 2006; Lavie & Rosenkopf, 2006), one can better understand how entrepreneurial firms attain superior performance via inter-firm alliances (Baum & Silverman, 2004; Jiang et al., 2010).

This chapter focuses on the different dimensions of the alliance portfolio configuration. Section 3.2 provides an overview of previous research, and Section 3.3 discusses definitions for the different dimensions of the alliance portfolio configuration used in this study. Section 3.4 provides the framework that links alliance portfolio configuration to the innovative performance of the entrepreneurial firm, based on the theoretical perspectives of the RBV and firm capability perspective. Section 3.5 provides a brief summary of this chapter.

3.2 Summary of previous alliance portfolio research

Research on alliance portfolio first emerged in the late 1990s as alliance researchers began to aggregate the firm's dyadic alliances and examine the cumulative effect of alliance networks on firm performance (George et al., 2001; Powell et al., 1996). What distinguishes the alliance portfolio from prior conceptualizations of alliance network is its *egocentric* focus (Dyer & Nobeoka, 2000; Gulati, 2007). Specifically, an alliance portfolio focuses on the firm that initiates and manages the portfolio, and frequently refers to it as the focal firm of the alliance portfolio (Hoffmann & Schlosser, 2001). Focal firms that succeed in generating a more effective portfolio configuration will achieve superior performance than their industry peers (Ozcan & Eisenhardt, 2009), as such focal firms are perceived as the 'strategic centre' that is actively collaborating with different types of partners to enhance its own competitiveness (Lorenzoni & Baden-

Fuller, 1995). Table 3.1 provides a review of recent studies on alliance portfolio and firm performance published in major management journals.

Table 3.1: Review of research on alliance portfolio

Journal Article	Year	Research Question	Analytical Framework	Research Setting	Independent Variable(s)	Dependent Variable(s)	Major Findings
Dyer, J. H. & Nobeoka, K. (2000) Creating and managing a high-performance knowledge-sharing network: The Toyota case. *Strategic Management Journal*, 21: 345-367.	2000	How does Toyota manage the process of sharing its knowledge at network level?	Toyota constructs a production network by developing bilateral and multilateral knowledge-sharing routines with its suppliers and partners within its network.	Interview 6 divisions of Toyota and 20 of its first-tier suppliers.	Phase 1: Create supplier association Phase 2: Link supplier association with Toyota Phase 3: Create sets of teams to rotate through suppliers for inter-firm learning and sharing.	Effective knowledge management among firms at the network	Firms build effective network through institutionalizing both organizations and routines of sharing and learning at network-level.
Stuart, T. E. (2000) Interorganizational alliances and the performance of firms: a study of growth and innovation rates in a high-technology industry. *Strategic Management Journal*, 21: 791-811.	2000	How do technology alliances impact the focal firm's performance?	The focal firm build 'portfolio of strategic coalitions' based on the resource profile of its partners.	150 global semiconductor firms from 1985 to 1991.	Inter-organizational alliances: 5 types of 'Horizontal' alliances between two semiconductor firms: joint product development, joint venture, technology exchange, licensing and marketing agreements.	Rate of innovation: patent citations Rate of sales growth: Sales of the firm in 1991	The advantage of AP is not determined by the size of portfolio but the characteristics of the partners, and inter-corporate alliances should be conceived as *access relationships* to partner's resources.
George, G., Zahra, S. A., Wheatley, K. K., & Khan, R. (2001) The effects of alliance portfolio characteristics and absorptive capacity on performance: a study of biotechnology firms. *Journal of High Technology Management Research*, *12*(2), 205-226.	2001	How do characteristics of alliance portfolio affect the absorptive capacity of the firm?	Social relational perspective	2456 alliances formed by 143 biopharmaceutical firms.	Characteristic of the portfolio: measured by the structure and the knowledge flow of the network. Structure is comprised of number of horizontal linkages & vertical linkages. Knowledge flow counts number of alliances that serve the function of knowledge generation & knowledge accesses.	Financial performance-measured by firm's yearly revenue Innovation performance-measured by number of products introduced to the market	By viewing a firm's aggregate alliances as a 'portfolio of strategic agreements', the paper shows that firm's alliances would have different role and objective that impact its performance. The performance would also be 'modified' by its own capacity.
Bamford, J. & Ernst, D. (2002) Managing an alliance portfolio. *McKinsey Quarterly*, 3. 29-39.	2002	How do firm systematically manage its alliance portfolio?	An alliance scorecard that integrated firm's AP fitness in financial, strategic, operational and relationship.	500 firms around the world (clients of McKinsey)	Financial fitness, strategic fitness, operational fitness and relationship fitness	Performance of the portfolio.	An effective portfolio management needs to be considered at the portfolio-level, and examines from multiple aspects.

Journal Article	Year	Research Question	Analytical Framework	Research Setting	Independent Variable(s)	Dependent Variable(s)	Major Findings
Parise, S. & Casher, A. (2003) Alliance Portfolio: Designing and Managing network of business-partner relationships. *Academy of Management Executive*, *17*(4), 25-39.	2003	How to design and manage a company's network of relationship based on a portfolio approach?	A portfolio approach perceives multilateral relationships as *collaborative network*.	Theory-based paper.	Design: Interdependency of partners & dynamic composition. Individual alliance: Relationship levers based on trust & knowledge exchange. Knowledge management: Processes and tools under possession.	Performance based on balance-score card approach that includes financial, operational, and relational measures.	A portfolio approach requires the incorporation of multilateral relations, dyadic relations and management of knowledge.
Vassolo, R. S., Anand, J. & Folta, T. B. (2004) Non-additivity in portfolios of exploration activities: a real options-based analysis of equity alliances in biotechnolog. *Strategic Management Journal*, 25: 1045–1061	2004	How does real options models explain firm behaviour under conditions of multiple investments?	Portfolio of exploration activities: alliances as simultaneous strategic investments in order to maximize 'option on the maximum value of several assets'	30 pharmaceutical firms with the most equity alliances in 1989 from BioScan and North Carolina directory	Industry Uncertainty: the standard deviation of a biotechnology stock index: Technology distance: measure of distance between equity partners in a pharmaceutical firm's alliance portfolio.	Decision (*termination*) on existing equity alliances. Acquisitions were coded '1' if the pharmaceutical firm acquired their biotechnology partner, '0' otherwise. Divestitures were coded 1 if the pharmaceutical firm exited a biotechnology partnership, and '0' otherwise.	This paper shows the importance to emphasis on the interactions between the portfolio and the firm, and suggests that models excluding such interactions risk being underspecified.
Wuyts, S., Dutta, S., & Stremersch, S. (2004) Portfolios of interfirm agreements in technology-intensive markets: consequences for innovation and profitability. *Journal of Marketing*, *68*(2), 88-100.	2004	What is the effect of portfolio characteristics on radical innovations?	Role of inter-firm network in generating technological diversity & repeated partnering	991 R&D agreements by 59 pharmaceutical companies from 1985 to 1998.	Technological diversity: follows Powell, Koput, and Smith-Doerr (1996) measurement of diversity Repeated Partnering: measured by the extent to which firms cooperate with the same partners in a given period of time.	Radical innovation: measured as the total number of new radical drugs of firm i that received FDA approval in year t.	High technological diversity and repeated partnerships have significant, positive effect to radical innovation of the portfolio.
Faems, D., Van Looy, B. & Debackere, K. (2005) Interorganizational Collaboration and Innovation: Toward a Portfolio Approach. *Journal of Product Innovation Managemen*t, 22: 238–250.	2005	How do inter-organizational collaborations benefit the innovation performance of the firm?	Diverse network of inter-organizational collaborations provides focal firm 1) access to complementary asset 2) encourage transfer of knowledge 3) spread costs of R&D.	Community Innovation Survey (CIS II) conducted with 2,164 Belgian manufacturing firms in 1997.	Inter-organizational collaborations agreements based on 7 types of partners: firms in the same industry, competitor, customer, consultant, supplier, universities, and research institute.	Innovation performance: Based on the survey	Positive relationship exist between Inter-organizational collaborations agreements and firm's innovation condition the firm build its alliances based on the portfolio approach, and form the agreement in the context of its own innovation strategies.

Journal Article	Year	Research Question	Analytical Framework	Research Setting	Independent Variable(s)	Dependent Variable(s)	Major Findings
Goerzen, A. & Beamish, P. W. (2005) The effect of alliance network diversity on multinational enterprise performance. *Strategic Management Journal*, *26*(4), 333-354.	2005	What is the effect of alliance network diversity on economic performance, and whether MNC have the organizational competency to manage the growing collection of alliances?	Portfolio Diversity variables: partner diversity, product, geographic, network size, industry, international experiences, capital structure, firm size, proprietary assets.	580 Japan-based MNEs. 13529 survey by the subsidiary.	Alliance Network Diversity: No of unique (not repeated) Intl JV partnerships, no of unique host country partner, no of unique industry partners.	Economic Performance: Operational profits (rather than net).	A disagreement with Powell et al (96) that network is conductive for performance, the paper argue network diversity does not necessarily led to higher performances
Reuer, J. J. & Ragozzino, R. (2006) Agency hazards and alliance portfolios. *Strategic Management Journal*, 27: 27-43.	2006	Does agency theory (separation of ownership & management) contribute to the formation of portfolios of IJV?	Agency Theory and Real options theory	All manufacturing firms in SIC 3000-3999 firms from 93 – 97.	Inside ownership: equity held by its officer & directors Financial leverage: debt / market capitalization. Multi-nationality: no of countries firm has foreign subsidiaries Acquisition: Firm's investment in acquisitions.	IJV Portfolio: No of equity JV from 93-97.	Firm formulate its international portfolio as the result of its concern on the best form of 'governance structures'
Dittrich, K., Duysters, G. & de Man, A. P. (2007) Strategic repositioning by means of alliance networks: The case of IBM. *Research Policy*, *36*(10), 1496-1511	2007	How does alliance network facilitate firm's large-scale strategic changes?	Network characteristic of exploration and exploitation-based strategy.	Longitudinal case study of IBM from 1991 to 2002.	(Focus on partner characteristics) exploration alliance -non-equity, high turnover, unrelated expertise Exploitation alliance -equity, low turnover, related expertise.	Strategic positions of the firm- production or service-oriented business	Firms can use its alliance network to shift its strategic posture from exploitation to exploration.
Heimeriks, K. H., Duysters, G. & Vanhaverbeke, W. (2007) Learning mechanisms and differential performance in alliance portfolios. *Strategic Organization*, *5*(4), 373-408.	2007	How does management mechanism affects performance of alliance portfolio?	Knowledge-based theory, esp. organizational learning	Survey of 192 Dutch internet firms	Alliance experience – number of years the alliance has formed prior at both individual level & firm level.	Perception of alliance performance from 1997 to 2001	Employment of alliance mechanism significantly improve the performance of firm's alliance portfolio

Journal Article	Year	Research Question	Analytical Framework	Research Setting	Independent Variable(s)	Dependent Variable(s)	Major Findings
Lavie, D. (2007) Alliance Portfolios and firm performance: A study of value creation and appropriate in the U.S. software industry. *Strategic Management Journal,* 28: 1187-1212.	2007	How do resources and competitive position of alliance partner affect the focal firm's performance?	Value creation mechanism, and the resources it generates; as well as value appropriation that distribute available profits among the focal firm and its partners.	367 US software firms from 1985 to 2001, and study the alliance activity from 1990 to 2001.	Network resources: Comprise of 5 variables (Technology network, marketing, financial, human, network prominence), measured by proxies of mean value. Relative Profits: Differences between partner and focal firm's RoA Alternative Tie: Ratio of alliances between partners and focal firm. Bilateral competition: percentage of match of primary industry of focal firm & partners Multilateral competition: Proportions of sales generated by firms based on industry	Market performance: Annual changes in the market value of firm's common stock by averaging 12 end of month value.	The study focus on 'inherent characteristics of the partners'. The focal firm's market performance is determined by how much network resources it generated from the portfolio and how it appropriates such resources.
Heimeriks, K. H., Duysters, G. & Canhaverbeke, W. (2007) Learning mechanisms and differential performance in alliance portfolio. *Strategic Organization*, *5*(4), 373-408.	2007	How learning mechanism at different experience level produce different performance effects of the portfolio?	Learning mechanism that impacts firms' portfolio performance is composed of two levels: group level of integrative mechanism & organizational-level of institutionalizing mechanism.	Survey of 192 VP and alliance managers from IT and other industries.	Alliance experience – number of years the alliance has formed prior at both individual level & firm level.	Achieving of goals stated in alliance portfolio.	The study finds experience and integrating prior experience produce positive effect, while institutionalizing prior experience 'might' not.
Goerzen, A. (2007) Alliance networks and firm performance: The impact of repeated partnerships. *Strategic Management Journal*, *28*(5), 487-509.	2007	What is the effect of repeated equity partnership to firm's performance?	Alliance Network: Relations with home country firms, relations with host country firms.	sample of 580 Japanese MNCs	Repeated partnerships: No of repeated equity alliance with home country + No of repeated equity alliance with host country firms = Total no of repeated relations.	Firm's economic performance- Return on capital	The repeated equity alliance with the same partner produced 'negative' effect on firm's performance.
Hoffmann, W. H. (2007) Strategies for managing a portfolio of alliances. *Strategic Management Journal*, 28: 827-856.	2007	What are the types of portfolio strategies at the business level, and how it interacts with business strategy and environment?	Alliance Portfolio: No of alliances, dispersion of the alliance, redundancy of the alliance, linkage intensity.	Two case studies (transport system, energy production) from Siemens between 1990 and 1999.	Alliance portfolio configuration: number of alliances based on contract, JV and minor equity, respectively.	Financial performance: measured by net operation profit after taxes & return on capital employed	3 Portfolio strategy: shaping, adapting and stabilizing are available for different environments.

Journal Article	Year	Research Question	Analytical Framework	Research Setting	Independent Variable(s)	Dependent Variable(s)	Major Findings
Lavie, D. & Miller, S. R. (2008) Alliance portfolio internationalization and firm performance. *Organization Science*, *19*(4), 623-646.	2008	How foreignness of partners in the portfolio affects the firm's financial performance?	Alliance Portfolio Internationalization (API): National differences in culture, location, institutions and economic between the focal firm and its partners.	Alliances of 330 US software firms (SIC 7371-7374) from 1990 to 2001.	API: Partner's country origin, cultural distance, geographic distance, institutional distances, economic distance. Foreign Partner experience: No of prior experiences	Financial performance: ROA	As foreignness of partners in the portfolio increase, the performance will initially decline, then improve, and decline again due to over-internationalization.
Yli-Renko, H. & Janakiraman, R. (2008) How Customer Portfolio Affects New Product Development in Technology-Based Entrepreneurial Firms. *Journal of Marketing*, *72*(5), 131-148.	2008	How do the customer portfolios affect new product development of technology-based entrepreneurial firms?	3 dimensions of customer portfolio: (1) the portfolio size, (2) revenue concentration (the extent to which the firm is dependent customers for its revenues), and (3) the relational embeddedness of relationships between the customer and the firm.	Longitudinal data on young firms in UK that operates in business-to-business markets in six technology-based industries.	*Size of the customer portfolio*: number of customers theirfirms sent an invoice to in 1997. *Revenue concentration within the customer portfolio*: percentage of total revenues in 1997 that came from the firm's single largest customer. *Relational embeddedness of the customer portfolio*: supplier and customer relationships adopted from Larson's(1992) study.	*New product development*: the count of new products developed by each firm during the 1998–2003	The results indicate that customer portfolio size has an inverse U-shaped relationship to the number of new products developed and that the more relationally embedded the customer set, the more new products the firm develops.
Heimeriks, K. H., Klijn, E. & Reuer, J. (2009) Building capabilities for alliance portfolios. *Long Range Planning*, *42*: 96-114.	2009	How firms build capabilities for its alliance portfolio?	Portfolio capabilities based on four operational dimensions: Functions, staffing, tool based training, and third party relationship.	192 firms over 3400 alliance from 97 to 2001.	Alliance portfolio size as categorical variable: No of alliances established 1997 – 2001. Alliance practices: 14 different practices as binary variable	Performance: percentage of original goals realized between 1997 and 2001.	Firm need to build capabilities in all 4 areas to successfully develop large alliance portfolios.
Ozcan, P. & Eisenhardt, K. M. (2009) Origin of alliance portfolios: Entrepreneurs, network strategies, and firm performance. *Academy of Management Journal*, *52*(2), 246-279.	2009	What is the role of top managers in high-performing alliance portfolio?	High-performing AP as the result of focal firm develop more central network position that allow it to accrue information, reputation and resources, as well as attracting best partners.	Case studies of 6 private US firms in wireless gaming industry.	Portfolio attributes (4 measurements): Diversity, Prominence of partners, Tie strength, Centrality of focal firm (see App B for detailed sub-measurements of each)	Firm performance: Market penetration as the proxy to its financial performance.	Firm that create high performing alliance conceive its portfolio based on the unique industry architecture it wants to create, instead of forming it as series of single ties.
Sarkar, M. B., Aulakh, P. S., Madhok, A. (2009) Process capabilities and value generation in alliance portfolios. *Organization Science*, *20*(3), 583-600.	2009	What are the set of process and patterns that conceptualized alliance portfolio management capability?	Alliance Portfolio Capital is consisted of 3 dimensions: Reputation of the focal firm, relational bond with partners, collective competiveness of the portfolio. .	Interview of 25 senior managers in alliance from 21 firms in multiple industries.	5-iteam scale survey to each area (see Table 2 for detailed questions) that measure the following: partnering proactiveness, relational governances, portfolio coordination, and alliance portfolio capital.	Market performances: scales in 4 aspects, including: (1) market share, (2) sales growth, (3) maker development, product development	alliance portfolio management capability can be understood from three dimensions: Formation, Relational, and Coordination

Journal Article	Year	Research Question	Analytical Framework	Research Setting	Independent Variable(s)	Dependent Variable(s)	Major Findings
Faems, D., De Visser, M., Andries, P., & Van Looy, B. (2010) Technology Alliance Portfolios and Financial Performance: Value-Enhancing and Cost-Increasing Effects of Open Innovation. *Journal of Product Innovation Management*, *27*(6), 785-796.	2010	How do technology alliance portfolios affect the financial performance of the firm?	Technology alliance portfolio is the result of the combination of impact by both value-enhancing and cost-increasing of the firm's strategy.	526 manufacturing firms based in Belgium that introduced at least one product or process innovation between 2002 and 2004 or that were engaged in innovation activities between 2002 and 2004	Product innovation performance: measured as the proportion of turnover in 2004 attributed to new or strongly improved products that the company introduced between 2002 and 2004 and that were new to the market	Technology alliance portfolio: the extent to which an organization collaborates with 6different kinds of partners, including: (1) suppliers; (2) customers; (3) competitors; (4) consultants; (5) universities; (6) research institutes	Empirical confirmation for the assumption of existing research that technology alliance portfolio diversity has an indirect positive impact on financial performance via increased product innovation performance.
Jiang, R. J., Tao, Q. T. & Santoro, M. D. (2010) Alliance portfolio diversity and firm performance. *Strategic Management Journal*, *31*(10), 1136-1144.	2010	How do variance in partner, functions and governance affects its financial performance?	Alliance Portfolio Diversity: 1. Partner diversity in industry, organization and national background. 2. Functional diversity in R&D exploration and marketing, manufacture, distribute exploitation. 3. Governance diversity in equity VS non-equity.	Global Auto Industry (SIC codes 3714, -51) from 1985 to 2005.	Industry diversity based on SIC code Organizational diversity Function diversity Governance diversity (see: MEASUREMSNET AND DATA SOURCES)	3 year average net profit margin (2000 – 2002 & 2005 – 2007).	Multidimensional construct AP that is built upon functional and governance diversity.
Duysters, G. & Lokshin, B. (2011) Determinants of Alliance Portfolio Complexity and Its Effect on Innovative Performance of Companies. *Journal of Product Innovation Management, 28*(4), 570-585.	2011	How do 'alliance portfolio complexity' impact focal firm's innovation?	Alliance complexity is determined by 1) International and domestic scope of AP 2) the variety of different alliance types in the portfolio	1800 firms from CIS survey in 98 and 2000.	Diversity: 4 Partnership Types Competitor, customer, supplier, and university research center Orientation: domestic partners (based in Netherland) and foreign partners (non-Netherland).	Innovativeness: Binary variable depending on whether the firm introduce new product to the market between 1998 to 2000.	Alliance portfolio complexity in terms of partner diversity allows the focal firm to scan and detect novel information.
Lavie, D. & Singh, H. (2012) The evolution of alliance portfolios: the case of Unisys. *Industrial and Corporate Change*, *21*(3), 763-809.	2011	How does alliance portfolio evolved from initiation to maturity?	Alliance Portfolio configuration is composed of partner composition and nature of the alliance relationships.	Case study on Unisys from 1990 to post 1999	(textual information derived from interviews and news periodicals Org structure Line of business Firm strategy Technology	Alliance Portfolio configuration: Network structures, Type of partners, type of agreements, nature of alliances, existence of joint activities, value proposition partners, alliance organization.	The configuration of alliance portfolio evolved with changes both macro- and micro- conditions.

Journal Article	Year	Research Question	Analytical Framework	Research Setting	Independent Variable(s)	Dependent Variable(s)	Major Findings
Yamakawa, Y., Yang, H., & Lin, Z. J. (2011) Exploration versus exploitation in alliance portfolio: Performance implications of organizational, strategic, and environmental fit. *Research Policy*, *40*(2), 287-296.	2011	How do firm's AP (understood as exploration Vis-a-vie exploitation orientation) affect its performance	AP Orientation (as the ratio of focal firm's exploration to exploitation).	95 firms from 5 industries over 8 years.	AP Orientation: ratio of focal firm's exploration to exploitation. Age: Based on no. of yrs since inception. Strategic orientation: based on previous work of Hambrick (93). Industry growth: growth rate of product shipments.	Firm Performance: RoA	The effect of AP orientation to firm's performance is moderated by firm's internal condition and the external industry environment.
Duysters, G., Heimeriks, K. H., Lokshin, B., Meijer, E. & Sabidussi, A. (2012) Do Firms Learn to Manage Alliance Portfolio Diversity? The Diversity-Performance Relationship and the Moderating Effects of Experience and Capability. *European Management Review*, *9*(3), 139-152.	2012	Do firms learn to manage alliance portfolio diversity?	Portfolio diversity has an inverted-U-shaped effect on the performance, unless it is moderated by experience.	Alliance Capability Assessment survey. The survey, conducted in 2006, covers strategic alliance activities, including: strategic supplier relationships, minority stakes, joint ventures, cross-licensing arrangements, joint marketing agreements, and research consortia.	Alliance portfolio diversity: Based on Herfindahl index derived from alliance types a firm reports being engaged in.	Alliance portfolio performance: Share of alliances in firm's portfolio that were successful. Categorical variable, taking values = 1, 2, 3, 4, and 5 according to five-point Likert scale (0–20%, 21–40%, 41–60%, 61–80%, 81–100%).	The findings show a curvilinear relationship between diversity and performance. More important, the study shows the key processes based on experiences through which firms learn to manage alliance portfolio diversity.
Mouri, N., Sarkar, M. B., & Frye, M. (2012). Alliance portfolios and shareholder value in post-IPO firms: The moderating roles of portfolio structure and firm-level uncertainty. *Journal of Business Venturing*, *27*(3), 355-371.	2012	How do structural differences between portfolios affect IPO firm's performance?	Alliance portfolio structure: vertical scope & functional diversity.	Manufacturing firms that IPO in 1996	Vertical scope of AP: No of alliances/ No of alliance partners. Functional diversity of AP: 4 categories: Product development mgmt., supply chain mgmt., customer relations mgmt., technology mgmt.	Firm performance: 4 years of shareholder return since the firm IPO.	Firms that possessed higher functional diversity is valued higher than firms than have high vertical scope.

Journal Article	Year	Research Question	Analytical Framework	Research Setting	Independent Variable(s)	Dependent Variable(s)	Major Findings
Oerlemans, L. A., Knoben, J. & Pretorius, M. W. (2013) Alliance portfolio diversity, radical and incremental innovation: The moderating role of technology management. *Technovation*, *33*(6), 234-246.	2013	How does alliance portfolio capability influences the relationship between alliance portfolio diversity and a firm's innovation outcomes?	Specific dimension of alliance portfolio diversity, namely, alliance portfolio partner diversity	Survey of South African firms in manufacturing, services, and wholesale with 10 or more employees that conducted economic activities in the period 1998–2000.	Partnerships with eight types of partners: (1) buyers, (2) suppliers, (3) competitors, (4) consultants, (5) research institutes, (6) universities, (7) own business group, and (8) an open category labeled 'other'.	innovation outcomes: self-reported measures of innovativeness that were developed for the Community Innovation Survey (CIS)	This suggests that the use of formal technology management practices is beneficial to manage highly diverse alliance portfolio with the inverted U-shaped relation between alliance portfolio diversity and a firm's innovation outcomes.
Caner, T. & Tyler, B. B. (2013) Alliance portfolio R&D intensity and new product introduction. *American Journal of Business*, *28*(1), 38-63.	2013	Whether alliance portfolio R&D intensity contributes to the number of new product approvals?	Focal firms' upstream and downstream alliances as part of the alliance portfolio	821 firm year observations for 146 biopharmaceutical firms operating in the USA	Alliance portfolio R&D intensity: Coded each alliance in a firm's alliance portfolio as either R&D or other.	number of new product approvals by U.S. FDA.	R&D intensity of firms' alliance portfolios is positively related to the focal firm's new product introductions.
de Leeuw, T., Lokshin, B. & Duysters, G. (2014) Returns to alliance portfolio diversity: The relative effects of partner diversity on firm's innovative performance and productivity. *Journal of Business Research*, *67*(9), 1839-1849.	2014	How do different types of technological alliances resulted in alliance portfolio diversity, and affect firm's performance?	Alliance portfolio diversity based on the partner types, and the effect it has to different dimensions of firm performance.	5 consecutive Community Innovation Surveys (CIS) conducted in 1996, 1998, 2000, 2004, and 2006 that includes 13,909 observations on11,279 innovating firms from a wide range of industries	Alliance partner Diversity: ratio of the number of partner types in the firm's alliance portfolio in 7 different types (customers, suppliers, competitors, commercial laboratories, research institutes, universities, and subsidiary firms)	Productivity performance: logarithm of sales per employee. Radical innovations: new products, and services. Incremental innovations: refinements in existing products, and services	Partner type diversity in a firm's alliance portfolio has an inverted U-shaped relationship with productivity and radical innovative performance and a positive relationship with incremental innovative performance.

The differences between alliance portfolios from more traditional studies of alliance network, such as alliance bloc, can be illustrated by comparing different industries. Typically, an alliance bloc competes with other alliance blocs to achieve a superior strategic position for its bloc members (Gomes-Casseres, 1997; Hoffmann, 2005). The airline industry is a classic example of such a phenomenon, with companies from different regions and nations allying with each other, and gradually evolving into three major alliance blocs – Star Alliance, SkyTeam and Oneworld – that compete for market share and flight routes (Gomes-Casseres, 2003). On the other hand, alliance portfolio focuses solely on how the portfolio of ties can enhance the competitive position of a single firm (Lavie & Miller, 2008; Wassmer, 2010). For instance, many firms in the biopharmaceutical industry have formed alliance portfolios in order to have better access to information and external resources that could benefit their own product development (Powell, 1998; Powell et al., 2005). Indeed, an alliance portfolio is initiated and managed exclusively for the benefit of the focal firm (Hoffmann, 2005, 2007). In short, the major distinction that separates alliance portfolio from alliance bloc is that, with alliance portfolio, economic benefits accrued from the alliance are usually retained solely by the focal firm, whereas with alliance bloc they are shared among its members (Hite & Hesterly, 2001).

The review on alliance portfolio shows that early studies largely aggregated all the focal firm's alliances and examined the cumulative effect of alliances on the firm's performance (Deeds & Hill, 1996; Deeds & Hill, 1999; Shan, 1990). The aggregation of all alliances is based on the rationale that this is the most effective way to account for the synergetic effect of external resources that the focal firm procures from its alliance portfolio (Stuart, 1999). These studies examined the effect of portfolio size on the firm's performance across a range of industries, including airline, automobile, biotech,

microprocessor and information technology (e.g., Lazzarini, 2007; Powell et al., 1996; Vanhaverbeke & Noorderhaven, 2001).

These studies demonstrated that superior performance can be attained when the company forms alliances in a deliberate fashion (George et al., 2001; Parise & Casher, 2003) and manages the collection of its alliances by maximizing their utility (Bamford & Ernst, 2002). For instance, Ahuja (2000) found that the more direct ties in a firm's egocentric network (i.e., alliance portfolio), the more innovative output the firm would accrue. While most studies have largely found a linear relationship between the number of direct ties and the number of innovation outputs (Ahuja, 2000; Baum et al., 2000; Stuart et al., 1999), in some cases the expected positive relationship was found to exhibit a curvilinear relationship, in which the performance of the focal firm reached a plateau once the aggregated alliances reached a certain size (Deeds & Hill, 1996). Such a phenomenon generated a stream of studies that have focused on the design of the alliance portfolio (Parise & Casher, 2003) by addressing the question of how the focal firm could effectively manage large number of alliances (Hoffmann, 2005, 2007).

One of the most frequent criticisms of focusing just on the aggregated size of the alliance portfolio is that it neglects to consider the different characteristics of alliance partners. Consequently, subsequent studies have shifted the focus away from portfolio size to the portfolio's diversity (e.g., Jiang et al., 2010; Wuyts & Dutta, 2012). These studies considered the portfolio's composition: type of tie, partner characteristics and purpose of the partnership (Duysters & Lokshin, 2011; Duysters et al., 2012). What is distinctive among studies of alliance portfolio diversity is the absence of a universal definition of what constitutes portfolio diversity, because different studies have defined diversity in different ways based on their particular research objective (Wassmer, 2010).

Diversity can be defined and measured by the purpose of the alliance (Baum et al., 2000), types of partners (Powell et al., 1996), and combinations of both partner and partnership types (Powell et al., 2005). Other studies have defined portfolio diversity based on the types of technological and business specializations that the focal firm engages in with its alliance partners (Jiang et al., 2010; Santoro & McGill, 2005). Typically, such studies are more interested in the strategic orientation of the firm than in the performance of the alliance (Wratschko, 2009; Yamakawa et al., 2011). For instance, Wratschko (2009) examined a firm's portfolio diversity based on the type of business the focal firm engages in with its alliance partner, and the type of technology that the alliance employs to determine if the focal firm is oriented toward R&D or commercialization.

Measuring portfolio diversity in different ways, depending on the objective of the study, has allowed researchers to study different outcomes. For instance, Bruyaka and Durand (2012) examined the role of portfolio diversity in the successful exit of high-tech firms. Zhang et al. (2007) found that the knowledge diversity sourced from different types of partner within the alliance portfolio positively affected the firm's subsequent alliance formation. Other studies have aggregated diversities across different levels, such as diversities in partnership, organization, ownership and institution, in order to explain variations in performance among homogenous firms (Cui & O'Connor, 2012; Jiang et al., 2010; Yamakawa et al., 2011). For instance, Jiang et al. (2010) defined portfolio diversity based on the partner's organizational background, including its national origin and ownership status, and found wide variations of portfolio diversity for a relatively homogenous group of firms that were the result of heterogeneities in partners' national origin, industry background and organizational attributes.

In addition to portfolio size and portfolio diversity, some studies have incorporated the concept of 'tie strength' from social network theory, and have examined the effect of alliance intensity on the firm's performance (Aggarwal & Hsu, 2009; Santoro & McGill, 2005). Since alliance studies typically define equity-based agreements as the most hierarchical governance mode (e.g., Folta, 1998; McGill, 2007), firms with a large number of equity-based agreements are perceived to have high portfolio intensity, and *vice versa*. This is because having a large number of equity-based agreements indicates an integrated relationship between the firm and its partners, with in-depth collaboration likely (Aggarwal & Hsu, 2009; McGill, 2007). Previous research has frequently examined the interaction of portfolio diversity with portfolio intensity to determine how firms utilize different types of partners to enhance their strategic objectives (George et al., 2001; Xu et al., 2007). For instance, Aggarwal and Hsu (2009) examined the tie strength of each alliance partner in conjunction with the type of alliance, to determine which portfolio composition is most conducive to breakthrough innovation. Frequently the focal firm would form equity-based ties when it is engaged in R&D-related activities, regardless of the partner type, and the higher the portfolio intensity, the more likely the firm would produce breakthrough innovations (Srivastava & Gnyawali, 2011).

In summary, the review conducted here shows that previous studies have identified alliance portfolio as a multifaceted construct with a significant effect on the performance of a firm.

3.3 The theoretical conceptualization of alliance portfolio configuration: size, diversity, intensity

Drawing upon existing research of alliance portfolio, I argue that the concept of alliance portfolio is a multifaceted construct that can be categorized into three major dimensions: portfolio size, portfolio diversity and portfolio intensity. This section discusses each of the dimensions and examines the theoretical underpinning of each dimension and the specific definition used in this study.

Portfolio size refers to the aggregation of all of the dyadic alliances between the focal firm and its partner. In this study, I defined portfolio size as the total number of dyadic alliances that a focal firm possesses. Studies on the effect of alliance portfolio on the focal firm have considered the cumulative effect of portfolio size either as a direct influence to the firm's performance (Ahuja, 2000; Mouri et al., 2012; Stuart et al., 1999; Wassmer, 2010), or as a contingent variable of another portfolio characteristic (Lavie, 2007; Lavie & Miller, 2008). Portfolio size plays an important role in the understanding of alliance portfolio configuration because it represents the quantity of resources and information available to the focal firm (Shan, 1990; Stuart, 1999). A large portfolio size usually indicates that the focal firm commands a large amount of resources (Ahuja, 2000; Baum et al., 2000). In addition, portfolio size signals the likely position that the focal firm would occupy within the industry network (Burt, 1992; Dyer & Singh, 1998). Large portfolio size very often signals a high degree of connectivity of the focal firm within its network (Powell et al., 1996). Both arguments on the benefits of large portfolio size underlie the fact that the focal firm is the sole beneficiary of large portfolio size. More importantly, portfolio size is measured by aggregating the total

number of either partners or partnerships that the focal firm has formed over a period of time (Baum & Silverman, 2004; Lavie, 2007; Stuart et al., 1999).

Portfolio diversity refers to the different partner types and varieties of partnership functions that exist within the portfolio. In this study, I defined portfolio diversity as comprising three broad partnership categories: vertical upstream alliance that focuses on R&D, vertical downstream alliance that focuses on commercialisation, and horizontal alliance that focuses on co-development activities. Portfolio diversity is considered an important attribute of alliance portfolio configuration, since high portfolio diversity can induce heterogeneities in resources and capabilities (Baum et al., 2000; Rothaermel, 2001). Previous studies of portfolio diversity have examined different diversity measures, including functional diversity (Rotharmel, 2001; Powell et al., 1996), partner diversity (Rothaermel & Deeds, 2004), technological and business specialization diversity (Santoro & McGill 2005; Santos & Eisenhardt, 2009), industry diversity (Jiang et al., 2010) and organizational and national diversity (Goerzen & Beamish, 2005; Shan et al., 1990). Often the measurement of the specific diversity index differs, depending on the context of the study. For instance, the measurement of functional diversity could be measured in either the exploration-exploitation dichotomy (e.g., Rothaermel & Deeds, 2004; Yamakawa et al., 2011) or based on the type of value-creation activities, such as R&D, manufacturing, marketing and distribution (e.g., Bruyaka & Durand, 2012; Goerzen & Beamish, 2005; Powell et al., 1996). While the measurement of portfolio diversity is not uniform, studies have most frequently defined portfolio diversity as different types of partnerships based on the alliance partner's function (Wassmer, 2010). Consequently, this study includes the function of the partnership in the definition of portfolio diversity.

Portfolio intensity refers to the partner's level of commitment to the alliance portfolio. This is indicated by the proportion of equity-ties present within the portfolio, and this is how I define portfolio intensity in this study. The presence of strong ties in the portfolio implies a high degree of confidence and trust between the focal firm and its portfolio partners (Tiwana, 2008). High portfolio intensity allows the firm to facilitate the exchange of tacit knowledge and fine-grained information that is otherwise not possible with arms-length relationships (Uzzi, 1996). This, in turn, allows the firm to make relation-specific investments, such as sharing proprietary knowledge on a routine basis, which greatly enhances its competitive advantage (Ozcan & Eisenhardt, 2009). For example, the creation of a proprietary knowledge-sharing network between Toyota and its suppliers provides detailed specifications and allows suppliers to tailor their production solely to meet Toyota's demand (Dyer & Nobeoka, 2000). While portfolio intensity is used less frequently than portfolio size and portfolio diversity to measure the effectiveness of the firm's performance, studies have acknowledged the importance of segregating equity-based ties from non-equity-based ties to better account for the effect of tie strength (Goerzen, 2007; Vassolo et al., 2004; Wratschko, 2009).

3.4 Alliance portfolio configuration and innovative performance of entrepreneurial firm

The effect of these three dimensions of alliance portfolio – size, diversity and intensity – on the performance of entrepreneurial firms has been separately examined in previous research. For instance, studies on portfolio size have focused on the process the entrepreneurial firms undertook in procuring resources from a large portfolio (Hoffmann, 2005, 2007). Studies focusing on portfolio diversity have concentrated on

different types of external linkages and the benefits to the entrepreneurial firm seeking to market its products (Arora & Gambardell, 1990; Jiang et al., 2010; Rothaermel & Deeds, 2004). Studies in portfolio intensity have focused on the choices of governance mode for entrepreneurial firms to effectively govern their large and diverse portfolios (Folta, 1998; McGill, 2007; Mudambi & Tallman, 2010). In essence, previous studies have examined the effect of different dimensions of alliance portfolio on firm performance.

I argue that, in order to have a holistic understanding of how alliance portfolio affects the performance of the entrepreneurial firm, all three dimensions of the alliance portfolio need to be studied simultaneously. The alliance portfolio configuration discussed in the previous section is a useful conceptual model, because it incorporates all three dimensions of the alliance portfolio. Knowledge-intensive industries have high rates of innovation, and I argue that the simultaneous consideration of the alliance portfolio configuration can enhance understanding of how inter-firm alliances affect the innovative performance of entrepreneurial firms. Indeed, entrepreneurial firms from knowledge-intensive industries are more likely to face demands to rapidly convert their scientific findings into marketable products in order to survive (Schoonhoven et al., 1990). Different dimensions of a firm's alliance portfolio allow it to overcome its intrinsic limitations through recruiting complementary partners (Baum et al., 2000) and acquiring external resources and endorsements (Rothaermel, 2001). All these activities are critical for the successful production of innovative outputs (Sampon, 2007; Schilling & Phelps, 2007; Tsai, 2009).

The positive effect of alliance portfolio configuration on firms' innovative outputs is underpinned by the theoretical perspective of the resource-based view (RBV) and firm

capability perspective. The RBV of the firm argues that a firm's likelihood of forming an alliance is dictated by the firm's resource needs and the type of tangible and intangible resources that the firm can procure from its partners. Extending from such a view, I argue that the formation of an alliance portfolio configuration allows entrepreneurial firms to gain access to different types of resources from different types of partners (Faems et al., 2005; Wuyts et al., 2004). The firm capability perspective draws from literature on the effect senior management team has on the firm's performance. This line of literature emphasises the critical role of the senior management team in influencing the firm's strategic direction and behaviour (Ding, 2011; Higgins & Gulati, 2006). Specifically, a firm's capability perspective argues that senior management can affect the firm's directions through deliberate selection and subsequent management of its inter-firm alliances (Higgins & Gulati, 2006; Grigoriou & Rothaermel, 2014). This study argues that the senior management team plays an instrumental role in designing, managing and monitoring the appropriation of resources from external alliance partners, thereby enabling the focal firm to maximize the utility of these external resources. The deliberate action of senior management in the firm's alliance management, in turn, facilitates procuring heterogeneous sets of resources that form the basis of each firm's unique capabilities (Eisenhardt & Martin, 2000; Teece, 2007). Extending from such a view, I argue that the firm's senior management team plays a predominant role in the appropriation of external resources that entrepreneurial firms utilize to enhance their innovativeness.

Both the RBV and the firm capability perspective highlight the importance of effectively managing external resources obtained from alliances. They point to three important issues that need to be clarified, related to how external resources can be integrated with internal resources, and what type of external resources are critical for

innovation. First, how do externally obtained alliance resources facilitate the entrepreneurial firm's innovative performance? By focusing on the interactions of three dimensions of alliance portfolio, this study provides empirical evidence of whether the deliberate configuration of the alliance portfolio increases or diminishes the firm's resources endowment, which in turn affects the firm's innovative performance. Second, to what extent do tangible resources, externally obtained from alliances, also play a role in innovation? By examining the mediating effect of tangible financial resources on a firm's innovative outputs, this study indicates the direct effect of both tangible and intangible resources. Third, to what extent could externally obtained resources complement internal resources? By concentrating on the capability of the senior managers to manage its alliances, this study addresses the question of resource appropriation from the firm's external alliances.

3.5 Chapter summary

This chapter has reviewed the literature on alliance portfolio, and has conceptualized alliance portfolio into three distinct dimensions: size, diversity and intensity. These three dimensions were then incorporated into a holistic alliance portfolio configuration, and the effect of this configuration on a firm's innovativeness was examined. The resource-based view and firm capability perspective provided a theoretical foundation for understanding the mechanism of alliance portfolio configuration on a firm's innovative outputs. The synthesis of these two theoretical views highlights the importance for firms to effectively manage external resources obtained from alliances, and to address three related issues: how external resources can be integrated with internal resources, what type of external resources are critical for innovation, and to

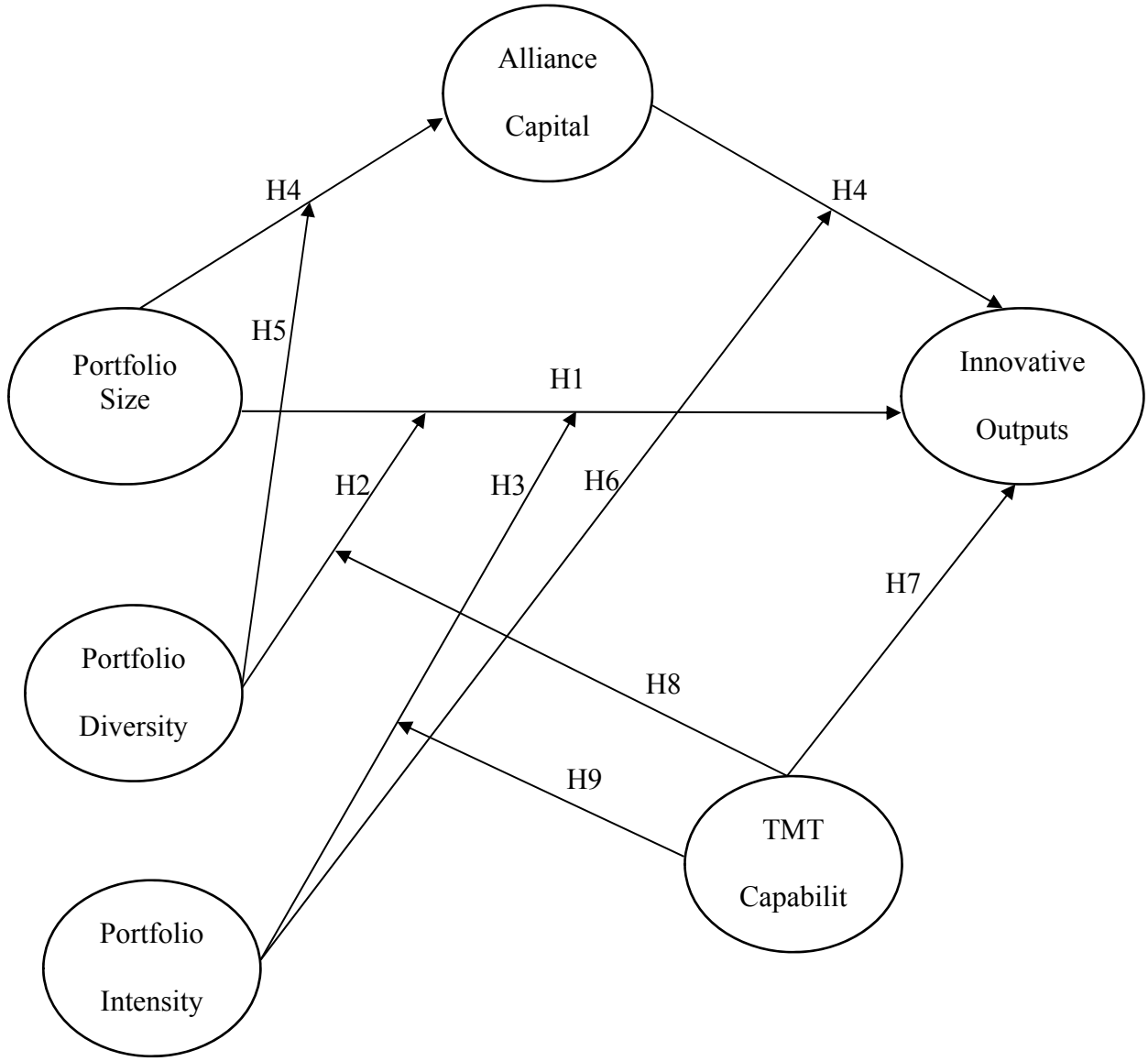
what extent externally obtained resources can complement internal resources. These issues are examined in the following chapter.

Chapter 4: Hypothesis Development

4.1 Alliance portfolio configuration and innovative output

The concept of alliance portfolio configuration is particularly useful for entrepreneurial firms in knowledge-intensive industries. These firms are impeded by a scarcity of resources to commercialize their discoveries, and therefore often engage in inter-firm alliances to mitigate their intrinsic disadvantages (Eisenhardt & Schoonhove, 1996) and enhance their success with product development (George et al., 2001). One common measure of entrepreneurial firms' innovative output in knowledge-intensive industries is new product developments (NPDs) (Caner & Tyler, 2013; Li et al., 2013). NPDs often result from acquiring and utilizing new knowledge (Rindfleisch & Moorman, 2001) that the entrepreneurial firm is able to source from its alliances (Phelps, 2010). Alliance portfolio configuration, in terms of its size, diversity and intensity, is therefore likely to impact a firm's new product development. Figure 4.1 presents the theoretical model.

Figure 4.1: Theoretical model of alliance portfolio configuration on entrepreneurial firm's innovative outputs



Section 4.2 examines interactions among three components of the alliance portfolio and the effect it has on the firm's innovative output. Section 4.3 examines the role of alliance capital in mediating the relationship between alliance portfolio and a firm's innovative output. Section 4.4 examines the role of the top management team (TMT) in moderating the relationship between alliance portfolio and firm's innovative output. Section 4.5 provides a brief summary of the chapter.

4.2 Effect of alliance portfolio on innovative output (H1–H3)

4.2.1 Portfolio size and innovative output

I propose a positive relationship between portfolio size and firm's innovative output, based on the argument that an entrepreneurial firm with a large portfolio size will be more likely to obtain additional resources that increase its innovative output. These firms can use two mechanisms to procure resources with a larger portfolio size. First, the firm can obtain resources directly from its alliance partners and deploy the resources internally to enhance its innovative output. A larger portfolio can provide greater opportunities for accessing resources externally. One of the driving motivations for entrepreneurial firms to form alliances is to compensate for the lack of resources that results from its small size (Lin et al., 2009; Mouri et al., 2012). The argument for direct resource access is supported by prior research: for instance, Ahuja (2000) showed that the rate of patent outputs of a high-tech firm increased as the number of dyadic ties with external partners increased, and Wuyts et al. (2004) found a positive correlation between portfolio size and successful new product developments for firms that operated in technology-intensive markets.

Second, a large portfolio size enables the firm to generate network resources. These sets of resources reside not within the firm, but in the alliance network in which the firm is embedded (Gulati, 1999), and they bestow information advantages and tacit knowledge to firms with access to them (Gulati, 1999; Lavie, 2006). I argue that large portfolio size often acts as a knowledge-sharing network, as it provides multiple channels to disseminate knowledge and exchange information (Dyer & Nobeoka, 2002).

Studies have shown that a knowledge-sharing network is highly conducive to innovation as it provides firms with the most up-to-date knowledge and immediate feedback (Ahuja, 2000; Tsai et al., 2008). A large network size is highly efficient for knowledge-sharing activities (Stuart & Podolny, 1996). For instance, Toyota is able to utilize the knowledge-sharing network between itself and its key suppliers to constantly adjust its supply chain (Dyer & Nobeoka, 2002). Furthermore, the potential for knowledge creation is higher with a large network that comprises non-redundant ties, as it allows a firm to access a greater range of network resources (Schilling & Phelps, 2007). Network resources are proprietary, as each firm configures a uniquely distinctive alliance portfolio for its own use, and proprietary resources procured from the firm's network are critical for increasing a firm's innovative output (Gulati, 1999; Powell et al., 1996). I therefore argue that network resources available from a large portfolio size facilitate the processes of knowledge sharing and exchange between the focal firm and its alliance partners, which benefits entrepreneurial firms' innovation output.

While I argue for the positive effect of portfolio size on firms' innovative output, prior studies have also found that a large number of alliances can generate redundant resources that impede performance (Baum et al., 2000; Deeds & Hill, 1996). While this is certainly highly likely, I argue that such concern is less relevant to entrepreneurial

firms that are constrained by their own shortage of resources resulting from their being small and new, and that the more external resources the firm can secure, the more likely it will be able to enhance its innovative output. The above arguments indicate that large portfolio size begets both additional opportunities for direct access to resources from external parties, and an expansive network conducive to knowledge sharing, with a resultant increase in innovative output:

H1: Portfolio size is positively related to innovative output for entrepreneurial firms.

4.2.2 The moderating role of portfolio diversity to portfolio size on innovative output

I propose that the direct relationship between portfolio size and a firm's innovative output, referred to in H1, is positively moderated by portfolio diversity. Portfolio diversity is defined as diversity in the alliance activities that allow the firm to procure heterogeneous sets of resources from its portfolio partners. H1 argues that a large portfolio allows a firm to procure more resources from its partners and generate additional network resources, and therefore portfolio size is positively related to the firm's innovative output. I argue in H2 that their relationship is positively moderated by portfolio diversity, because higher portfolio diversity indicates access to heterogeneous partners and partnerships that offer non-redundant resources to the firm. Entrepreneurial firms can increase their portfolio diversity by adding new types of partnership that increase the heterogeneity of their partnerships (Jiang et al., 2010). Greater partnership heterogeneity provides access to different types of partners, each with distinct

knowledge domains (Duysters & Lokshin, 2011), and provides different type of external resources (Baum et al., 2001) from which the focal firm can draw.

In addition, greater partnership heterogeneity provides the entrepreneurial firm with complementary partners along every stage of its value chain activities (Wuyts & Dutta, 2012). Increased portfolio diversity is often indicated by firms engaging in both explorative-type alliances with research-oriented organizations and exploitative-type alliances with commerce-oriented organizations (Rothaermel & Deeds, 2004). Heterogeneity in partnerships bestows new sets of resources and capabilities, which successful entrepreneurial firms often use, in conjunction with their existing resources, to enhance their innovative activities (Vassolo et al., 2004).

Successful entrepreneurial firms are able to leverage their portfolio diversity to create a context that is beneficial. For example, Mouri et al. (2012) identified that diversity in partnership functions positively moderated the effect of portfolio size on a firm's financial performance on the public stock market. The reasons for this are twofold: first, firms with more diverse partnership functions are perceived by external parties to have access to a wider range of knowledge and capabilities deemed critical to the firm's innovative output and, second, more diverse partnership functions indicate that the firm is more strategically flexible and is able to choose the most compatible partners. Both of these characteristics are highly valued by external investors, as reflected in the firm's superior financial returns on the public stock market.

High portfolio diversity is also likely to mitigate any potentially negative effects of redundant ties that generate overlapping resources for the focal firm. This is because high portfolio diversity expands the firm's range of alliance partners, and provides access to non-redundant capabilities from different types of partners (Goerzen &

Beamish, 2005). This argument suggests that high portfolio diversity is instrumental in expanding the firm's scope of alliance activities with different types of partners. This expansion, in turn, induces further capabilities and resources, enhancing the firm's innovative output. Therefore portfolio diversity positively moderates the direct effect of portfolio size and innovative output:

H2: Portfolio diversity positively moderates the positive relationship between portfolio size and innovative output for entrepreneurial firms.

4.2.3 The moderating role of portfolio intensity to portfolio size on innovative output

I propose that the direct relationship between portfolio size and a firm's innovative output is positively moderated by the portfolio intensity. Portfolio intensity is defined as the proportion of equity-based ties to the total number of alliances in the firm's alliance portfolio. A proprietary resource, in the form of specialized knowledge, is critical for an increase in the firm's innovative output. To successfully produce innovative output, entrepreneurial firms must both generate specialized knowledge, such as patents, and implement appropriate safeguards to ensure benefits flow back to the firm. Hypothesis 3 proposes that high portfolio intensity minimizes the hazard of misappropriating the firm's proprietary resources by providing a safeguarding mechanism. Empirical evidence supports the claim that high portfolio intensity is conductive to safeguarding a firm's appropriation processes. For instance, Aggarwal and Hsu (2009) found that the positive relationship between the number of alliances and the rate of new patents in the

pharmaceutical industry is conditional upon the level of equity-based cooperation between the focal firm and its portfolio partners.

Being able to reduce opportunistic behaviour is especially important for entrepreneurial firms when forming alliances with incumbents. As discussed for H1 in Section 4.2.1, a large portfolio offers additional access to both partner resources and network resources. Entrepreneurial firms frequently ally with industry incumbents to gain access to complementary assets that allow the firms to turn their proprietary knowledge into commercial products (Stuart et al., 2007), and market them through the incumbent's distribution network (Colombo et al., 2006). However, such a strategy often runs the risk of unintended dissemination of knowledge during the dyadic exchanges (Cohen & Levinthal, 1990). This risk is compounded because incumbent firms are resourceful and possess generic capability in large-scale production (Chandler et al., 1992), and so often adopt the strategy of reverse engineering to imitate an entrepreneurial firm's innovation without infringing its patents (Teece, 2000). In light of such problems, firms that engage in knowledge-intensive collaborations must establish sufficient administrative control of their own proprietary knowledge during the processes of exchange to avoid being exploited or imitated (Das & Teng, 1996; Folta, 1998).

I argue that entrepreneurial firms address this shortfall by configuring a more intensive portfolio to effectively safeguard the appropriation of their proprietary knowledge, since intensive portfolios made of strong ties reduce the likelihood of exploitative behaviour by external partners (Folta, 1998; Reuer & Tong, 2010; Vassolo et al., 2004). In summary, entrepreneurial firms that adopt more intensive alliances in

their portfolio would be able to minimize the potential of opportunistic behaviour and ensure they benefit from the appropriation processes:

H3: Portfolio intensity positively moderates the positive relationship between portfolio size and innovative output for entrepreneurial firms.

4.3 The mediating effect of alliance capital on innovative output (H4–H6)

The mediating mechanism focuses on the tangible financial resources generated from the alliance portfolio, and how this resource affects the innovative output of the entrepreneurial firm. I argue that externally sourced financial capital is an important benefit of the alliance portfolio and an antecedent of innovative output. Externally sourced financial capital is critical for entrepreneurial firms, which have abundant knowledge stock (Deeds & Decarolis, 1999; Faems et al., 2005) yet often lack sufficient internal financial capital to convert their proprietary technological breakthroughs into commercial products (Coombs & Deeds, 2000; Deeds & Decarolis, 1999). Hence, financial capital procured from alliance partners plays a significant role in contributing to entrepreneurial firms' higher innovative output. This externally sourced financial capital is termed 'alliance capital' to differentiate it from other forms of financial capital raised through other means (Coombs & Deeds, 2000; Deeds et al., 1997; Gopalakrishnan et al., 2008).

I argue in this section that alliance capital plays a critical role in the generation of entrepreneurial firms' innovative output, because alliance capital is typically sourced from partners with in-depth knowledge of the firms' absorptive capacity and innovative

capability (De Carolis et al., 2009; Zahra et al., 2008). This section delineates the mechanism by which alliance capital facilitates the process of generating innovative output.

4.3.1 Interaction between portfolio size and alliance capital on innovative output

I propose that alliance capital mediates the relationship between portfolio size and innovative output. Most often, external partners are motivated to form an alliance with an entrepreneurial firm to gain access to its proprietary knowledge (Deeds et al., 1997; Janney & Folta, 2003) and, in turn, provide alliance capital to the entrepreneurial firm (Deeds & Hill, 1996). Portfolio partners are willing to provide alliance capital to entrepreneurial firms because the firm has control of its proprietary knowledge, and can determine with whom it will share this knowledge (Higgins, 2007). Since external partners often lack publicly available information to objectively evaluate the entrepreneurial firms, potential partners use the presence of large portfolio size to judge the extent of the firm's level of internal knowledge (Higgins & Gulati, 2003; Stuart, 1999). This creates an iteration, whereby the firm's attractiveness is embodied in a large portfolio, which, in turn, increases the firm's attractiveness and helps it attract more new alliance partners (Rothaermel, 2002). The sum effect of these iterations is the generation of new venues for alliance capital and new partners for the entrepreneurial firm (Deeds et al., 2004). The net result is that, as portfolio size expands, additional infusion of alliance capital provides more financial capital to the entrepreneurial firm.

The availability of alliance capital to the entrepreneurial firm combines with pre-existing knowledge stock, allowing the entrepreneurial firm to generate higher

innovative output than it otherwise could. Availability of financial capital is critical in knowledge-intensive industries, since the process of product development is often lengthy and suffers high failure rates. For instance, in the biopharmaceutical industry, only 1 out of 3000 scientific discoveries is successfully converted to a commercial product (Pisano, 2006). The high failure rate compels many entrepreneurial firms to finance only projects with the highest chance of success and forfeit discoveries with less potential (Pisano, 2010). Alliance capital remedies the problem of resource scarcity for the firm by providing financial capital to complement the firm's pre-existing knowledge stock, allowing the firm to expand its project development activities, and consequently increasing its success with innovative output. In summary, a large portfolio size signals the firm's attractiveness, which induces more capital from its alliance partners. Large amounts of alliance capital allow the entrepreneurial firm to undertake more projects and carry out higher numbers of trials, and this, in turn, increases its level of innovative output, despite the high failure rate:

Hypothesis 4: The direct effect of portfolio size on innovative output is mediated by the amount of alliance capital for entrepreneurial firms.

4.3.2 Moderation of portfolio diversity on the mediating effects of alliance capital

Extending from H4, I further argue that high portfolio diversity intensifies the positive relationship between portfolio size and alliance capital, thus strengthening the mediating role of alliance capital. I argue that, for the same portfolio size, firms with higher portfolio diversity can often induce alliance partners to provide more alliance capital. As stated in Section 4.2.2 in relation to H2, high portfolio diversity can lead to

heterogeneous sets of resources that are critical for generating more innovative output. Building on H2, I argue that high portfolio diversity acts as a signal for attracting alliance capital from portfolio partners. This is because portfolio partners determine the amount of alliance capital they provide to the entrepreneurial firm based primarily on the firm's likelihood of securing heterogeneous resources.

Since entrepreneurial firms lack a proven track record, alliance partners must estimate the probability of innovative output from the heterogeneous resources that the firm already possesses (Baum & Oliver, 1996; Park et al., 2002). Furthermore, the presence of heterogeneous sets of resource allows the focal firm to recombine its own internal resources with different sets of external resources to generate superior technological resources that are most critical for its innovative output (Cui & O'Connor, 2012; Wuyts & Dutta, 2012). The presence of superior technological resources acts as a primary driver to attract larger amounts of alliance capital. This argument is supported with empirical findings. For instance, Gopalakrishnan et al. (2008) found that entrepreneurial firms are more likely to receive larger amount of financial capital in the initial stages of an alliance if the firm has significant technological knowledge resources, and if the infusion of external alliance capital would be conducive to efficiently using this technological knowledge to produce innovative output. Based on the above reasoning, I argue high portfolio diversity will positively moderate the relationship between portfolio size, alliance capital and innovative output:

H5: Portfolio diversity will moderate the mediating effect of alliance capital such that the relationship of portfolio size, alliance capital and innovative output will be stronger under high portfolio diversity than under low portfolio diversity for entrepreneurial firms.

4.3.3 Moderation of portfolio intensity on the mediating effects of alliance capital

I also argue that the mediating relationship of alliance capital is likely to be strengthened with higher portfolio intensity, and that higher portfolio intensity is likely to bring in more alliance capital for a portfolio of the same size. This is because high portfolio intensity indicates joint ownership of intellectual property and proprietary knowledge (Oxley, 1997). Joint ownership is critical in attracting additional amounts of alliance capital because it indicates aligned interest between the focal entrepreneurial firm and its alliance partners in the sharing of control rights (Panico, 2011).

Appropriate allocation of control rights is especially critical in knowledge-intensive industries since most innovative output is likely to require ownership of intellectual property and proprietary knowledge (Hagedoorn et al., 2005). By forming equity-based alliances, both the entrepreneurial firm and its partner can share the benefits generated by the ownership of intellectual property and proprietary knowledge (Rindfleisch & Moorman, 2001; Tiwana, 2008), and avoid premature termination of the alliance (Diestre & Rajagopalan, 2012). Since equity-based alliances guarantee benefits generated by intellectual property, and proprietary knowledge will be accrued to both the entrepreneurial firm and its equity-based alliance partners, I argue alliance partners are more likely to provide additional alliance capital for the same portfolio size to assure the success of the product development. In short, entrepreneurial firms with higher portfolio intensity are likely to attract larger amounts of alliance capital for the same portfolio size, which enhance the firm's innovative output:

H6: Portfolio intensity will moderate the mediating effect of alliance capital, such that the relationship of portfolio size, alliance capital and innovative output will be

stronger under high portfolio intensity than under low portfolio intensity for entrepreneurial firms.

4.4 Interaction between alliance portfolio and top management team (H7–H9)

In this section, I examine how the capability of the top management team (TMT) interacts with the alliance portfolio to affect the firm's innovative output. The TMT plays an especially instrumental role in the firm's output as it allocates firm resources and sets the firm's strategic directions (Eisenhardt & Schoonhove, 1996), focusing particularly on the firm's capacity to absorb and process scientific knowledge. An effective TMT is capable of recognizing the value of new knowledge, synthesizing it with current knowledge and applying it for commercial purposes (Cohen & Levinthal, 1990; Gupta & Govindarajan, 2000; Zaheer, 1995). The three hypotheses in this section propose a direct positive direct relationship between the TMT's capability and the firm's innovative output (H7), a three-way interactive relationship among the TMT's capability, portfolio diversity and portfolio size (H8), and a three-way interactive relationship among the TMT's capability, portfolio intensity and portfolio size (H9).

4.4.1 The TMT's capability and innovative output

I argue that the capability of an entrepreneurial firm's TMT has a positive effect on its innovative output. TMT capability is defined as the capacity of senior management to identify research with commercial potential and make strategic decisions that

facilitate the commercialization of scientific findings (Deeds et al., 2000; Luo & Deng, 2009). Such capability is based on specialized knowledge, and is often proxied by the TMT members undertaking advanced education, such as a PhD (Casper, 2007; Ding, 2011; Rothaermel & Hess, 2007).

The TMT contributes toward innovative output by directly and indirectly increasing the firm's knowledge stock: directly by allocating internal resources to increase the rate of successful scientific discoveries (Rothaermel & Hess, 2007; Zucker et al., 1998), and indirectly through attracting and retaining productive researchers (Casper, 2007; Ding, 2011). The TMT's direct involvement affects the firm's innovative output because breakthrough scientific discoveries often require large investment over a long time (e.g., Casper & Murray, 2005; Liao et al., 2009; Smith & Tushman, 2005). Therefore the TMT needs to be competent in identifying potential opportunities from its existing projects, and allocating sufficient internal resources to bring the opportunity to fruition. My argument is supported by previous studies that have found the firm's capacity for R&D depends on the TMT's knowledge base and the research team it recruits (Deeds et al., 2000; Rothaermel & Hess, 2007).

Successful scientific breakthroughs are rare and valuable events, and few researchers are capable of accomplishing such a feat (Zucker et al., 1998). I argue that a competent and well-informed TMT is more likely to make the appropriate decision on who to recruit. The TMT is more likely to make informed decisions and increase the firm's chance of successful breakthrough findings if TMT members have advanced training or higher degrees in the relevant field (Ding, 2011; Gulati & Higgins, 2003; Stuart et al., 2007). In summary, firms with a TMT that possesses capabilities to facilitate the accumulation of knowledge stock are more likely to generate higher innovative output:

H7: The TMT's capability is positively related to innovative output for entrepreneurial firms.

4.4.2 Interactive effect of portfolio diversity, portfolio size and the TMT's capability on the firm's innovative output

So far I have discussed the effect of alliance portfolio and the TMT on the firm's innovative output separately; however, it is very likely the two may complement each other, and therefore I argue for a positive interaction between the TMT's capability and alliance portfolio. The discussion for H2 argued that portfolio diversity positively moderates the effect of portfolio size as it increases the likelihood of procuring heterogeneous resources from different types of partnerships; however, this raises the question of effective partner selection for innovation. I argue that a TMT with a high level of capability allows the entrepreneurial firm to make informed choices regarding the selection of new partners that can provide heterogeneous resources to complement to the focal firm's internal resource stocks. And therefore I hypothesize that a high TMT capability will further strengthen the moderating influence of portfolio diversity on portfolio size.

As previously stated in H2, entrepreneurial firms configure diverse portfolios with the aim of procuring heterogeneous sets of tangible and intangible recourses that the firm itself does not possess internally, in order to increase its innovation output. This intention, however, is contingent upon selecting compatible partners that share the same strategic orientation as the firm (Ozcan & Eisenhardt, 2009). The shared strategic orientation aligns the interests of both parties, and therefore facilitates sharing of

resources across organizational boundaries, especially if the given resource is proprietary (Sarkar et al., 2001; Rauch et al., 2009). I argue that partner selection could be a burden for entrepreneurial firms, since new partners that possess complementary resources are often from an unfamiliar field. Unfamiliarity of new partners can sometimes see entrepreneurial firms forming alliances with partners that possess complementary resources, but interests or strategic orientations that differ from that of the entrepreneurial firm (Park & Ungson, 2001). Previous studies have found that the selection of incompatible partners is likely to induce additional costs to the firm for alliance management (Heimeriks & Duysters, 2007). This can be an onerous burden, as most entrepreneurial firms lack internal resources for dedicated alliance functions (Kale et al., 2002). In short, the positive moderating effect of high portfolio diversity is very likely to be substantially reduced by incompatible partners.

I argue that entrepreneurial firms with a highly capable TMT are more likely to be able to identify compatible new partners with which to jointly develop relationship-specific assets for innovation (Casper & Murray, 2005; Ibarra et al., 2005). This is because a capable TMT can be expected to have high degree of technical knowledge (Li et al., 2008; Zucker et al., 1998), which allows the TMT to select the most appropriate external partners. Empirical studies support this argument, and have found that firms with higher innovative output typically have both a knowledgeable TMT and diverse sets of partners (Alexiev et al., 2010; Casper & Murray, 2005). For instance, Alexiev et al. (2010) found that the TMT's advice-seeking behaviour influenced the likelihood of a small or medium-sized company succeeding in exploratory innovation. In short, I argue that the interaction between portfolio diversity and TMT plays a critical role in determining a firm's rate of innovative output. Based on the above reasoning, I argue that a highly capable TMT is more likely to identify suitable alliance partners and so

procure external resources efficiently, while minimizing any additional costs for alliance management:

H8: The interaction among portfolio size, portfolio diversity and innovative output will be positively moderated by the TMT's capability, such that the interaction will be stronger as the TMT's capability increases for entrepreneurial firms.

4.4.3 Interactive effect of portfolio intensity, portfolio size and the TMT's capability on firm's innovative output

The discussion about H3 in Section 4.2.3 postulates that a high portfolio intensity positively moderates the relationship of portfolio size and innovative output, as the presence of large number of strong ties reduces potential exploitation of proprietary knowledge. Reduced opportunistic behaviour allows for more in-depth collaborations, which leads to a larger level of innovative output. Taking a capability perspective, this section elaborates the mechanisms within the firm by highlighting the TMT's role in choosing the appropriate governance mode to result in more efficient exchange of both dyadic and network resources across organizational boundaries.

I argue that a highly capable TMT strengthens the moderating effect of portfolio intensity, which, in turn, positively moderates the direct effect of portfolio size on innovative output. This is because such a TMT is able to select the appropriate governance safeguards to ensure that the benefits accrued from high portfolio intensity are captured by the focal firm. High portfolio intensity is often configured when the firm is R&D-oriented, and strong ties are formed to ensure exploitative behaviour is minimized (Folta, 1998; Vassolo et al., 2004). A capable TMT is often better at

choosing the appropriate governance mode for the alliance portfolio, because the personnel are likely to be more knowledgeable and better able to identify the value of the resources being shared in the R&D alliances. In addition, I argue that a highly competent TMT is better at utilizing proprietary resources provided by equity-based alliances, because in this case the personnel can more efficiently assimilate existing and newly acquired alliance resources. Often, new knowledge is generated through effective assimilation of new and old knowledge (Lowik et al., 2012), and effective resource assimilation is critical for the production of innovative output (Rost, 2011). Based on the above reasoning, I argue a TMT with high level of capability is more efficient at assimilating proprietary resources, and therefore more likely to generate new knowledge that leads to increased innovative output:

H9: The interaction among portfolio size, portfolio intensity and innovative output will be positively moderated by TMT's capability, such that the interaction will be stronger as TMT's capability increase for entrepreneurial firms.

4.5 Chapter summary

This chapter has proposed nine hypotheses to delineate the interactions among different portfolio dimensions, as well as the interaction between senior managers and a firm's alliance portfolio and the cumulative effect of this on the firm's innovative outputs. The first three hypotheses examined the interaction among alliance portfolio configuration; hypotheses 4–6 examined the mechanism in which portfolio resources are procured from the alliance portfolio; and hypotheses 7–9 examined the interaction

between TMT and alliance portfolio. In addition, all nine hypotheses examined the effect of these elements on the firm's innovative outputs.

Chapter 5: Research Setting

5.1 Empirical context

To empirically verify the proposed model, I selected dedicated biotechnology firms (DBF) that utilize genetics-related knowledge to produce human therapeutic products in the biopharmaceutical industry in the U.S. Human therapeutic products usually focus on one of four areas: human diagnostics, therapeutics, vaccines and for-profit contract research (Calabrese et al., 2000). I focused solely on DBFs located in the U.S. because this is the only country with a sufficiently large number of DBFs that achieve commercial success.

The biopharmaceutical industry began in the U.S. in the 1970s with the introduction of techniques in recombining DNA (Hughes, 2011). The commercial success of the first DBF, Genentech, validated the commercial possibilities of DBFs, and a small group of DBFs began to emerge in the 1980s as the result of university spin-offs and investments from incumbent pharmaceutical firms. By the 1990s, clusters of DBFs were emerging in coastal cities of California and Massachusetts, with South San Francisco, San Diego and Boston the three most popular locations (Powell et al., 2005).

I chose DBFs for this study for three main reasons. First, products from the biopharmaceutical industry differ from traditional pharmaceutical products in that the former are created using processes based on knowledge of biological mechanisms and genetics, whereas the latter are developed through synthesis of chemical compounds (Shan et al., 1994; Zhang et al., 2007). The difference between the two is that the

development of human therapeutic products in the biopharmaceutical industry requires advanced knowledge in genetic engineering that was first discovered in 1973, whereas therapeutic products in the pharmaceutical industry employ chemical engineering knowledge and techniques that have been in existence since the early 19th century (Pisano, 2006). Therefore human therapeutic products can be considered innovative. In short, products developed in the biopharmaceutical industry are knowledge intensive, and therefore provide an appropriate context to test how the configuration of the alliance portfolio can affect the innovative outputs of entrepreneurial firms.

Second, DBFs that adopt genetic engineering production methods are typically small and young entrepreneurial companies (Calabrese et al., 2000). Genetic engineering employed by DBFs is a relatively nascent field with many of its subfields still conducting basic research to understand the DNA sequence of particular genes, the types of protein produced by different strand of genes, and how different protein cells and enzymes interact. Most new DBFs in the biopharmaceutical industry are founded with the sole objective of commercializing accumulated proprietary knowledge of specific genes into human therapeutic products (Lazonick & Tulum, 2011; Pisano, 2010), which they sell on to larger incumbent pharmaceutical firms once the breakthrough discovery has been achieved. Therefore most DBFs remain small and cease to be independent very early in the firm's development (Bruyaka & Durand, 2012). The entrepreneurial nature of DBFs fits the boundaries of the model proposed in this thesis.

Third, alliance is much more frequently used as a strategic tool in the biopharmaceutical industry than in other forms of corporate growth, such as vertical integration and acquisition. In addition to using inter-firm alliances to acquire new

knowledge to develop innovative products, DBFs also use their alliances to acquire external resources. This is because it can take up to 12 years, and three testing trials, to successfully convert scientific discoveries into human therapeutic drugs approved by the Food and Drug Administration (FDA, 2009). DBFs must rely on external partners for resources during the various developmental stages. In fact, DBFs commonly leverage multiple alliances with complementary organizations across the whole spectrum of the value chain (Stuart et al., 2007), which allows DBFs to not just procure new knowledge but also gain access to distribution networks that would otherwise be too costly for the DBF to develop (Pisano, 2006; Rothaermel, 2001). As a result, even successful DBFs are more likely to opt for inter-firm alliances to commercialize their research, rather than choosing a strategy of vertical integration. The common practice of inter-firm alliances allowed me to measure different dimensions of alliance portfolio in my model.

In summary, DBFs that focus on utilizing genetics-related knowledge to produce human therapeutic products in the biopharmaceutical industry represent entrepreneurial firms that are actively engaged in alliances for the development and commercialization of innovative products. My choice of DBFs from the U.S. biopharmaceutical industry is in line with previous studies that have examined the effect of inter-firm alliances on the innovative performance of entrepreneurial firms (e.g., Deeds & Hill, 1996; George et al, 2001; Powell et al., 1996; Rothaermel & Deeds, 2004).

Section 5.2 explains the characteristics of each database used. Section 5.3 provides details of the selection and coding of the data, and Section 5.4 describes the characteristics of the final data set. Section 5.5 provides a brief summary of the chapter.

5.2 Data sources

This section describes the characteristics of databases I used to develop the sample of DBFs in the study. These databases included *BioCentury Directory, BioScan Directory, Factiva, Orbis,* and *Recombinant Capital Directory*.

BioCentury Directory is an online subscription-based directory that covers biotech companies in U.S. The directory tracks changes in firms' product development and top management team, and specializes in integrating new product information and relevant financial information. For publicly listed companies, *BioCentury Directory* provides updates on the firm's financial performance after the announcement of its testing trials. For privately listed companies, the database provides update on the firm's private fundraising activities after the announcement of its testing trials. In addition, the database provides updates of changes in the firm's senior management team, including background of new hires and departing executives (BioCentury, 2010).

BioScan Directory, published annually by BioWorld since 1989, provides organizational information of companies in the biotechnology and pharmaceutical industries. *BioScan* provides one of the most comprehensive listing of DBFs in U.S. and across the globe, and hence is one of the most frequently used databases by researchers examining inter-firm alliance activities in the biopharmaceutical industries (BioScan, 2010). The information provided by *BioScan Directory* includes founding year, location of headquarters, status of the company, number of employees, scope of business activities, amount of capital received from external parties, name of external parties that provide funding, number of private placements and the amount raised from private placements. It also provides dyadic alliance information on the firm, though not as detailed and comprehensive as in *Recombinant Capital Directory.*

Factiva is a search database produced by the financial information company, Dow Jones Inc. The database allows searches of the company's public announcements, and news clips related to the company. The database is noted for its wide coverage that includes trade journals, newspapers and related periodicals (Factiva, 2010).

Orbis is a firm-level database that is produced by the private company Bureau van Dijk. The database covers more than 125 million private and public companies across all OECD countries. While the database does not specifically provide information for companies' alliance or product development activities, it provides comprehensive background information of both publicly listed and private firms, including location of headquarters, location of subsidiaries, industry in which the firm is engaged, number of employees, year of incorporation and ownership information (Orbis, 2010).

Recombinant Capital Directory, also known as RECAP, is a San Francisco-based research company that has since been acquired by Deloitte. The directory is a subscription-based online directory that lists detailed information for firms' individual alliance activities (Recombinant Capital, 2010). The database is noted for its comprehensive data that track firms' alliance information and clinical trials in the life sciences industry. Its historical record is especially rich concerning alliance activities. Information includes name and type of partner, type of partnership, detailed information of the dyadic alliance if it is publicly announced, amount of financial capital involved, presence of equity ties and equity investments, and termination year of the alliance if it took place.

5.3 Data collection

I began constructing the sample dataset by surveying firms that appeared in the *BioScan Directory,* and selected those with the relevant SIC code. The SIC code is used to categorize the industry in which the firm is engaged. The SIC code for the biopharmaceutical industry includes categories 2834 (Pharmaceutical preparations), 2835 (*In Vitro* and *In Vivo* diagnostic substances) and 2836 (Biological products, except diagnostic substances). Over 70 per cent of firms dedicated to the production of human therapeutic products are categorized primarily in SIC 2835, with the rest divided between SICs 2834 and 2836 (Rothaermel, 2001). I first checked the description in *BioScan Directory*, and removed from the dataset any firms not engaged in developing human therapeutic products. I then checked for reliability of the firms' information by cross-validating from at least two independent sources (Lavie & Rosenkof, 2006; Rosenkopf & Schilling, 2007), in this case *BioCentury Directory* and *Recombinant Capital Directory*. I included only DBFs that are listed in at least two of the three directories (i.e., *BioScan Directory*, *BioCentury Directory* and *Recombinant Capital Directory*) as information could then be triangulated to ensure its validity. This yielded a potential dataset of 508 DBFs with headquarters in the U.S. and that are engaged in the commercial development of human therapeutic products.

DBFs were included in the sample for empirical testing if they met all of three criteria: (1) the firm was established after 1990; (2) the firm did not received funding support from large conglomerates at its inception; (3) the firm has fewer than 500 employees. Limiting the sample to DBFs established after 1990 excluded older firms that have now become well-established and resourceful entities. Firms excluded from the sample for this reason included Amgen, Genetech and Xomo, the largest DBFs in

the biopharmaceutical industry, which are typically engaged in inter-firm alliances to distribute their products and no longer carry out innovations. This cohort of DBFs often forms alliances with large established consumer goods companies for the manufacturing and distribution of final products (Pisano, 2006). The exclusion of these older and larger DBFs in the sample ensured the data set comprised exclusively entrepreneurial firms that faced the joint liabilities of being small and new.

I also excluded DBFs that received support from large conglomerates at their inception. For instance, GE Healthcare was excluded, although it is engaged in human therapeutics; however, the firm was founded with the support of General Electrics, one of the Fortune 500 companies. Such firms have had access to resources from their parent group from the beginning, and consequently have not had to face the problem of resource shortages. These DBFs are not entrepreneurial, and so I excluded them from the sample.

The rationale of capping number of employees at less than 500 employees was to ensure the firm met the condition of 'liability of smallness'. The choice of 500 employees as the cut-off value follows previous studies that have focused on examining the effect of inter-firm alliances on small firms (Li et al., 2008; Reuer et al., 2006; Roy & Simpson, 1981). Also, since typical DBFs tend to hire scientists and engineers to enhance their technological competencies before hiring marketing and administrative personals, limiting the employee size ensures that the DBFs are oriented towards scientific discovery, rather than marketing existing products.

The screening of the original 508 DBFs with these three criteria yielded 262 firms. From the 262 firms, I further excluded firms with fewer than two dyadic alliances, as such an alliance configuration does not constitute an alliance portfolio. (In particular,

three alliances are required to calculate alliance diversity of an alliance portfolio.) Following this final round of exclusions, 238 DBFs were finally used in the statistical analysis.

I used *Recombinant Capital Directory* to compile alliance events of the sampled firms from the year of their inception until 2009. This information typically included name and type of partner, year when the partnership was formed, termination year (if announced), type of partnership, governance (if the alliance is equity), financial capital that the DBF received from the partnership, and whether the dyadic alliance is an equity-based alliance. This information was then used to construct variables related to alliance portfolio, including portfolio size, portfolio diversity and portfolio intensity, as discussed in the next chapter.

I used *BioCentury Directory* to trace the progress of new product developments (used as the dependent variable) of DBFs in the sample. Since *BioCentury Directory* specializes in tracking annual changes in firms' product development, it accurately indicates the number of products under development and the number of products ready for market on a yearly basis.

I collected information about the firm, including founding year, location of headquarters and employee size from both *BioScan Directory* and *Orbis.* This information was subsequently used for the control variables. The headquarters location helped to identify whether the firm was located within a technology cluster.

5.4 Description of final sample

The final dataset consisted of 238 DBFs with information on the DBFs and their alliance activities. I followed procedures used in previous studies to measure the independent and the dependant variables that introduced a time lag between them (Rothaermel, 2002; Shan et al., 1994). Each DBF's dyadic alliance activities were accounted for from its inception until the end of 2009, thus allowing sufficient time to include all scientific discoveries with commercial potential. The alliance data collected for each firm from its inception until 2009 were used as independent variables in the subsequent statistical testing. Data for product developments were used as the dependent variable for statistical testing, and were collected in 2010 to account for performance time lag. The final sample accounted for 2501 alliances.

The average DBF in the sample was 12 years old with 93 employees. Each firm had an average of 11 alliances with two equity-based alliances from its inception until 2009. An average age of 12 years old was relatively young for the biopharmaceutical industry, considering that the industry began development in the 1970s, and most commercially successful firms, such as Genetech, have an average age of over 20 years.

To illustrate typical data entries, Appendix 1 shows the entry of Aastrom Biosciences in the dataset, and Appendix 2 shows the entry of Acadia Pharmaceuticals.

5.5 Chapter summary

This chapter has provided the rationale for choosing dedicated biotechnology firms based in the U.S. that concentrated on the production of human therapeutic products:

their products were highly innovative and firms in the sample set were very entrepreneurial. The final dataset comprised 238 firms, which formed a total of 2501 alliances between 1990 and 2009. Information on individual alliances was collected predominately from three datasets: *BioScan Directory*, *BioCentury Directory* and *Recombinant Capital Directory.* The dependent variable was measured in 2010, and reflected the number of new product developments by each firm.

Chapter 6: Empirical Analysis and Results

6.1 Dependent variable

Innovative output. Innovative output measures the number of new products an entrepreneurial firm has under development. Following prior research that used 'new product developments' as a dependent variable to examine the effect of alliances on an entrepreneurial firm's capability to generate innovative output (e.g., George et al., 2001; Rothaermel, 2001; Hoang & Rothaermel, 2005), for each firm I counted the number of products under commercial development but not yet introduced to the market by 2010. I used number of products under development, rather than products sold, because the production of knowledge-intensive products in the biopharmaceutical industry can be very lengthy as a result of strict regulatory hurdles, and counting products under development was the optimal way of measuring innovative output (Rothaermel, 2001; Santoro & McGill, 2005). Similar to previous studies (Ding et al., 2010; McGill & Santoro, 2009), I measured the firm's innovative output based on *BioScan Directory* and cross-checked with *BioCentury Directory*. The firms in the sample has an average of 6.9 products under development in 2010 (s.d. = 12.85).

6.2 Explanatory variables

[Please contact the author for detailed description]

6.3 Control variable

[Please contact the author for detailed description]

6.4 Data analysis and results

6.4.1 Descriptive statistics

Table 6.1 reports the descriptive statistics and the correlations among the study's variables. The average firm in the sample had 6.9 new products under development and had formed 10.5 dyadic alliances since its inception, with 17 per cent of them formed as equity-based ties. On average, the portfolio diversity was 0.42, indicating a modestly diversified portfolio. The average firm was 11.8 years old and had 93 employees, and was engaged in two business fields. Sixty-four per cent of the firms in the sample were publicly listed on the stock exchange, 43 per cent had received government funding, and 29 per cent had formed their first university alliance with one of the top 10 research universities in the U.S. The correlation matrix shows that the dependent variable is correlated to explanatory variables, ranging from .02 to .21. The low to moderate correlations indicate that problem of multi-collinearity is unlikely to be significant (Aiken & West, 1991).

Table 6.1 also indicates that correlation among three dimensions of alliance portfolio is not particularly high, with portfolio size not significantly correlated to portfolio diversity at .00, and .13 ($p < .01$) with portfolio intensity. This indicates that the three dimensions are distinctive characteristics of alliance portfolio.

Table 6.1: Descriptive statistics

Means, Standard Deviations and Correlations

	Mean	S.D.	1	2	3	4	5	6	7	8	9	10	11	12
1. Innovative Output	6.9	12.85												
2. TMT's Capability	0.47	0.29	0.15**											
3. Alliance Capital (US$ million)	275.83	544.05	0.25***	0.33***										
4. Portfolio Size	10.5	5.55	0.21***	0.44***	0.26***									
5. Portfolio Diversity	0.42	0.18	-0.02	-0.01	-0.08	0.00								
6. Portfolio Intensity	0.17	0.16	0.02	0.35***	0.19***	0.13**	0.06							
7. Age (year)	11.89	4.76	0.11*	0.17**	0.14**	0.22**	0.06	0.07						
8. Cluster	0.37	0.48	-0.07	0.16*	0.06	0.22**	0.09	0.12**	0.07					
9. Government Support	0.43	0.50	.26***	.29***	.26***	0.09	0.03	0.14*	0.21**	0.15*				
10. Business Scope	2.05	0.84	0.04	0.05	0.05	0.08	0.1	0.02	0.01	0.00	-0.01			
11. Firm Size (employee number)	93.07	100.99	0.20**	0.09	0.17**	0.25**	0.02	-0.08	0.54***	-0.04	0.28***	0.03		
12. Status	0.64	0.48	0.00	0.40***	0.15**	0.19**	0.21**	.30***	0.23**	0.18**	0.15*	0.07	0.77	
13. University Alliance	0.29	0.45	0.24**	0.27**	0.20**	0.20**	-0.01	.15**	0.08	0.10	0.24**	0.08	.20**	0.08

N = 238
* $p < 0.05$
** $p < 0.01$
*** $p < 0.001$

6.4.2 Analytical methods

Since both the dependent variable (innovative output) and the mediating variable (alliance capital) are count variables representing a limited range of positive integer variables, including multiple zero values, the variables are not normally distributed and are skewed. It is skewed in the sense that the dependent variable is bounded at the lower end of the distribution by zero, meaning that dependent variable cannot go below zero. Ordinary least squares (OLS) regression techniques are inappropriate since they can lead to an asymptotic analysis; instead, this study used the generalized linear model for analysis. For the generalized linear model, two types of regression can be used: Poisson regression and negative binomial regression. For the sample, several statistical tests reject the assumption of Poisson-regression, including the equality of mean and variance of the endogenous variable (Greene, 2003; Luo & Deng, 2009). On the other hand, negative binomial regression does not assume an equal mean and variance. In addition, the negative binomial regression model corrects for over-dispersion in the data, which occurs when the variance is greater than the conditional mean (Osgood, 2000; Paternoster & Brame, 1997).

Based on the above reasoning, I adopted a negative binomial regression model with maximum likelihood estimation procedure to test all nine hypotheses. The use of negative binomial regression to test the effect of inter-firm alliances on the subsequent innovative performance of the firm is in line with previous studies, many of which have adopt a similar research design and data set (e.g., Coombs et al., 2009; Durand et al., 2008; Luo & Deng, 2009; Rothaermel, 2001, 2002).

6.4.3 Analysis of direct and moderating effect of alliance portfolio configuration on innovative output (H1–H3)

Hypotheses 1–3 tested both the direct effect and the moderating effect of alliance portfolio on a firm's innovative output. Specifically, Hypothesis 1 tested the direct effect of portfolio size on innovative output; Hypothesis 2 tested the moderating effect of portfolio diversity on the positive relationship of portfolio size and innovative output; and Hypothesis 3 tested the moderating effect of portfolio intensity on the positive relationship of portfolio size and innovative output. Table 6.2 reports the results of the analysis.

I used innovative output in 2010 as the dependent variable. Model 1 is the baseline model with only the control variables; Model 2 includes all of the direct effects; Model 3 includes the interactive effect of portfolio diversity; Model 4 includes the interactive effect of portfolio intensity; and Model 5 shows the full model. In order to create the interaction term for both portfolio diversity and portfolio intensity, I first mean-centred all three relevant explanatory variables: portfolio size, portfolio diversity and portfolio intensity (Aiken & West, 1991). I then multiplied portfolio size by portfolio diversity for the diversity moderator, and multiple portfolio size by portfolio intensity for the intensity moderator.

Table 6.2: Negative binomial regression results for new product development

Variables	Model 1	Model 2	Model 3	Model 4	Model 5
Control variables					
Size	0.00(.00)**	.00(.00)*	.00(.00)*	.00(.00)*	.00(.00)
Age	0.00(.02)	.00(.02)	.00(.02)	–.00(.02)	–.00(.02)
Status	–.15(.16)	–.24(.16)	–.27(.17)	–.23(.17)	–.28(.17)*
Government Support	0.72(.16)***	.79(.16)***	.81(.16)***	.76(.16)***	.80(.16)***
Scope	0.07(.08)	.08(.08)	.07(.08)	.11(.08)	.09(.08)
University Alliance	0.59(.16)***	.67(.17)***	.65(.17)***	.67(.17)***	.62(.17)***
Cluster	–.25(.15)***	–.38(.15)*	–.37(.15)**	–.38(.15)**	–.33(.15)**
Main effect					
Portfolio Size		.06(.01)***	.06(.01)***	.06(.01)***	.05(.02)***
Moderating variables					
Portfolio Diversity		.05(.40)	.05(.40)	.02(.40)	.05(.40)
Portfolio Intensity		1.12(.44)**	1.16(.44)**	1.05(.45)**	1.12(.45)**
Interaction Effects					
Portfolio Size x Portfolio Diversity			–.10(.07)		–.17(.07)**
Portfolio Size x Portfolio Intensity				–(.01).01**	–.02(.01)***
Constant	1.02(.30)***	.24(.37)	.26(.37)	.33(.37)	.43(.37)
Chi-square	86.66	115.23	117.49	118.42	124.78
Log likelihood	–672.53	–657.75	–656.61	–.656.15	–652.97
Improvement over Base (Chi-square)		28.57	30.83	31.76	38.12

N = 238
* $p < 0.05$
** $p < 0.01$
*** $p < 0.001$

This discussion of results is based on Model 5. I found strong support for Hypothesis 1, which predicts a direct relationship between portfolio size and the firm's innovative output ($B = .05$; $p < .001$). Model 5 also shows the significance of the interaction term between portfolio diversity and portfolio size ($B = –.17$; $p < .01$), which supports Hypothesis 2; however, it should be noted that the interaction is not significant in Model 3. In addition, I also found significant relationship between portfolio intensity and portfolio size ($B = .02$; $p < .001$), which provides support for Hypothesis 3.

In order to gain further insight into how the interaction terms moderates the relationship between portfolio size and firm's innovative output, I plotted the predicted relationship at low and high portfolio diversity and low and high intensity (Aiken & West, 1991). I considered one standard deviation below and above the mean to represent the low and high values of portfolio diversity and portfolio intensity. Figure 6.1 presents the moderating role of portfolio diversity (Hypothesis 2). The interaction graph indicates that firms with high portfolio diversity exhibited a stronger direct relationship between the portfolio size and the firm's innovative output, than did firms with low portfolio diversity. Figure 6.2 presents the moderating role of portfolio intensity (Hypothesis 3). The interaction graph indicates that the change in dependent variable (innovative output) was much greater in high portfolio intensity than in low portfolio intensity, which is in line of the prediction made in Hypothesis 3.

Figure 6.1: Interaction of portfolio diversity and portfolio size on innovative output

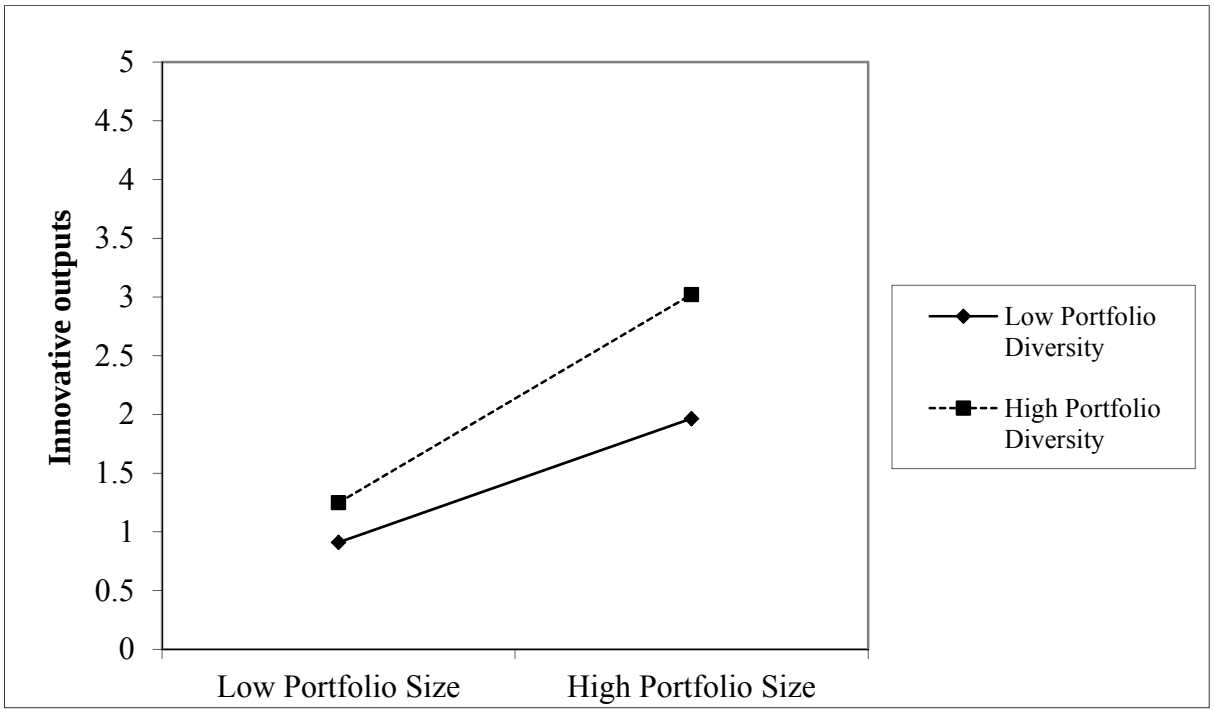
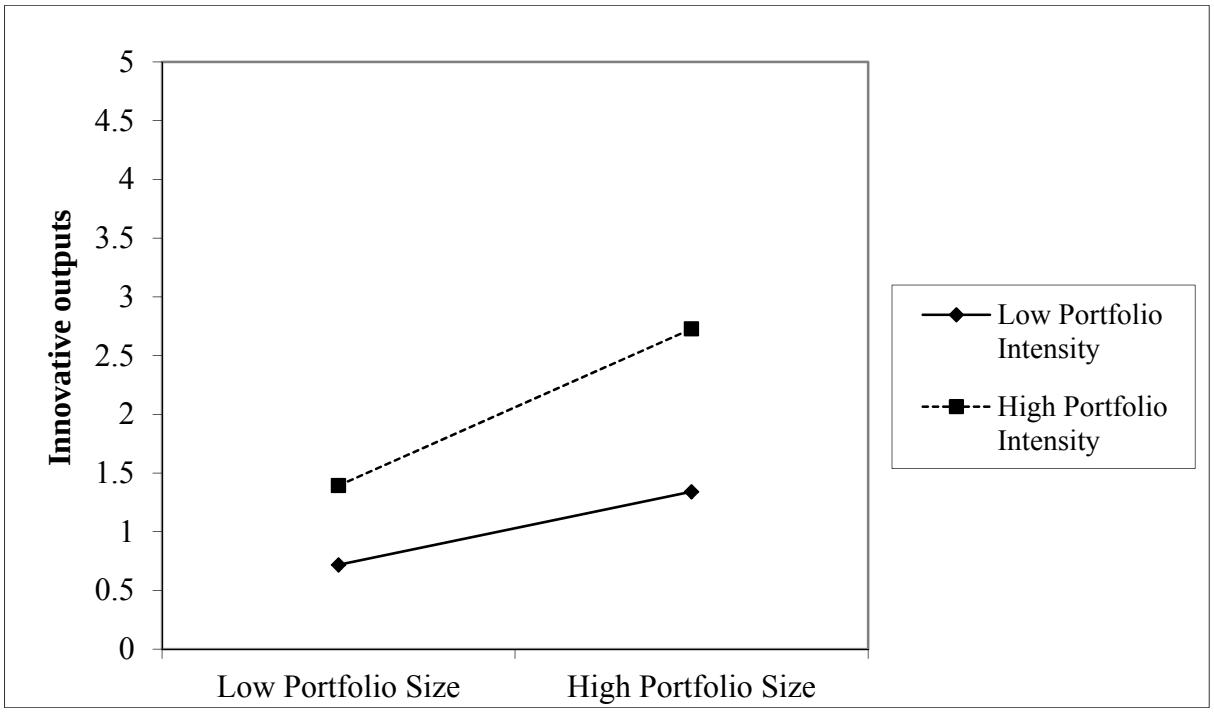


Figure 6.2: Interaction of portfolio intensity and portfolio size on innovative output



6.4.3 Analyses for Hypothesis 4

Hypothesis 4 was a mediation test of alliance capital on the relationship between portfolio size and innovative output. I tested the mediating effect of alliance capital based on the procedure used by Baron and Kenny (1986). Based on Baron and Kenny's approach, Model 1 represents the relationship between the portfolio size and alliance capital, Model 2 represents the relationship between portfolio size and innovative output, and Model 3 tests the mediating relationship by adding the mediator, alliance capital, to the relationship of portfolio size and innovative output. The mediating effect existed if the mediator was significant and the independent variable became insignificant or less significant in Model 3. As discussed earlier in Section 6.4.2, I used negative binomial regression in light of the dependent variable's characteristic. Lastly, although log transformation is usually taken to minimize effects of extreme value, since negative binomial regression can effectively deal with large positive integers, and multiple zero, I calculated alliance capital without the log form. The findings are summarized in Table 6.3.

Model 1 estimated the relationship between the explanatory variable and the mediator, and showed portfolio size to be positive and significant to alliance capital (B = .12, p < .001). Model 2 estimated the relationship between the explanatory variable and the dependent variable, and showed portfolio size to be positive and significant to innovative output (B = .06, p < .001). Model 3 estimated the mediating model, which included the alliance capital, and showed the mediator to be highly significant (B = .27, p < .001). I also found in Model 3 a reduced significance of portfolio size (B = .04, p < .01); however, portfolio size remained significant. I used Sobel testing to determine the significance of the mediation effect. The Sobel test result was (t = 3.24, p<.001). The

result indicates that alliance capital partially mediated the relationships of portfolio size and innovative output.

Table 6.3: Mediation analysis for Hypothesis 4

Variables	Model 1 (Alliance Capital)	Model 2 (Innovative Output)	Model 3 (Innovative Output)
Firm Size	–00(.00)	.00(.00)	.00(.00)
Age	1.9(.52)***	.76(.55)	.68(.56)
Status	.47(.14)***	–.21(.16)	–.43(.17)**
Government Support	1.00(.15)***	.78(.16)***	.71(.16)***
Scope	.21(.08)**	.09(.08)	.04(.08)
University Alliance	.53(.16)***	.62(.16)***	.62(.17)***
Cluster	.13(.14)	–.36(.15)**	–.38(.15)**
Portfolio Size	.12(.02)***	.06(.01)***	.04(.01)**
Alliance Capital			.27(.07)***
Constant	0.73	–0.28	–0.16
Chi-square	200.54	110.46	123.64
Log likelihood	–1475.67	–660.13	–653.54

Standard errors are in parentheses
N = 238
*P< 0.05
**P<0.01
***P < 0.001

6.4.4 Analyses for hypotheses 5 and 6

Hypotheses 5 and 6 tested whether the mediating effect of alliance capital is moderated by portfolio diversity (H5) and portfolio intensity (H6). Hypothesis 5 tested the moderating effect of portfolio diversity on portfolio size, alliance capital and innovative output. Hypothesis 6 tested the moderating effect of portfolio intensity on portfolio size, alliance capital and innovative output. I used PROCESS, developed by Preacher & Hayes (2008), to test the moderated mediation. I chose Model 58 to test for the moderated mediation, and obtained a bootstrapped confidence interval at 95 per cent with 1,000 resamples for both hypotheses.

Table 6.4 shows the result of the moderating effect of portfolio diversity on both the mediator (e.g., alliance capital) and the dependent variable (e.g., innovative output). I found no significant moderating effect between portfolio size and alliance capital, nor did I find portfolio diversity had any significant moderating effect between alliance capital and innovative output.

Table 6.5 shows the result of the moderating effect of portfolio intensity on both the mediator (e.g., alliance capital) and the dependent variable (e.g., innovative output). I found no significant moderating effect between portfolio size and alliance capital, nor did I find portfolio intensity had any significant moderating effect between alliance capital and innovative outputs. In summary, neither Hypothesis 5 nor Hypothesis 6 was supported.

Table 6.4: Regression result for Hypothesis 5

	Mediator (Alliance Capital) Variable Model			
Predictor	***B***	***SE***	***t***	***P***
Constant	–1.12	0.23	–4.77	0.00
Portfolio Size	0.07	0.01	5.75	0.00
Portfolio Diversity	–0.44	0.33	–1.32	0.19
Portfolio Size x Portfolio Diversity	–0.02	0.05	–0.29	0.77
	Dependent (Innovative Outputs) Variable Model			
Predictor	***B***	***SE***	***t***	***P***
Constant	5.01	3.10	1.61	0.11
Portfolio Size	0.36	0.16	2.25	0.03
Portfolio Diversity	–0.56	4.25	–0.13	0.89
Alliance Capital	0.84	0.84	0.99	0.32
Alliance Capital x Portfolio Diversity	–1.27	3.41	–3.03	0.64

N = 238

Table 6.5: Regression result for Hypothesis 6

	Mediator (Alliance Capital) Variable Model			
Predictor	***B***	***SE***	***t***	***P***
Constant	–0.92	0.22	–4.22	0.00
Portfolio Size	0.06	0.01	5.55	0.00
Portfolio Intensity	2.44	0.38	6.41	0.00
Portfolio Size x Portfolio Intensity	–0.03	0.08	–0.39	0.69
	Dependent (Innovative Outputs) Variable Model			
Predictor	***B***	***SE***	***t***	***P***
Constant	4.45	3.23	1.37	0.17
Portfolio Size	0.36	0.17	2.23	0.03
Portfolio Intensity	–6.61	5.76	–1.15	0.25
Alliance Capital	1.47	0.95	1.55	0.12
Alliance Capital x Portfolio Intensity	–4.63	5.45	–1.15	0.25

N = 238

6.4.5 Regression analysis for hypotheses 7–9

Hypothesis 7 tested the direct effect of the TMT's capability to produce innovative output; Hypothesis 8 tested the three-way interactions of portfolio size, portfolio diversity and the TMT's capability; and Hypothesis 9 tested the three-way interactions of portfolio size, portfolio intensity and the TMT's capability. To test these three hypotheses, I followed previous studies that had investigated three-way interactions (e.g., Hitt et al., 2001; Li et al., 2013; Zahra, 1996). I first mean-centred all relevant independent variables, including portfolio size, portfolio diversity, portfolio intensity and TMT's capability. I then created four interaction terms: Portfolio Size x Portfolio Diversity, Portfolio Size x TMT's Capability, Portfolio Diversity x TMT's Capability, and Portfolio Size x TMT's Capability x Portfolio Diversity, in order to test Hypothesis 8. I repeated the same procedure to test Hypothesis 9 by replacing portfolio diversity with portfolio intensity.

Model 1 in tables 6.6 and 6.7 was the base model with control variables. Model 2 in Table 6.6 provided the empirical results for Hypothesis 7. I found significant and positive results to support Hypothesis 7 ($B = .74$, $P < .01$). Model 3 in tables 6.6 and 6.7 included all the direct effects. Model 4 in tables 6.6 and 6.7 included three interaction terms to test the two-way interactions for portfolio diversity and portfolio intensity. Model 5 in tables 6.6 and 6.7 included the three-way interaction term for portfolio diversity and portfolio intensity.

Table 6.6 summarizes the results for Hypothesis 8. I found no significant two-way interaction of portfolio size, portfolio diversity and TMT's capability in Model 4, nor did I find any significant three-way interaction among portfolio size, portfolio diversity

and TMT's capability in Model 5. Since no significant results were found, Hypothesis 8 was not supported.

Table 6.7 summarizes results for Hypothesis 9. I found a significant two-way interaction for both Portfolio Size x Portfolio Intensity ($B = –.01$, $P < .05$), and TMT's capability x Portfolio Intensity ($B = 1.72$, $P < .01$) in Model 4. In addition, I found a significant and positive three-way interaction for Portfolio Size x TMT's Capability x Portfolio Intensity ($B = .33$, $P < .01$), and therefore Hypothesis 9 was supported. The interaction is graphically displayed in Figure 6.3.

Table 6.8 summarizes the empirical results for all of nine hypotheses. Six of the nine hypotheses proposed in Chapter 4 were supported, with Hypothesis 4 indicating partial mediation.

Table 6.6: Results of analysis of three-way interaction for portfolio diversity on innovative performance

Variables	Model 1	Model 2	Model 3	Model 4	Model 5
Size	0.00(.00)**	.00(.00)	.00(.00)	.00(.00)	.00(.00)
Age	0.00(.02)	.70(.55)	.81(.56)	1.01(.57)**	.99(.57)**
Status	–.15(.16)	.38(.17)**	–.31(.18)**	–.36(.18)**	–.34(.19)**
Government Support	0.72(.16)***	.63(.16)***	.75(.16)***	.75(.17)***	.76(.17)***
Scope	0.07(.08)	.08(.08)	.10(.08)	07(.08)	.08(.08)
University Alliance	0.59(.16)***	.53(.16)**	.65(.17)***	.59(.17)***	.59(.17)***
Cluster	–.25(.15)***	–.21(.15)	–.37(.15)**	–.34(.16)**	–.33(.16)**
TMT Capability		.74(.28)**	.06(.32)	.14(.32)	.10(.33)
Portfolio Size			.06(.01)***	.06(.02)***	.07(.02)***
Portfolio Diversity			.03(.41)	.02(.41)	.02(.41)
Portfolio Intensity			1.12(.45)**	1.10(.45)**	1.16(.45)**
Two way interaction					
Portfolio Size x Portfolio Diversity				–.11(.07)	–.14(.07)*
Portfolio Size x TMT Capability				.19(.13)	.26(.15)*
TMT Capability x Portfolio Diversity				–3.75(.49)	–3.69(.57)
Three way interaction					
Portfolio Size x Portfolio Diversity x TMT's Capability					.10(.10)
Constant	1.02(.30)***	.16(.57)	–.52(.61)	–.73(.62)	–.72(.62)
Constant	1.02(.30)***	.16(.57)	–.52(.61)	–.73(.62)	–.72(.62)
Chi-square	86.66	94.92	117.38	123.72	124.62
Log Likelihood	–672.53	–667.9	–656.67	–653.5	–653.05
Improvement over Base (Chi-square)		8.26	30.72	37.06	37.96

N = 238
* $p < 0.05$
** $p < 0.01$
*** $p < 0.001$

Table 6.7: Results of analysis of three-way interaction for portfolio intensity on innovative performance

Variables	Model 1	Model 2	Model 3	Model 4	Model 5
Size	0.00(.00)**	.00(.00)	.00(.00)	.00(.00)	.00(.00)
Age	0.00(.02)	.70(.55)	.81(.56)	.79(.57)	.72(.57)
Status	–.15(.16)	.38(.17)**	–.31(.18)**	–.27(.18)**	–.34(.19)**
Government Support	0.72(.16)***	.63(.16)***	.75(.16)***	.76(.17)***	.74(.17)***
Scope	0.07(.08)	.08(.08)	.10(.08)	.15(.09)*	.15(.09)*
University Alliance	0.59(.16)***	.53(.16)**	.65(.17)***	.63(.17)***	.63(.17)***
Cluster	–.25(.15)***	–.21(.15)	–.37(.15)**	–.32(.16)**	–.29(.16)**
TMT Capability		.74(.28)**	.06(.32)	.04(.33)	.09(.32)
Portfolio Size			.06(.01)***	.05(.02)***	.03(.02)
Portfolio Diversity			.03(.41)	.10(.42)	.22(.42)
Portfolio Intensity			1.12(.45)**	–.00(.61)	–.29(.62)
Two way interaction					
Portfolio Size x Portfolio Intensity				–.01(.01)*	–.01(.01)
Portfolio Size x TMT Capability				–.09(.15)	–.36(.21)*
TMT Capability x				1.72(.67)**	1.95(.64)***
Portfolio Intensity					
Three way interaction					
Portfolio Size x					–.33(.16)**
Portfolio Intensity x					
TMT's Capability					
Constant	–1.02(.30)***	.16(.57)	–.52(.61)	–.31(.64)	–.01(.66)
Chi-square	86.66	94.92	117.38	130.6	134.91
Log Likelihood	–672.53	–667.9	–656.67	–650.06	–647.91
Improvement over Base (Chi-square)		8.26	30.72	43.94	48.25

N = 238
* $p < 0.05$
** $p < 0.01$
*** $p < 0.001$

Figure 6.3: Interaction of portfolio size, portfolio intensity and TMT's capability on innovative performance

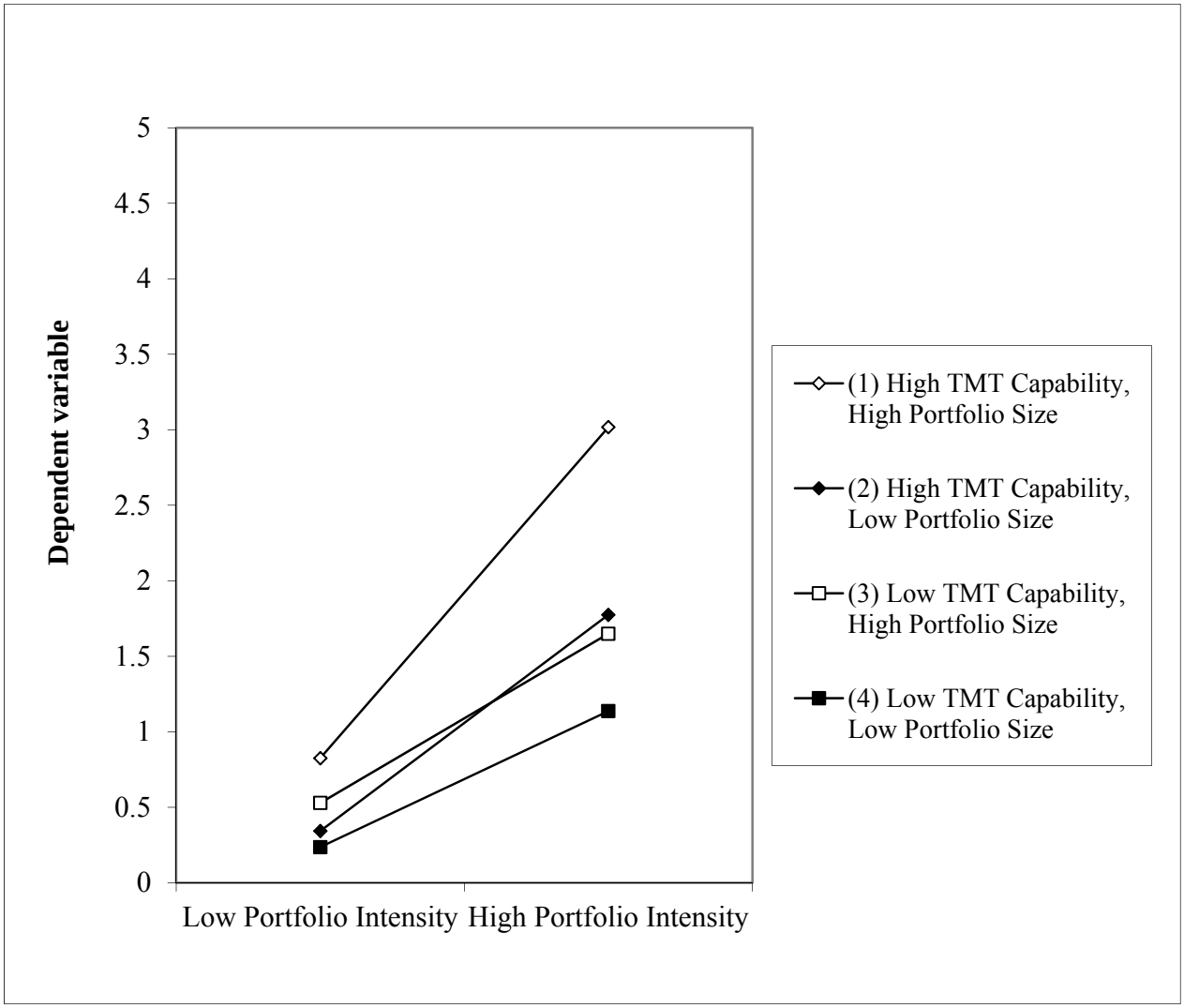


Table 6.8: Summary of empirical results from hypotheses testing

Hypothesis	Supported
H1: Portfolio size is positively related to innovative output.	Yes
H2: Portfolio diversity positively moderates the positive relationship between portfolio size and innovative output.	Yes
H3: Portfolio intensity positively moderates the positive relationship between portfolio size and innovative output.	Yes
H4: The direct effect of portfolio size to the entrepreneurial firms' innovative output is positively mediated by the amount of alliance capital.	Yes, Partial Mediation
H5: Portfolio diversity will moderate the relationship of portfolio size and alliance capital such that the relationship will be stronger under high portfolio diversity than under low portfolio diversity.	No
H6: Portfolio intensity will moderate the relationship of alliance capital and innovative outputs such that the mediated relationship will be stronger under high portfolio intensity than under low portfolio intensity.	No
H7: The TMT's capability is positively related to innovative output.	Yes
H8: The interaction among portfolio size, portfolio diversity and innovative outputs will be positively moderated by the TMT's capability, such that the interaction will be stronger as the TMT's capability increases.	No
H9: The interaction among portfolio size, portfolio intensity and innovative output will be positively moderated by the TMT's capability, such that the interaction will be stronger as the TMT's capability increase.	Yes

6.5 Chapter summary

This chapter has provided the empirical analysis for the nine hypotheses presented in Chapter 4. The first part of the chapter explained the coding of each variable and portfolio dimension, and also the dependent variable, mediators and control variables. The second part of the chapter provided the results of the empirical testing. I found empirical support for hypotheses 1–3 and hypotheses 7 and 9. Hypothesis 4 demonstrated partial mediation. No results were found for hypotheses 5, 6 and 8.

Chapter 7: Discussion of Empirical Results

7.1 Introduction

This chapter discusses the empirical findings described in the previous chapter. Nine hypotheses were proposed to test the research questions posed in Chapter 1. These hypotheses investigated interactions among different dimensions of the alliance portfolio, the mediating role of alliance capital, the interaction among the TMT's capability with different dimensions of the alliance portfolio, and the effect each of these on an entrepreneurial firm's innovative output. Chapter 6 described how six of the nine proposed hypotheses were supported, with hypotheses 5, 6 and 8 not supported. This chapter discusses the implication of these findings, and provides possible reasons why those three hypotheses were not supported. This chapter also discusses the implications of the partial mediation finding for Hypothesis 4.

7.2 Effects of alliance portfolio configuration on innovative output (H1–H3)

Hypotheses 1, 2 and 3 were proposed to answer the first research question – *'How do different dimensions of an alliance portfolio interact to generate innovative outputs by an entrepreneurial firm?'* For Hypothesis 1, I argue that portfolio size exhibits a positive effect on the firm's innovative outputs. I further argue for hypotheses 2 and 3 that portfolio diversity and intensity positively moderate the relationship between portfolio size and the firm's innovative output, respectively. The empirical result

supports the argument that the larger the portfolio size, the more innovative output that the firm can generate. In addition, as predicted in hypotheses 2 and 3, the relationship between portfolio size and the firm's innovative output is positively moderated by a portfolio of greater diversity and stronger intensity. While I found support for hypotheses 1 and 3 in each of the five models presented in Table 6.2., I found support for Hypothesis 2 only in the full model.

The findings from the first three hypotheses further elucidate our understanding of the role of portfolio configuration in inter-firm research. Previous studies have examined individual dimensions of the alliance portfolio, and their findings underscore the importance of alliance configuration to a firm's innovativeness (Baum et al., 2000; Gulati, 1995; Powell et al., 1996). The findings of this study extend previous research in two directions. First, this study found an alliance portfolio's configuration of the three dimensions (i.e., size, diversity and intensity) plays a critical role in the innovativeness of small entrepreneurial firms. Second, the finding broadens the tendency of similar previous studies to focus randomly on just one or two characteristics of the alliance portfolio (Rothaermel, 2001; Rothaermel & Deeds, 2004; Shan et al., 1994). The finding highlights the need to examine all three dimensions of the portfolio simultaneously when testing for the effect of alliance portfolio on a firm's innovativeness.

7.3 Mediating effects of alliance capital on innovative output (H4–H6)

Hypotheses 4, 5 and 6 were proposed to answer the second research question – *'How do tangible financial resources procured externally from the firm's alliance partners mediate the effect alliance portfolio has on the innovative outputs of an entrepreneurial firm?'* With Hypothesis 4, I argue that the larger the portfolio size, the more likely that the entrepreneurial firm would procure a larger amount of alliance capital to utilize in increasing its innovative output. I further argue that this mediating relationship is positively moderated by portfolio diversity and portfolio intensity, respectively, in Hypothesis 5 and Hypothesis 6. More specifically, I argue for Hypothesis 5 that increases in portfolio diversity would positively moderate the mediating relationship of portfolio size, alliance capital and innovative outputs. Likewise, in Hypothesis 6, I argue that portfolio intensity would positively moderate the mediating relationship of portfolio size, alliance capital and innovative outputs in such a way that the focal firm will secure a larger amount of alliance capital with a higher degree of portfolio intensity.

I found partial support for Hypothesis 4. This finding further expands on prior research by providing empirical evidence on the positive contribution of alliance capital to the entrepreneurial firm's innovative output. Prior studies have focused on firm-level characteristics that are conductive for procuring alliance capital (Coombs & Deeds, 2000; Coombs et al., 2006). Although these studies imply that a larger amount of alliance capital is conducive to the firm's performance, such a claim still lacks empirical support, especially in the context of small entrepreneurial firms seeking to increase their innovative output. The finding from Hypothesis 4 provides empirical evidence of a

positive effect of alliance capital on innovative outputs; moreover, the finding of partial mediation indicates that entrepreneurial firms are procuring not just tangible resources, such as alliance capital, but are also procuring other type of resources from portfolio partners. This explains the positive and significant direct effect of portfolio size on innovative outputs after controlling for the indirect effect through alliance capital. These resources could include technology know-how and firm legitimacy (Kelly & Rice, 2001). The reason for this finding is that most entrepreneurial firms lack sufficient resources in their initial developmental stages, and they resort to their alliances to compensate for their own shortage of resources (Eisenhardt & Schoonhove, 1996). Irrespective of what the entrepreneurial firms procure, the finding of Hypothesis 4 indirectly indicates that resources above and beyond tangible financial resources obtained from alliance partners are important for innovation. The presence of different types of partners within the portfolio allows the firm to procure different types of tangible and intangible resources it needs to enhance its innovative output.

The moderating effect of portfolio diversity (H5), and portfolio intensity (H6) on the mediating relationship of portfolio size, alliance capital and innovative output was not supported. The reason why Hypothesis 5 was not supported could be due to the restrictive nature of the dependent variable. The dependent variable used in this study included only those innovative outputs that have successfully passed through screening and initial testing trials, where the failure rate can be as high as 90 per cent (Munos, 2009; Pisano, 2010). In other words, the innovative output includes only the 10 per cent of innovations with the highest likelihood of being a commercial success, and ignores the 90 per cent of discoveries with less chance of success. However, I argue it is more likely that heterogeneous sets of external resources, procured from portfolio diversity, are most useful to the entrepreneurial firm during the initial testing trials, because it is

during this phase that the entrepreneurial firm seeks to convert technological knowledge into new discoveries. In short, due to the restrictive measurement of innovative output, I am unable to affirm the moderating effect of portfolio diversity in Hypothesis 5.

For Hypothesis 6, I argue that no significant moderating relationship of portfolio intensity was found because of the restrictive nature of the mediating variable. While high portfolio intensity indicates joint ownership of portfolio, which allows for additional external financial capital from alliance partners, I argue that the alliance capital might be too restrictive to take into account all external financial capital procured by the firm. This is because the external capital may not always take the form of alliance capital: it could be supplied through non-alliance financing activities, including equity investments, private placements and loans by prominent investment banks and venture capitalists. All these forms of financing activities are supplied as the result of appropriate allocation of control rights between the focal firm and its portfolio partners, and provide necessary financial capital for the firm to carry out its innovative activities. However, as the study focused only on the alliance capital procured from the alliance portfolio, it did not measure other forms of financial resources, and the possibility that firms might procure external financial capital in the context of greater portfolio intensity was not included in the analysis. In short, due to the restrictive measurement of alliance capital, I am unable to affirm the moderating effect of portfolio intensity in Hypothesis 6.

7.4 Interaction among alliance portfolio configuration and the TMT's capability on innovative output (H7–H9)

Hypotheses 7, 8 and 9 were proposed to answer the third question – *'How do top management team's capabilities interact with the firm's alliance portfolio to affect the innovative outputs of an entrepreneurial firm?'* In Hypothesis 7, I argue that the TMT's capability has a direct effect on the innovative outputs of the entrepreneurial firm. I further argue that there exists an interactive relationship among TMT's scientific capability, portfolio diversity and portfolio size on innovative outputs in Hypothesis 8, and on interactive relationship among the TMT's scientific capability, portfolio intensity and portfolio size on innovative outputs in Hypothesis 9.

For Hypothesis 7, I found a significant relationship between the TMT's capability and innovative outputs, after controlling for firm and alliance-related variables. This is consistent with previous research of TMT background and its positive effect on the firm's innovativeness (Ding, 2011; Hsu et al., 2007; Stuart & Podolny, 1996). The empirical finding suggests that the TMT's capability plays a critical role in the increase of a firm's innovative output, through either allocation of resources within the firm, or through attraction and retention of productive researchers that increase the firm's innovative output.

I found no significant result for Hypothesis 8, in which I argue that entrepreneurial firms with a highly capable TMT are more likely to be able to identify and select new partners from a diverse alliance portfolio that is compatible with the focal firm. I argue, however, that limitations on the variable may influence the findings. Such limitations can be understood in two ways.

First, this study categorized different types of partnerships into three broad groups for portfolio diversity: vertical upstream research-oriented alliances, vertical-downstream commercialization-oriented alliances and horizontal co-development alliances. While such classification encompasses all likely possible combinations of alliances, it does not clearly distinguish different types of partners and their roles when interacting with the firm's upper echelon. For example, vertical upstream alliances are R&D partnerships with different research-oriented institutions, such as universities, for-profit research labs and not-for-profit research institutions. Yet the moderating effect of the TMT's capability on portfolio diversity may be significant in the context of partnerships with universities, because the firm needs to determine which university offers the technology with the most potential, but it may be less significant in partnerships with for-profit research labs. In other words, the TMT's capability to identify appropriate external partners from a wide external portfolio may be more evident in individual partnerships than in an aggregated alliance portfolio.

Second, this study chose innovative outputs as the dependent variable, and did not consider other likely dependent variables that would be affected with the interaction of the TMT's capability and portfolio diversity. More specifically, it is likely that higher portfolio diversity combined with greater TMT capability would impact the rate of new alliance formation, as the TMT could better judge who would be appropriate alliance partners. However, as a result of this research focusing on the effect of a firm's alliance portfolio on its innovative output, other likely dependent variables that could possibly demonstrate the significant effect of portfolio diversity were not included in this analysis.

I found significant support for Hypothesis 9, which indicates a positive interaction among the TMT's capability, portfolio size and portfolio intensity. This finding suggests a complementary relationship between the TMT's capability and portfolio intensity, in that the positive effect of portfolio intensity on innovative outputs could be further enhanced with a highly capable TMT.

7.5 Chapter summary

This chapter has discussed the empirical findings. First, results from the empirical testing for hypotheses 1–3 confirm the utility of the alliance portfolio configuration in understanding how a focal firm's alliance portfolio can affect its innovative performance. Second, the presence of partial mediation found in Hypothesis 4 indirectly indicates that entrepreneurial firms are likely to procure various tangible and intangible resources needed on top of financial resources to enhance their own innovative output. Third, the finding of the positive effect of the TMT's capability, both directly and indirectly, via use of equity ties that affect the firm's innovative outputs (hypotheses 7–9) indicates the importance in taking into account TMT's capability to manage alliance portfolio when considering the effect of alliance portfolio configuration. Lastly, this chapter provided some possible explanations as to why no results were found for hypotheses 5, 6 and 8. The predominant reason was attributed to the restrictive nature of different variables.

Chapter 8: Conclusion

8.1 Summary of the study

This study was motivated by the three research questions about alliance portfolio and innovative outputs of entrepreneurial firms that were discussed in Chapter 2:

RQ 1: How do different dimensions of an alliance portfolio interact to generate innovative outputs by an entrepreneurial firm?

RQ 2: How do tangible financial resources procured externally from the firm's alliance partners mediate the effect of alliance portfolio on the innovative outputs of an entrepreneurial firm?

RQ 3: How do top management team's capabilities interact with the firm's alliance portfolio to affect the innovative outputs of an entrepreneurial firm?

This study conceptualized alliance portfolio as a multi-dimensional construct consisting of three distinct dimensions: size, diversity and intensity. It synthesized the resource-based view and firm capability perspectives, and developed a new theoretical model to examine how an entrepreneurial firm's alliance portfolio can affect its own innovative outputs. Nine hypotheses were proposed to describe the theoretical model. The model was empirically tested on a sample of 238 dedicated biotechnology firms based in the U.S. Each firm had three or more alliances, and the data included 2501 alliances spanning from the inception of each firm until 2009. The dependent variable was measured in 2010. Due to the nature of the dependent variable, this study adopted the negative binomial regression method to test all nine hypotheses.

The empirical testing found a direct and positive effect of portfolio size on innovative outputs, with the relationship being positively moderated by both high portfolio diversity and high portfolio intensity. The empirical testing also found partial mediation of alliance capital on innovative outputs, indicating that entrepreneurial firms procure not only financial resources, but also other types of resources, from their portfolio partners. In terms of interaction between the alliance portfolio and senior management, the empirical testing found that the top management team's capability has a direct effect on the firm's innovative output, and it also interacts positively with portfolio intensity to moderate the direct effect of portfolio size on innovative output.

8.2 Theoretical implications

This thesis extends our understanding of alliances of entrepreneurial firms from three aspects. The first theoretical implication of this thesis concerns the configuration of alliance portfolio. Previous research often randomly chose just one or two portfolio dimensions as the focus (Duysters et al., 2012; Faems et al., 2005; Jiang et al., 2010), and examined the effect of these on the firm's performance. I argue in this thesis that the three dimensions of an alliance portfolio – size, diversity and intensity – need to be studied simultaneously because of the possible significant interactions among these three dimensions and their simultaneous effect upon firm performance. The proposed theoretical model of alliance portfolio configuration on a firm's innovative output demonstrates the utility of simultaneously examining the interactions of a portfolio's size, diversity and intensity on firms' innovativeness. This suggests that future studies should adopt a holistic approach to understand the configuration and the performance implication of an alliance portfolio.

The second implication is concerned with the mechanism of how a firm's alliance portfolio translates into its innovative outputs. This thesis suggests that firms use a mediating mechanism to generate alliance capital from their alliance portfolio, and this alliance capital then facilitates greater innovative output. Previous research had assumed the pivotal contribution of external financial resources to a firm's innovativeness, and therefore focused on addressing the firm-level characteristics that can help the focal firm to attract financial capital (Deeds et al., 1997; Deeds et al., 2004). Financial capital was therefore often studied as the dependent variable. However, the positive effect of alliance capital on the entrepreneurial firm's innovativeness has not been empirically verified. This thesis fills this gap in understanding by providing empirical support for alliance capital's positive effect on innovative outputs. In addition, the results show that, while external financial resources are important, entrepreneurial firms are likely to also procure other types of resources through their alliance portfolio. Both intangible and tangible resources are indispensable for entrepreneurial firms to achieve successful innovative output. Future studies should therefore consider different types of resources that alliance portfolio can generate in order to enhance the firm's innovative output.

The third theoretical implication advances the resource-based view on inter-firm alliances. Previous research has drawn upon the resource-based view to explain the motivation of forming an alliance portfolio (Lavie, 2006; Powell et al., 1996). Such studies have dwelt on the different type of resources that firms can obtain from their alliance partners. In contrast, this study proposes that, although alliance portfolio provides access to external resources, the impact of these resources on innovative output also hinges on whether the firm has the internal capability to manage these resources. The empirical finding verifies this line of reasoning, suggesting that internal resources complement, rather than substitute for, the impact of external resources on innovation.

In order to better understand how entrepreneurial firms utilize their alliance portfolio to induce better innovative performance, future studies should investigate the upper echelon's capability to manage the firm's portfolio partners and the different type of resources it can procure from its portfolio partners.

8.3 Managerial implications

This thesis provides practical implications for business managers on alliance formation and management. First, managers need to move their focus beyond merely increasing the number of alliances to a deliberate configuration of a multi-dimensional alliance portfolio (Faems et al., 2012; Parise & Casher, 2003). Empirical evidence from this study suggests that a multi-dimensional alliance portfolio should consist of not just a suitable number of alliances, but also diverse types of partners. This is because high portfolio diversity provides the focal firm with a constellation of alliances with different types of organizations and institutions across the industry value chain, which all enable the entrepreneurial firm to procure different types of resources. In addition to the deliberate choice of diverse partners, managers also need to focus on portfolio formulation and the governances of these alliances (Hoffmann, 2005; Hoffmann & Schaper-Rinkel, 2001). Specifically, managers should recognize that the adoption of equity-based alliances is instrumental in reducing potential opportunistic behaviour and resolving appropriation hazards that can arise from misaligned interests between the firm and its partners.

Second, managers need to develop distinct sets of capability to manage the multi-dimensional portfolio that its firm had configured. Both portfolio diversity and portfolio

intensity require more attention from managers for effective management. Previous studies have provided different advice because they focused on the inter-personal network of the upper echelon and its potential effect on firm performance (Heimeriks & Duysters, 2007; Lee & Park, 2008). The distinct sets of capabilities possessed by senior managers are exemplified through the direct and indirect influences of these capabilities on the management of the firm's alliance portfolio. Highly competent senior management can identify suitably complementary alliance partners and select the most appropriate governance form for the firm (Duysters et al., 2012). The correct choice of governance mode is instrumental in minimizing appropriation hazards and opportunistic behaviour, especially when entrepreneurial firms are partnered with large incumbent firms and the former are likely to possess proprietary knowledge that the latter lack.

Third, managers should not focus merely on acquiring financial resources from their portfolio partners, but instead should seek to procure different types of resources to maximize the value of an alliance portfolio. While firms can deploy their alliance portfolios to obtain funding for identifying new opportunities, adopting new strategic directions and extending their corporate activities (George et al., 2001; Yamakawa, 2011), this study argues that financial capital obtained from alliances is not the only important resource that entrepreneurial firms can use for innovation. This is especially the case when an entrepreneurial firm lacks resources in the initial phases of its product development. While this study found alliance portfolios contribute toward the focal firm's alliance capital, it is highly likely that entrepreneurial firms would not have all the necessary tangible and intangible resources at their disposal, and therefore managers should not confine themselves to only one type of resources, but instead should seek to procure both tangible and intangible resources from different types of partners.

8.4 Limitations of the study

The results of this study should be interpreted with some caution. The first limitation of this study is generalizability. This study chose alliance portfolios initiated and managed by entrepreneurial firms from the biopharmaceutical industry in the U.S. The reason for this choice is that the generation of innovative output in this industry can be lengthy and require more resources than are immediately available to most entrepreneurial firms. Consequently, firms in this industry that seek to generate innovative output must resort to forming alliances to procure resources. The unique context of the biopharmaceutical industry may not be applicable to other industries where innovative output occurs more quickly and so firms' dependence on their alliance portfolio to procure external resources is not as urgent (Hagedoorn, 1993; Hagedoorn & Narula, 1996).

The second limitation is concerned with causation. This study used a cross-sectional design and, although this study allowed for a time lag between formation of the alliance portfolio and innovative output, strict causation cannot be established. In other words, I cannot rule out the possibility that higher innovative output may affect the configuration of alliance portfolio and alliance capital.

The third limitation is concerned with the validity of archival data. Although the data sources chosen are widely acknowledged as the most comprehensive available for the biopharmaceutical industry in the U.S., and although most related research is also based on this data set, there is still a possibility that the data set could be limited. The reason is that most entrepreneurial firms are private firms and are therefore not obliged to publicize their corporate activities. In addition, since knowledge for innovative output is often proprietary, firms may be unlikely to divulge all details of an alliance, even when

the alliance is made public. This limitation can be particularly serious for studies that are concerned with how alliance portfolios affect firms' innovative performance, as has been recognized by other researchers (Powell & Snellman, 2004).

8.5 Future research agenda

This thesis has proposed an empirically verified theoretical model of alliance portfolio and innovation for entrepreneurial firms. Building on the initial support of the model, further research agenda could explore other avenues. Future studies could take a more nuanced measure of portfolio size, diversity and intensity to better gauge how the configuration of an alliance portfolio can affect the innovative output of entrepreneurial firms. Specifically, in regards to portfolio size, future studies could take into account the termination time of the alliance, or adopt a five-year period as the time during which the alliance is effective (Lavie, 2006). In this way, analysis could more accurately reflect the changing dynamics of the alliance portfolio, instead of treating a firm's portfolio as a static construct.

As for portfolio diversity, future research could adapt the study by Powell et al. (2005), which identified 24 possible combinations for portfolio diversity. Such an approach would allow for an even more in-depth analysis of portfolio diversity, and could pinpoint the type of alliance activities and alliance partners that are most conductive to firms' innovative performance. Future studies could also take a more precise measurement of portfolio intensity by considering the different percentage of equity by each partner of the alliance, and identify the type of equity ties that can generate the most innovative outputs.

In addition, future studies could employ the theoretical framework developed here to study a wider range of dependent variables, such as the effect of alliance portfolio configuration on the attractiveness of entrepreneurial firms. Such research could proceed in two ways. First, researchers could examine whether entrepreneurial firms are able to attract new partners with their existing alliance portfolio, and establish more alliances subsequent to the formation of its expanded alliance portfolio. Alternatively, they could examine whether high portfolio diversity and high portfolio intensity within the portfolio make entrepreneurial firms a more attractive acquisition target, so that they subsequently experience a higher rate of acquisition.

8.6 Concluding remarks

To conclude, this thesis has addressed some of the crucial debates on alliance portfolio of entrepreneurial firms. Building on the resource-based view and the firm capability perspective, this thesis has presented a new theoretical model that consists of (1) a configuration of alliance portfolio formed by the attributes of size, diversity and intensity; (2) the role of the configuration of alliance portfolio on innovation; and (3) the complementary role of the top management team's capability on innovation. These ideas were empirically tested on the biotechnology firms in the U.S. This thesis advances the theoretical understanding of a configuration of alliance portfolio and its complex interactive effect with the top management team's capability on innovative outputs. As such, the thesis contributes to our understanding of the alliance portfolio of entrepreneurial firms.

References

Acar, W. & Sankaran, K. (1999) The myth of the unique decomposability: specializing the Herfindahl and entropy measures? *Strategic Management Journal*, *20*(10), 969-975.

Adams, C. P. & Brantner, V. V. (2010) Spending on new drug development. *Health Economics*, *19*(2), 130-141.

Adegbesan, J. A. & Higgins, M. J. (2011) The intra-alliance division of value created through collaboration. *Strategic Management Journal*, *32*(2), 187-211.

Adler, P. S. & Kwon, S. W. (2002) Social capital: Prospects for a new concept. *Academy of Management Review*, *27*(1), 17-40.

Aggarwal, V. A. & Hsu, D. H. (2009) Modes of cooperative R&D commercialization by start-ups. *Strategic Management Journal*, *30*(8), 835-864.

Ahuja, G. (2000) Collaboration networks, structural holes, and innovation: A longitudinal study. *Administrative Science Quarterly, 45*(3), 425-455.

Aiken, L. S. & West, S. G. (1991) *Multiple regression: Testing and interpreting interactions*. Sage.

Alexiev, A. S., Jansen, J. J., Van den Bosch, F. A. & Volberda, H. W. (2010) Top management team advice seeking and exploratory innovation: the moderating role of TMT heterogeneity. *Journal of Management Studies*, *47*(7), 1343-1364.

Al-Laham, A. & Souitaris, V. (2008) Network embeddedness and new-venture internationalization: Analyzing international linkages in the German biotech industry. *Journal of Business Venturing, 23*(5), 567-586.

Anderson, J. C., Hankinson, H. & Johanson, J. (1994) Dyadic Business Relationships within a Business Network. *Journal of Marketing*, *58*(4), 1-15

Ardichvili, A., Cardozo, R. & Ray, S. (2003) A theory of entrepreneurial opportunity identification and development. *Journal of Business Venturing*, *18*(1), 105-123.

Argyres, N. S. & Liebeskind, J. P. (2002) Governance inseparability and the evolution of US biotechnology industry. *Journal of Economic Behaviour & Organization*, *47*(2), 197-219.

Arora, A. & Gambardella, A. (1990) Complementariness and external linkages: The strategies of the large firms in biotechnology. *Journal of Industrial Economics*, *38*(4), 361-379.

Arya, B. & Lin, Z. (2007) Understanding collaboration outcomes from an extended resource-based view perspective: The roles of organizational characteristics, partner attributes, and network structures? *Journal of Management*, *33*(5), 697-723.

Audretsch, D. B. (2003) *The role of small firms in US biotechnology cluster in Biotechnology in Comparative Perspective*. (ed Gerhard Fuchs).

Bae, J. & Gargiulo, M. (2004) Partner substitutability, alliance network structure, and firm profitability in the telecommunications industry. *Academy of Management Journal, 47*(6), 843-859.

Bamford, J. D., Gomes-Casseres, B. & Robinson, M. S. (2003) *Mastering alliance strategy: a comprehensive guide to design, management, and organization*. John Wiley and Sons.

Bamford, J. & Ernst, D. (2002) Managing an alliance portfolio. *McKinsey Quarterly*, 3: 29-39.

Barley, S. R., Freeman, J. & Hybels, R. (1992) Strategic alliances in commercial biotechnology. *Networks and Organizations*. Harvard Business School Press, Boston, M.A.

Barney, J.B. (1991) Firm resources and sustained competitive advantage. *Journal of Management, 17*(1), 99-120.

Barney, J. B. (2001) Resource-based theories of competitive advantage: A ten-year retrospective on the resource-based view. *Journal of Management*, *27*(6), 643-650.

BarNir, A. & Smith, K. A. (2002) Inter-firm alliances in the small business: The role of social networks. *Journal of Small Business Management*, *40*(3), 219-232.

Baron, R. M. & Kenny, D. A. (1986) The moderator–mediator variable distinction in social psychological research: Conceptual, strategic, and statistical considerations. *Journal of Personality and Social Psychology*, *51*(6), 1173-1198.

Barringer, B. R. & Harrison, J. S. (2000) Walking a tightrope: Creating value through inter-organizational relationships. *Journal of Management, 26*(3), 367-403.

Batjargal, B. N. (2003) Social capital and entrepreneurial performance in Russia: A longitudinal study. *Organization Studies*, *24*(4), 535-556.

Batjargal, B. N. & Liu, M. (2004) Entrepreneurs' access to private equity in China: The role of social capital. *Organization Science*, *15*(2), 159-172.

Baum, J & Oliver, C. (1991) Institutional linkages and organizational mortality. *Administrative Science Quarterly*, *36*(2), 187-218.

Baum, J. A. & Oliver, C. (1996) Toward an institutional ecology of organizational founding. *The Academy of Management Journal, 39*(5), 1378-1427.

Baum, J. A., Calabrese, T. & Silverman, B. S. (2000) Don't go it alone: Alliance network composition and startups' performance in Canadian biotechnology. *Strategic Management Journal, 21*(3), 267-294.

Baum, J. A. & Silverman, B. S. (2004) Picking winners or building them? Alliance, intellectual, and human capital as selection criteria in venture financing and performance of biotechnology start-ups. *Journal of Business Venturing*, *19*(3), 411-436.

Bayona, C., García-Marco, T. & Huerta, E. (2001) Firms' motivations for cooperative R&D: an empirical analysis of Spanish firms. *Research Policy, 38*(8), 1289-1307.

Bensaou, M. (1999) Portfolio of buyer-supplier relationships. *Sloan Management Review*, Summer, 35-44.

Berry, C. H. (1975) *Corporate Growth and Diversification*. Princeton, NJ: Princeton University Press.

Bhide, A. (2000) *The origin and evolution of new businesses*. Oxford University Press on Demand.

Bianchi, T. (2001) With and without co-operation: two alternative strategies in the food-processing industry in the Italian South. *Entrepreneurship & Regional Development*, *13*(2), 117-130.

BioCentury (2010) *Biopharmaceutical Database*, Oxford: BioCentury International.

BioScan (2010) *BioScan Database*, North Carolina: BioWorld.

Birley, S. (1985) The role of networks in the entrepreneurial process. *Journal of Business Venturing*, *1*(1), 107-117.

Blau, P. M. (1977) *Inequality and heterogeneity: A primitive theory of social structure*. New York: Free Press.

Blodgett, L. L. (1991) Partner contributions as predictors of equity share in international joint ventures. *Journal of International Business Studies*, *22*(1), 63-78.

Borgatti, S. P. & Foster, P. C. (2003) The network paradigm in organizational research: A review and typology. *Journal of Management*, *29*(6), 991-1013.

Brass, D. J., Galaskiewicz, J., Greve, H. R. & Tasi, W. (2004) Taking stock of networks and organization: A multilevel perspective. *Academy of Management Journal*, *47*(6), 795-817.

Brouthers, K. D., Nakos, G. & Dimitratos, P. (2014). SME Entrepreneurial Orientation, International Performance, and the Moderating Role of Strategic Alliances. *Entrepreneurship Theory and Practice*, online edition.

Brown, S. L. & Eisenhardt, K. M. (1995) Product development: Past research, present findings, and future directions. *Academy of Management Review*, *20*(2), 343-378.

Bruderl, J. & Schussler, R. (1990) Organizational mortality: The liabilities of newness and adolescence. *Administrative Science Quarterly*, *35*(3), 530-547.

Brush, C. G., Greene, P. G. & Hart, M. M. (2001) From initial idea to unique advantage: The entrepreneurial challenge of constructing a resource base. *Academy of Management Executive*, *15*(1): 64-78.

Bruyaka, O. & Durand, R. (2012) Sell-off or shut-down? Alliance portfolio diversity and two types of high tech firms' exit. *Strategic Organization*, *10*(1), 7-30.

Burt, R.S. (1987) Social contagion and innovation: Cohesion versus structural equivalence. *American Journal of Sociology, 92*(6), 1287-1335.

Burt, R. S. (1992) *Structural Holes: The social structure of competition.* Cambridge, MA: Harvard University Press.

Burt, R. S. (2000) The network structure of social capital. *Research in Organizational Behaviour*, 22: 345-423.

Burt, R. S. (2005) *Brokerage and Closure: An introduction to social capital.* New York: Oxford University Press.

Cabrera, A. & Cabrera, E. F. (2002) Knowledge-sharing dilemmas. *Organization Studies*, *23*(5), 687-710.

Calabrese, T., Baum, J.A. & Silverman, B. (2000) Canadian biotechnology start-ups, 1991 – 1997: The role of incumbents' patent and strategic alliance in controlling competition. *Social Science Research*, *29*(4), 503-534.

Calof, J. L. (1994) The relationship between firm size and export behaviour revisited. *Journal of International Business Studies*, *25*(2), 367-387.

Cameron, A. C. & Trivedi, P. K. (1986) Econometric models based on count data. Comparisons and applications of some estimators and tests. *Journal of Applied Econometrics*, *1*(1), 29-53.

Caner, T. & Tyler, B. B. (2013) Alliance portfolio R&D intensity and new product introduction. *American Journal of Business*, *28*(1), 38-63.

Carayannis, E. G., Alexander, J. & Ioannidis, A. (2000) Leveraging knowledge, learning, and innovation in forming strategic government–university–industry (GUI) R&D partnerships in the US, Germany, and France. *Technovation*, *20*(9), 477-488.

Casciaro, T. (2003) Determinants of governance structure in alliances: the role of strategic, task and partner uncertainties. *Industrial and Corporate Change*, *12*(6), 1223-1251.

Castanias, R. P. & Helfat, C. E. (1991) Managerial resources and rents. *Journal of Management*, *17*(1), 155-171.

Casper, S. & Murray, F. (2005) Careers and clusters: Analysing the career network dynamic of biotechnology clusters. *Journal of Engineering and Technology Management*, *22*(1), 51-74.

Casper, S. (2007) How do technology clusters emerge and become sustainable? Social network formation and inter-firm mobility within the San Diego biotechnology cluster. *Research Policy*, *36*(4), 438-455.

Chandler, A. D. (1992) Organizational capabilities and the economic history of the industrial enterprise. *Journal of Economic Perspectives*, *6*(3), 79-100.

Chandler, A. D., Hikino, T., Von Nordenflycht, A. & Chandler, A. D. (2009) *Inventing the Electronic Century: The Epic Story of the Consumer Electronics and Computer Industries, with a new preface* (Vol. 47). Harvard University Press.

Chandler, A. D. (2009) *Shaping the industrial century: The remarkable story of the evolution of the modern chemical and pharmaceutical industries* (Vol. 46). Harvard University Press.

Chang, K. (2008) The strategic alliance of the biotechnology firm. *Applied Economic*, *40*(23): 3089-3100.

Chatterji, A. K. (2009) Spawned with a silver spoon? Entrepreneurial performance and innovation in the medical device industry. *Strategic Management Journal*, *30*(2): 185-206.

Chesbrough, H. (2003) The governance and performance of Xerox's technology spin-off companies. *Research Policy*, *32*(3), 403-421.

Child, J & Faulkner, D. (1998) *Strategies of cooperation: managing alliances, networks, and joint ventures*. Oxford University Press.

Christensen, C. M. & Rosenbloom, R. S. (1995) Explaining the attacker's advantage: Technological paradigms, organizational dynamics, and the value network. *Research Policy*, *24*(2), 233-257.

Chung, S. A., Singh, H. & Lee, K. (2000) Complementarity, status similarity and social capital as drivers of alliance formation. *Strategic Management Journal*, *21*(1), 1-22.

Coase, R. H. (1937). The nature of the firm. *Economica*, *4*(16), 386-405.

Cohen, W. M. & Levinthal, D. A. (1990) Absorptive capacity: A new perspective on learning and innovation. *Administrative Science Quarterly*, *35*(1), 128-152.

Coleman, J. S. (1988) Social capital in the creation of human capital. *American Journal of Sociology*, 95-120.

Coleman, J. S. (1990) *Foundations of Social Theory***.** Cambridge, MA: Harvard University Press

Colombo, M.G., Grilli, L. & Piva, E. (2006) In search of complementary assets: The determinants of alliance formation of high-tech start-ups. *Research Policy*, *35*(8), 1166-1199.

Combs, J. G., Ketchen Jr. D. & Hoover, V. L. (2004) A strategic groups approach to the franchising-performance relationship. *Journal of Business Venturing*, *19*(6), 877-897.

Conti, A., Thursby, M., & Rothaermel, F. T. (2013) Show me the right stuff: Signals for high-tech startups. *Journal of Economics & Management Strategy*, *22*(2), 341-364.

Coombs, J. E. & Deeds, D. L. (2000) International alliances as sources of capital: Evidence from the biotechnology industry. *Journal of High Technology Management Research*, *11*(2), 235-253.

Coombs, J. E., Mudambi, R. & Deeds, D. L. (2006) An examination of the investments in US biotechnology firms by foreign and domestic corporate partners. *Journal of Business Venturing*, *21*(4), 405-428.

Coombs, J. E., Deeds, D. L. & Ireland, D. R. (2009) Placing the choice between exploration and exploitation in context: A study of geography and new product development. *Strategic Entrepreneurship Journal*, *3*(3), 261-279.

Cooper, A. C., Gimeno-Gascon, F. J. & Woo, C. Y. (1994) Initial human and financial capital as predictors of new venture performance. *Journal of Business Venturing*, *9*(5), 371 – 395.

Covin, J. G. & Slevin, D. P. (1988) The influence of organization structure on the utility of an entrepreneurial top management style. *Journal of Management Studies*, *25*(3), 217-234.

Covin, J. G. & Slevin, D. P. (1989) Strategic management of small firms in hostile and benign environments. *Strategic Management Journal*, *10*(1), 75-87.

Cui, A. S. & O'Connor, G. (2012) Alliance portfolio resource diversity and firm innovation. *Journal of Marketing*, *76*(4), 24-43.

Cullen, W. C. & Dibner, M. D. (1993) Strategic alliances in biotechnology: Imperatives for the 1990s. *Biotechnology Review*, *1*(1), 110-119.

Das, T. K. & Teng, B.S. (1996) Risk types and inter-firm alliance structures. *Journal of Management Studies*, *33*(6), 827-843.

Das, T. K. & Teng, B.S. (2000) A resource-based theory of strategic alliances. *Journal of Management, 26*(1), 31-61.

Das, T. K., & Teng, B. S. (2002) The dynamics of alliance conditions in the alliance development process. *Journal of Management Studies*, *39*(5), 725-746.

Das, T. K. (2005) Deceitful behaviours of alliance partners: potential and prevention. *Management Decision*, *43*(5), 706-719.

David, R. J. & Han, S. K. (2004) A systematic assessment of the empirical support for transaction cost economics. *Strategic Management Journal*, *25*(1), 39-58.

Davidsson, P. & Honig, B. (2003) The role of social and human capital among nascent entrepreneurs. *Journal of Business Venturing*, *18*(3), 301-331.

De Bettignies, J. E. (2008) Financing the entrepreneurial venture. *Management Science*, *54*(1): 151-166.

De Carolis, D. M., Yang, Y., Deeds, D. L. & Nelling, E. (2009) Weathering the storm: The benefit of resources to high-technology ventures navigating adverse events. *Strategic Entrepreneurship Journal*, *3*(2), 147-160.

Deeds, D. L., Decarolis, D. & Coombs, J. E. (1997) The impact of firm specific capabilities on the amount of capital raised in an initial public offering: Evidence from the biotechnology industry. *Journal of Business Venturing*, *12*(1), 31-46.

Deeds, D. L. & Decarolis, D. M. (1999) The impact of stocks and flows of organizational knowledge on firm performance: an empirical investigation of the biotechnology industry. *Strategic Management Journal*, *20*(10), 953-968.

Deeds, D. L., DeCarolis, D. & Coombs, J. (2000) Dynamic capabilities and new product development in high technology ventures: an empirical analysis of new biotechnology firms. *Journal of Business Venturing*, *15*(3), 211-229.

Deeds, D. L. & Hill, C. W. (1996) Strategic alliances and the rate of new product development: an empirical study of entrepreneurial biotechnology firms. *Journal of Business Venturing, 11*(1): 41-55.

Deeds, D. L., & Hill, C. W. (1999) An examination of opportunistic action within research alliances: Evidence from the biotechnology industry. *Journal of Business Venturing*, *14*(2), 141-163.

Deeds, D. L., Mang, P. Y. & Frandsen, M. L. (2004) The influence of firms' and industries' legitimacy on the flow of capital into high-technology ventures. *Strategic Organization*, *2*(1), 9-34.

Dias, J. & Marico, V. M. (2009) The impact of resource conditions and environmental uncertainty on inter-firm alliance strategies. *Applied Economics*, *43*(6), 757-765.

Dickson, P. H. & Weaver, K. M. (1997) Environmental determinants and individual-level moderators of alliance use. *Academy of Management Journal*, *40*(2), 404-425.

Dickson, P. H., Weaver, K. M. & Hoy, F. (2006) Opportunism in the R&D alliances of SMES: The roles of the institutional environment and SME size. *Journal of Business Venturing*, *21*(4): 487-513.

Diestre, L. & Rajagopalan, N. (2012) Are all 'sharks' dangerous? New biotechnology ventures and partner selection in R&D alliances. *Strategic Management Journal*, *33*(10), 1115-1134.

DiMasi J., Hansen, R. & Grabowski, H. (2003) The price of innovation: new estimates of drug development costs. *Journal of Health Economics, 22*(2), 151-185.

Ding, W. W., Levin, S. G., Stephan, P. E., & Winkler, A. E. (2010) The impact of information technology on academic scientists' productivity and collaboration patterns. *Management Science*, *56*(9), 1439-1461.

Ding, W. W. (2011) The impact of founders' professional-education background on the adoption of open science by for-profit biotechnology firms. *Management Science*, *57*(2), 257-273.

Dittrich, K., Duysters, G. & de Man, A. P. (2007) Strategic repositioning by means of alliance networks: The case of IBM. *Research Policy*, *36*(10), 1496-1511.

Dollinger, M. J. & Golden, P. A. (1992) Interorganizational and collective strategies in small firms: Environmental effects and performance. *Journal of Management*, *18*(4), 695-715.

Donckels, R. & Lambrecht, J. (1995) Networks and small business growth: An explanatory model. *Small Business Economics*, *7*(4), 273-289.

Dubini, P. & Aldrich, H. (1991) Personal and extended networks are central to the entrepreneurial process. *Journal of Business Venturing*, *6*(5), 305-313.

Durand, R., Bruyaka, O. & Mangematin, V. (2008) Do science and money go together? The case of the French biotech industry. *Strategic Management Journal*, *29*(12), 1281-1299.

Duysters, G. & Lokshin, B. (2011) Determinants of alliance portfolio complexity and its effect on innovative performance of companies. *Journal of Product Innovation Management*, *28*(4), 570-585.

Duysters, G., Heimeriks, K. H., Lokshin, B., Meijer, E., & Sabidussi, A. (2012) Do firms learn to manage alliance portfolio diversity? The diversity-performance relationship and the moderating effects of experience and capability. *European Management Review*, *9*(3), 139-152.

Dyer, J. H. & Singh, H. (1998) The relational view: Cooperative strategy and sources of interorganizational competitive advantage. *The Academy of Management Review*, *23*(4), 660-679.

Dyer, J. H. & Nobeoka, K. (2000) Creating and managing a high-performance knowledge-sharing network: the Toyota case. *Strategic Management Journal*, *21*(3), 345-367.

Ebers, M. (1997) *The formation of inter-organizational networks*. Oxford, Oxford University Press.

Eberhard, M. & Craig, J. (2013) The evolving role of organisational and personal networks in international market venturing. *Journal of World Business*, *48*(3), 385-397.

Edwards, J. R. & Lambert, L. S. (2007) Methods for integrating moderation and mediation: a general analytical framework using moderated path analysis. *Psychological Methods*, *12*(1), 1-22.

Eisenhardt, K. M. (1989) Agency Theory: An assessment and review. *The Academy of Management Review, 14*(1), 57-74.

Eisenhardt, K. M. & Martin, J. A. (2000) Dynamic capabilities: What are they? *Strategic Management Journal*, *21*(10), 1105-1121.

Eisenhardt, K. M. & Schoonhove, C. B. (1990) Organizational growth: Linking founding team, strategy, environment, and growth among U.S. semiconductor ventures, 1978-1988. *Administrative Science Quarterly, 35*(3), 504-529.

Eisenhardt, K. M. & Schoonhove, C. B. (1996) Resource-based view of strategic alliance formation: Strategic and social effects in entrepreneurial firms. *Organization Science*, *7*(2): 136-150.

Elfring, T. & Hulsink, W. (2003) Netowkrs in entrepreneurship: The case of high-technology firms. *Small Business Economics*, *21*(4), 409-422.

Ernst, H., Lichtenthaler, U. & Vogt, C. (2011) Retracted: The impact of accumulating and reactivating technological experience on R&D alliance performance. *Journal of Management Studies*, *48*(6), 1194-1216.

Factiva (2010) *Factiva Database*, Dow Jones Industry: DowJones.

Faems, D., Looy, B.V. & Debackere, K. (2005) Interorganizational collaboration and innovation: Toward a portfolio approach. *Journal of Product Innovation Management*, *22*(3), 238-250.

Faems, D., Janssens, M., Madhok, A. & Van Looy, B. (2008) Toward an integrative perspective on alliance governance: Connecting contract design, trust dynamics, and contract application. *Academy of Management Journal*, *51*(6), 1053-1078.

Faems, D., De Visser, M., Andries, P. & Van Looy, B. (2010) Technology alliance portfolios and financial performance: Value-enhancing and cost-increasing effects of open innovation. *Journal of Product Innovation Management*, *27*(6), 785-796.

Faems, D., Janssens, M., & Neyens, I. (2012) Alliance portfolios and innovation performance connecting structural and managerial perspectives. *Group & Organization Management*, *37*(2), 241-268.

Fisher, L. M. (1996) How strategic alliance work in biotech. *Strategy and Business*, First Quarter: 1- 7.

Florin, J., Lubatkin, M. & Schulze, W. (2003) A social capital model of high-growth ventures. *Academy of Management Journal*, *46*(3), 374-384.

Folta, T. B. (1998) Governance and uncertainty: The tradeoff between administrative control and commitment. *Strategic Management Journal*, *19*(11), 1007-1028.

Food and Drug Administration (FDA) (2009) *Orange Book: approved drug products with therapeutic equivalence evaluation*s. FDA, Silver Spring, MD.

Freeman, C. (1991) Networks of innovators: A synthesis of research issues. *Research Policy*, *20*(5), 499-514.

Fudenberg, D. & Tirole, J. (1990) Moral hazard and renegotiation in agency contracts. *Econometrica, 58*(6), 1279-1319.

Fuller, A. W. & Rothaermel, F. T. (2012) When stars shine: The effects of faculty founders on new technology ventures. *Strategic Entrepreneurship Journal*, *6*(3), 220-235.

García-Canal, E., Duarte, C. L., Criado, J. R. & Llaneza, A. V. (2002) Accelerating international expansion through global alliances: A typology of cooperative strategies. *Journal of World Business*, *37*(2), 91-107.

George, G., Zahra, S. A., Wheatley, K. K. & Khan, R. (2001) The effects of alliance portfolio characteristics and absorptive capacity on performance: A study of biotechnology firms. *Journal of High Technology Management Research*, *12*(2), 205-226.

Geyskens, I., Steenkamp, J. & Kumar, N. (2006) Make, buy, or ally: A transaction cost theory meta-analysis. *Academy of Management Journal*, *49*(3), 519-543.

Gilding, M. (2008) The tyranny of distance': Biotechnology networks and clusters in the antipodes. *Research Policy*, *37*(6), 1132-1144.

Goerzen, A. & Beamish, P. W. (2003) Geographic scope and multinational enterprise performance. *Strategic Management Journal*, *24*(13), 1289-1306.

Goerzen, A. & Beamish, P. W. (2005) The effect of alliance network diversity on multinational enterprise performance. *Strategic Management Journal*, *26*(4), 333-354.

Goerzen, A. (2007) Alliance networks and firm performance: The impact of repeated partnerships. *Strategic Management Journal*, *28*(5), 487-509.

Gomes-Casseres, B. (1997) *The Alliance Revolution: the new shape of business rivalry*. Harvard University Press.

Gomes-Casseres, B. (2003) Competitive advantage in alliance constellations. *Strategic Organization*, *1*(3): 327-335.

Gopalakrishnan, S., Scillitoe, J. L. & Santoro, M. D. (2008) Tapping deep pockets: The role of resources and social capital on financial capital acquisition by biotechnology firms in biotech–pharma alliances. *Journal of Management Studies*, *45*(8), 1354-1376.

Grandori, A. & Soda, G. (1995) Inter-firm networks: Antecedents, mechanisms and forms. *Organization Studies*, *16*(2): 183 – 214.

Granovetter, M. (1973) Economic action and social structure: The problem of embeddedness. *American Journal of Sociology, 91*(3): 485-510.

Grant, R. M. & Baden-Fuller, C. (1995) A knowledge-based theory of inter-firm collaboration. *Academy of Management Proceedings,* 1: 17-21.

Grant, P. & Perren, L. (2002) Small business and entrepreneurial research: Meta-theories, paradigms and prejudices. *International Small Business Journal, 20*(2), 185-211.

Greene, W. H. (2003) *Econometric analysis*. Pearson Education India.

Greve, H. R., Baum, J. A., Mitsuhashi, H., & Rowley, T. J. (2010) Built to last but falling apart: Cohesion, friction, and withdrawal from interfirm alliances. *Academy of Management Journal*, *53*(2), 302-322.

Grigoriou, K., & Rothaermel, F. T. (2014) Structural microfoundations of innovation: The role of relational stars. *Journal of Management*, *40*(2), 586-615.

Gulati, R. (1995) Social structure and alliance formation patterns: A longitudinal analysis. *Administrative Science Quarterly*, *38*(1), 85-112.

Gulati, R. (1998) Alliances and networks. *Strategic Management Journal*, *19*(4): 293

Gulati, R. (1999) Network location and learning: the influence of network resources and firm capabilities on alliance formation. *Strategic Management Journal*, *20*(5), 397-420.

Gulati, R. (2007) *Managing network resources: alliances, affiliations and other relational assets*. Oxford: Oxford University Press.

Gulati, R. & Higgins, M. C. (2003) Which ties matter when? The contingent effects of interorganizational partnerships on IPO success. *Strategic Management Journal*, *24*(2), 127-144.

Gulati, R. & Singh, H. (1998) The architecture of cooperation: Managing coordination costs and appropriation concerns in strategic alliances. *Administrative Science Quarterly, 43*(4): 781-814.

Gulati, R. & Sytch, M. (2007) Dependence asymmetry and joint dependence in interorganizational relationships: Effects of embeddedness on a manufacturer's performance in procurement. *Administrative Science Quarterly*, *52*(1), 32- 69.

Gupta, A. K. & Govindarajan, V. (2000) Knowledge flows within multinational corporations. *Strategic Management Journal*, *21*(4), 473-496.

Haeussler, C. & Higgins, M. J. (2012) *Explaining preferences for control rights in strategic alliances: A property rights and capabilities perspective approach* (No. w18364). National Bureau of Economic Research.

Haeussler, C., Patzelt, H. & Zahra, S. A. (2012) Strategic alliances and product development in high technology new firms: The moderating effect of technological capabilities. *Journal of Business Venturing*, *27*(2), 217-233.

Hagedoorn, J. (1993) Understanding the rationale of strategic technology partnering: interorganizational modes of cooperation and sectoral differences. *Strategic Management Journal*, *14*(5), 371-385.

Hagedoorn, J. (2003) Sharing intellectual property rights—an exploratory study of joint patenting amongst companies. *Industrial and Corporate Change*, *12*(5), 1035-1050.

Hagedoorn, J., Cloodt, D. & Van Kranenburg, H. (2005) Intellectual property rights and the governance of international R&D partnerships. *Journal of International Business Studies*, *36*(2), 175-186.

Hagedoorn, J. & Narula, R. (1996) Choosing organizational modes of strategic technology partnering: International and sectoral differences. *Journal of International Business Studies*, *27*(2), 265-294.

Hair, J. F., Tatham, R. L., Anderson, R. E. & Black, W. (1995) *Multivariate data analysis* (Vol. 6). Upper Saddle River, NJ: Pearson Prentice Hall.

Hallen, B. L. (2008) The causes and consequences of the initial network positions of new organizations: From whom do entrepreneurs receive investments? *Administrative Science Quarterly*, *53*(4), 685-718.

Hakansson, H. & Ford, D. (2002) How should companies interact in business networks? *Journal of Business Research, 55*(2), 133-139.

Hambrick, D. C., Cho, T. S. & Chen, M. J. (1996) The influence of top management team heterogeneity on firms' competitive moves. *Administrative Science Quarterly*, 659-684.

Hamel, G., Doz, Y.L. & Prhalad, C. K. (1989) Collaborate with your competitors and win. *Harvard Business Review, 67*(1), 190-197.

Heimeriks, K. H. & Duysters, G. (2007) Alliance capability as a mediator between experience and alliance performance: An empirical investigation into the alliance capability development process. *Journal of Management Studies*, *44*(1), 25-49.

Heimeriks, K. H., Duysters, G. & Canhaverbeke, W. (2007) Learning mechanisms and differential performance in alliance portfolio. *Strategic Organization*, *5*(4), 373-408.

Heimeriks, K. H., Klijn, E. & Reuer, J. (2009) Building capabilities for alliance portfolios. *Long Range Planning*, *42*(1), 96-114.

Hennart, J. F. (1988) A transaction costs theory of equity joint ventures. *Strategic Management Journal*, *9*(4), 361-374.

Hennart, J. F. & Reddy, S. (1997) The choice between merger & acquisitions and joint ventures: The case of Japanese investors in the United States. *Strategic Management Journal*, *18*(1), 1-12.

Higgins, M. J. (2007) The allocation of control rights in pharmaceutical alliances. *Journal of Corporate Finance*, *13*(1), 58-75.

Higgins, M. C. & Gulati, R. (2003) Getting off to a good start: The effects of upper echelon affiliations on underwriter prestige. *Organization Science*, *14*(3), 244-263.

Higgins, M. C. & Gulati, R. (2006) Stacking the deck: The effects of top management backgrounds on investor decisions. *Strategic Management Journal*, *27*(1), 1-25.

Higgins, M. J. & Rodriguez, D. (2006) The outsourcing of R&D through acquisitions in the pharmaceutical industry. *Journal of Financial Economics*, *80*(2), 351-383.

Higgins, M. J., Stephan, P. E. & Thursby, J. G. (2011) Conveying quality and value in emerging industries: Star scientists and the role of signals in biotechnology. *Research Policy*, *40*(4), 605-617.

Hill, C. W. & Rothaermel, F. T. (2003) The performance of incumbent firms in the face of radical technological innovation. *Academy of Management Review*, *28*(2), 257-274.

Hite, J. M. & Hesterly, W. S. (2001) The evolution of firm networks: From emergence to early growth of the firm. *Strategic Management Journal*, *22*(3), 275-286.

Hitt, M., Dacin, M. , Levitas, E., Arregle, J., & Borza, A. (2000) Partner selection in emerging and developed market contexts: Resource-based and organizational learning perspectives. *Academy of Management Journal, 43*(3), 449-467.

Hitt, M. A., Biermant, L., Shimizu, K. & Kochhar, R. (2001) Direct and moderating effects of human capital on strategy and performance in professional service firms: A resource-based perspective. *Academy of Management journal*, *44*(1), 13-28.

Hoang, H. & Antoncic, B. (2003) Network-based research in entrepreneurship: A critical review. *Journal of Business Venturing*, 18: 165-197.

Hoang, H. & Rothaermel, F. T. (2005) The effect of general and partner-specific alliance experience on joint R&D project performance. *Academy of Management Journal*, *48*(2), 332-345.

Hoetker, G. & Mellewigt, T. (2009) Choice and performance of governance mechanisms: matching alliance governance to asset type. *Strategic Management Journal*, *30*(10), 1025-1044.

Hoffmann, W. H. (2005) How to manage a portfolio of alliances. *Long Range Planning*, *38*(2), 121-143.

Hoffmann, W. H. (2007) Strategies for managing a portfolio of alliances. *Strategic Management Journal*, *28*(8), 827-856.

Hoffmann, W. H. & Schaper-Rinkel, W. (2001) Acquire or Ally? A strategy framework for deciding between acquisition and cooperation. *Management International Review*, *41*(2), 131-159.

Hoffmann, W. H. & Schlosser, R. (2001) Success factors of strategic alliance in small and medium-sized enterprises - An empirical survey. *Long Range Planning, 34*(3), 357-381.

Hsu, D. (2007) Experienced entrepreneurial founders, organizational capital, and venture capital funding. *Research Policy*, *36*(5), 722-741.

Hsu, D. H., Roberts, E. B., & Eesley, C. E. (2007) Entrepreneurs from technology-based universities: Evidence from MIT. *Research Policy*, *36*(5), 768-788.

Hughes, S. S. (2011) *Genentech: the beginnings of biotech*. University of Chicago Press.

Human, S. E. & Provan, K. G. (2000) Legitimacy building in the evolution of small-firm multilateral networks: A comparative study of success and demise. *Administrative Science Quarterly, 45*(2), 327-365.

Ibarra, H., Kilduff, M., & Tsai, W. (2005) Zooming in and out: Connecting individuals and collectivities at the frontiers of organizational network research. *Organization Science, 16*(4), 359-371.

Inkpen, A. C. & Tsang, E. W. (2005) Social capital, networks, and knowledge transfer. *Academy of Management Review*, *30*(1), 146-165.

Ireland, R. & Hitt, M. (2002) Alliance management as a source of competitive advantage. *Journal of Management, 28*(3), 413-446.

Jack, S. L. (2005) The role, use and activation of strong and weak network ties: A qualitative analysis. *Journal of Management Studies*, *42*(6), 1233-1259.

Janney, J. J. & Folta, T. B. (2003) Signaling through private equity placements and its impact on the valuation of biotechnology firms. *Journal of Business Venturing*, *18*(3), 361-380.

Jarillo, J. C. (1988) On strategic networks. *Strategic Management Journal, 9*(1), 31-41.

Jarillo, J. C. (1989) Entrepreneurship and growth: The strategic use of external resources. *Journal of Business Venturing*, *4*(2), 133-147.

Jiang, R., Qingjiu, T. T., & Santoro, M. D. (2010) Alliance portfolio diversity and firm performance. *Strategic Management Journal, 31*(10), 1136-1144.

Joskow, P. (1987) Contract duration and relationship-specific investments: Empirical evidence from coal markets. *American Economic Review*, *77*(1), 168-185.

Judd, C. M., Kenny, D. A. & McClelland, G. H. (2001) Estimating and testing mediation and moderation in within-subject designs. *Psychological Methods*, *6*(2), 115-134.

Kale, P., Singh, H. & Perlmutter, H. (2000) Learning and protection of proprietary assets in strategic alliances: building relational capital. *Strategic Management Journal*, *21*(3), 217-237.

Kale, P. & Singh, H. (2007) Building firm capabilities through learning: the role of the alliance learning process in alliance capability and firm-level alliance success. *Strategic Management Journal*, *28*(10), 981-1000.

Kale, P., Dyer, J. H. & Singh, H. (2002) Alliance capability, stock market response, and long-term alliance success: the role of the alliance function. *Strategic Management Journal*, *23*(8): 747-767.

Kanter, R. M. (1994) Collaborative advantage: The art of alliances**.** *Harvard Business Review*, *72*(4), 96-108.

Kenis, P. & Knoke, D. (2002) How organizational field networks shape inter-organizational tie-formation rates. *Academy of Management Review*, *27*(2), 275-293.

Kenny, D. A., Kashy, D. & Bolger, N. (1998) Data analysis in social psychology. in Gilbert, D., Fiske, S., & Lindzey, G. (Eds.), *Handbook of social psychology*. New York:McGraw-Hill.

Kelly, D. J. & Rice, M. P. (2001) Technology-based strategic actions in new firms: The influence of founding technology resources. *Entrepreneurship: Theory & Practice*, *26*(1), 55-73.

Ketchen, D. & Shook, C. (1996) The application of cluster analysis in strategic management research: an analysis and critique. *Strategic Management Journal*, *17*(6), 441-458.

Khanna, T. (1998) The scope of alliances. *Organization Science*, *9*(3), 340-355.

Khanna, T., Gulati, R. & Nohria, N. (1998) The dynamics of learning alliances: competition, cooperation, and relative scope. *Strategic Management Journal*, *19*(3), 193-210.

Kim, J. W. & Higgins, M. C. (2007) Where do alliances come from? The effects of upper echelons on alliance formation. *Research Policy*, *36*(4), 499-514.

Kilduff, M. & Krackhardt, D. (1994) Bringing the individual back in: A structural analysis of the internal market for reputation in organizations. *Academy of Management Journal, 37*(1), 87-108.

Kirkels, Y. & Duysters, G. (2010) Brokerage in SME networks. *Research Policy, 39*(3), 375-385.

Kloyer, M. (2011) Effective control rights in vertical R&D collaboration. *Managerial and Decision Economics*, *32*(7), 457-468.

Kloyer, M. & Scholderer, J. (2012) Effective incomplete contracts and milestones in market-distant R&D collaboration. *Research Policy*, *41*(2), 346-357.

Knight, D., Pearce, C. L., Smith, K. G., Olian, J. D., Sims, H. P., Smith, K. A. & Flood, P. (1999) Top management team diversity, group process, and strategic consensus. *Strategic Management Journal*, *20*(5), 445-465.

Knight, G. A. & Cavusgil, S. T. (2004) Innovation, organizational capabilities, and the born-global firm. *Journal of International Business Studies*, *35*(2), 124-141.

Kogut, B. (1988) Joint ventures: Theoretical and empirical perspectives. *Strategic Management Journal*, *9*(4), 319-332.

Kogut, B. (1989) The stability of joint ventures: Reciprocity and competitive rivalry. *Journal of Industrial Economics*, *38*(2), 183-198.

Koka, B. R. & Prescott, J. E. (2002) Strategic alliances as social capital: A multidimensional view. *Strategic Management Journal*, *23*(9), 795-816.

Kotabe, M. & Scott, S. K. (1995) The role of strategic alliances in high-technology new product development. *Strategic Management Journal*, *16*(8), 621-636.

Knight, G. (1997) Cross-cultural reliability and validity of a scale to measure firm entrepreneurial orientation. *Journal of Business Venturing, 12*(3), 213-225.

Krause, M. R., Serlin, R. C., Ward, S. E., Rony, R. Y. Z., Ezenwa, M. O., & Naab, F. (2010) Testing mediation in nursing research: Beyond Baron and Kenny. *Nursing Research*, *59*(4), 288.

Lahiri, N. & Narayanan, S. (2013) Vertical integration, innovation, and alliance portfolio size: Implications for firm performance. *Strategic Management Journal*, *34*(9), 1042-1064.

Larson, A. (1991) Partner networks: Leveraging external ties to improve entrepreneurial performance. *Journal of Business Venturing*, *6*(3), 173-188.

Larson, A. (1992) Network dyads in entrepreneurial settings: A study of the governance of exchange relationships. *Administrative Science Quarterly*, *37*(1), 76-104.

Larson, A. (1993) A network model of organization formation. *Entrepreneurship Theory & Practice*, 17: 5-15.

Lavie, D. (2006) The competitive advantage of interconnected firms: an extension of the resource-based view. *Academy of Management Review, 31*(3), 638-658.

Lavie, D. & Rosenkopf, L. (2006) Balancing exploration and exploitation in alliance formation. *Academy of Management Journal, 49*(6), 797-818.

Lavie, D. (2007) Alliance portfolios and firm performance: A study of value creation and appropriation in the US software industry. *Strategic Management Journal*, *28*(12), 1187-1212.

Lavie, D., & Miller, S. R. (2008) Alliance portfolio internationalization and firm performance. *Organization Science*, *19*(4), 623-646.

Lavie, D. & Singh, H. (2012) The evolution of alliance portfolios: The case of Unisys. *Industrial and Corporate Change*, *21*(3), 763-809.

Lazonick, W. & Tulum, Ö. (2011) US biopharmaceutical finance and the sustainability of the biotech business model. *Research Policy*, *40*(9), 1170-1187.

Lazzarini, S. G. (2007) The impact of membership in competing alliance constellations: Evidence on the operational performance of global airlines. *Strategic Management Journal*, *28*(1), 345-381.

Lechnera, C., Dowlingb, M. & Welpec, I. (2006) Firm networks and firm development: The role of the relational mix. *Journal of Business Venturing*, *21*(4), 514-540.

Lee, C., Lee, K. & Pennings, J. (2001) Internal capabilities, external networks, and performance: A study on technology-based ventures. *Strategic Management Journal*, *22*(6), 615-640.

Lee, H. U. & Park, J. H. (2008) The influence of top management team international exposure on international alliance formation. *Journal of Management Studies*, *45*(5), 961-981.

Lee, H., Kelley, D., Lee, J. & Lee, S. (2012) SME survival: The impact of internationalization, technology resources, and alliances. *Journal of Small Business Management*, *50*(1), 1-19.

Leiblein, M. J., Reuer, J. J. & Dalsace, F. (2002) Do make or buy decisions matter? The influence of organizational governance on technological performance. *Strategic Management Journal*, *23*(9), 817-833.

Lerner, J. & Merges, R. P. (1998) The control of technology alliances: An empirical analysis of the biotechnology industry. *Journal of Industrial Economics*, *46*(2), 125-156.

Levinthal D. A. & March J. G. (1993) The myopia of learning. *Strategic Management Journal*, *14*(2), 95-112.

Li, D., Eden, L., Hitt, M. A. & Ireland, R. D. (2008) Friends, acquaintances, or strangers? Partner selection in R&D alliances. *Academy of Management Journal*, *51*(2), 315-334.

Li, Q., Maggitti, P. G., Smith, K. G., Tesluk, P. E. & Katila, R. (2013) Top management attention to innovation: The role of search selection and intensity in new product introductions. *Academy of Management Journal*, *56*(3), 893-916.

Liao, J. J., Kickul, J. R. & Ma, H. (2009). Organizational dynamic capability and innovation: an empirical examination of internet firms. *Journal of Small Business Management*, *47*(3), 263-286.

Liebeskind, J. P., Oliver, A. L., Zucker, L. & Brewer, M. (1996) Social networks, learning, and flexibility: Sourcing scientific knowledge in new Biotechnology firms. *Organization Science*, *7*(4), 428-443.

Lin, Z. J., Yang, H. & Arya, B. (2009) Alliance partners and firm performance: resource complementarity and status association. *Strategic Management Journal*, *30*(9), 921-940.

Link, A. N. & Rees, J. (1990) Firm size, university based research, and the returns to R&D, *Small Business Economics*, *3*(1), 1-38.

Lorenzoni, G. & Ornati, O. A. (1988) Constellations of firms and new ventures. *Journal of Business Venturing*, *3*(1), 41-57.

Lorenzoni, G. & Baden-Fuller, C. (1995) Creating a strategic center to manage a web of partners. *California Management Review*, *37*(3), 146-163.

Lowik, S., Van Rossum, D., Kraaijenbrink, J. & Groen, A. (2012) Strong ties as sources of new knowledge: How small firms innovate through bridging capabilities. *Journal of Small Business Management*, *50*(2), 239-256.

Lu, J. W. & Beamish, P. W. (2006) Partnering strategies and performance of SMEs' international joint ventures. *Journal of Business Venturing*, *21*(4), 461-486.

Lumpkin, G. T. & Dess, G. G. (1996) Clarifying the entrepreneurial orientation construct and linking it to performance. *Academy of Management Review*, *21*(1), 135-172.

Luo, X. & Deng, L. (2009) Do birds of a feather flock higher? The effects of partner similarity on innovation in strategic alliances in knowledge-intensive industries. *Journal of Management Studies*, *46*(6), 1005-1030.

Mahoney, J.T. & Pandian, J. R. (1992) The resource-based view within the conversation of strategic management. *Strategic Management Journal, 13*(5), 363-380.

Mangematin, V., Lemarié, S., Boissin, J. P., Catherine, D., Corolleur, F., Coronini, R. & Trommetter, M. (2003) Sectoral system of innovation, SMEs development and heterogeneity of trajectories. *Research Policy*, *32*(4), 621-638.

Manolova, T.S., Manev, I. M. & Gyoshev, B. S. (2010) In good company: the role of personal and inter-firm networks for new-venture internationalization in a transition economy. *Journal of World Business*, *45*(3), 257-265.

March, J. G. (1991) Exploration and exploitation in organizational learning. *Organization Science*, *2*(1), 71-87.

Marino, L., Strandholm, K., Steensma, H. K. & Weaver, K. M. (2002). The moderating effect of national culture on the relationship between entrepreneurial orientation and strategic alliance portfolio extensiveness. *Entrepreneurship Theory and Practice*, *26*(4), 145-160.

Maurer, I. & Ebers, M. (2006) Dynamics of social capital and their performance implications: Lessons from biotechnology start-ups. *Administrative Science Quarterly, 51*(2), 262-292**.**

McEvily, B. and Zaheer, A. (1999) Bridging ties: A source of firm heterogeneity in competitive capabilities. *Strategic Management Journal*, *20*(12), 1133-1156.

McGill, J. P. (2007) Technological knowledge and governance in alliances among competitors. *International Journal of Technology Management*, *38*(1), 69-89.

McGill, J. P. & Santoro, M. D. (2009) Alliance portfolios and patent output: The case of biotechnology alliances. *IEEE Transaction on Engineering Management*, *56*(3), 388-401.

Mellewigt, T., Madhok, A., & Weibel, A. (2007) Trust and formal contracts in interorganizational relationships—substitutes and complements. *Managerial and Decision Economics*, *28*(8), 833-847.

Mesquita, L. F. &Lazzarini, S. G. (2010) Horizontal and vertical relationships in developing economies: Implications for smes' access to global markets. *International Studies in Entrepreneurship, 26*(1), 31-66.

Meyer, G. D., Alvarex, S. A. & Blasick, J. (1997) Benefits of technology-based strategic alliances: An entrepreneurial perspective. *Frontiers of Entrepreneurship Research*. Bason Park.

Milanov, H. & Fernhaber, S. A. (2014) When do domestic alliances help ventures abroad? Direct and moderating effects from a learning perspective. *Journal of Business Venturing*, *29*(3), 377-391.

Mitchell, W. & Singh, K. (1996) Survival of business using collaborative relationships to commercialized complex goods. *Strategic Management Review*, *17*(3), 169-195.

Mouri, N., Sarkar, M. B. & Frye, M. (2012) Alliance portfolios and shareholder value in post-IPO firms: The moderating roles of portfolio structure and firm-level uncertainty. *Journal of Business Venturing*, *27*(3), 355-371.

Mowery, D. C., Oxley, J. E. & Silverman, B. S. (1996) Strategic alliances and inter-firm knowledge transfer. *Strategic Management Journal*, *17*(2), 77-91.

Mowery, D., Brian, J. & Silverman, B. (1998) Technological overlap and inter-firm cooperation: implications for the resource-based view of the firm. *Research Policy*, *27*(5), 507-523.

Mudambi, R. & Swift, T. (2011) Proactive R&D management and firm growth: A punctuated equilibrium model. *Research Policy*, *40*(3), 429-440.

Mudambi, S. M. & Tallman, S. (2010) Make, buy or ally? Theoretical perspectives on knowledge process outsourcing through alliances. *Journal of Management Studies*, *47*(8), 1434-1456.

Munos, B. (2009) Lessons from 60 years of pharmaceutical innovation. *Nature Reviews Drug Discovery*, *8*(12), 959-968.

Nahapiet, J. & Ghoshal, S. (1998) Social capital, intellectual capital, and the organizational advantage. *Academy of Management Review*, *23*(2), 242-266.

Nohria, N. & Garcia-Pont, C. (1991) Global strategic linkages and industry structure. *Strategic Management Journal*, *12*(1), 105-124.

Oerlemans, L. A., Knoben, J. & Pretorius, M. W. (2013) Alliance portfolio diversity, radical and incremental innovation: The moderating role of technology management. *Technovation*, *33*(6), 234-246.

Ohame, K. (1989) The global logic of strategic alliances. *Harvard Business Review*, Mar-Apri: 143-154.

Oliver, A. L. & Ebers, M. (1998) Networking network studies: An analysis of conceptual configurations in the study of inter-organizational relationships. *Organization Studies, 19*(4), 549-583.

Oliver, A. L. (2001) Strategic alliances and the learning life-cycle of biotechnology firms. *Organization Studies*, *22*(3), 467-489.

Okamuro, H. (2007) Determinants of successful R&D cooperation in Japanese small businesses: The impact of organizational and contractual characteristics. *Research Policy*, *36*(10), 1529-1544.

Orbis (2010) *Orbis - Bureau van Dijk Database*, OECD: Bureau van Dijk Database.

Osgood, D.W. (2000) Poisson-based regression analysis of aggregate crime rates. *Journal of Quantitative Criminology, 16*(1), 21-43.

Owne-Smith, J. & Powell, W. W. (2004) Knowledge networks as channels and conduits: The effects of spillovers in the Boston biotechnology community. *Organization Science, 15*(1), 5-21.

Oxley, J. E. (1997) Appropriability hazards and governance in strategic alliances: A transaction cost approach. *Journal of law, Economics, and Organization*, *13*(2), 387-409.

Ozcan, P. & Eisenhardt, K. M. (2009) Origin of alliance portfolios: Entrepreneurs, network strategies, and firm performance. *Academy of Management Journal*, *52*(2), 246-279.

Panico, C. (2011) On the contractual governance of research collaborations: Allocating control and intellectual property rights in the shadow of potential termination. *Research Policy*, *40*(10), 1403-1411.

Parhankangas, A. & Arenius, P. (2003) From a corporate venture to an independent company: a base for taxonomy for corporate spin-off firms. *Research Policy*, *32*(3), 463-481.

Parise, S. & Casher, A. (2003) Alliance portfolio: Designing and managing network of business-partner relationships. *Academy of Management Executive*, *17*(4), 25-39.

Park, K. H. & Lee, K. (2006) Linking the technological regime to the technological catch-up: Analyzing Korea and Taiwan using the US patent data. *Industrial and Corporate Change*, *15*(4), 715-753.

Park, S. H. & Russo, M. V. (1996) When competition eclipses cooperation: An event history analysis of joint venture failure. *Management Science, 42*(6), 875-890.

Park, S. H. & Ungson, G. R. (2001) Interfirm rivalry and managerial complexity: A conceptual framework of alliance failure. *Organization Science*, *12*(1), 37-53.

Park, S. H., Chen, R., & Gallagher, S. (2002) Firm resources as moderators of the relationship between market growth and strategic alliances in semiconductor start-ups. *Academy of Management Journal, 45*(3), 527-545.

Paternoster, R. & Brame, R. (1997) Multiple routes to delinquency? A test of developmental and general theories of crime. *Criminology, 35*(1), 49-84.

Peteraf, M. A. (1993) The cornerstones of competitive advantage: a resource-based view. *Strategic Management Journal, 14*(3), 179-191.

Pfeffer, J. & Salanick, G. R. (1978) *The external control of organization*. New York, Harper & Row.

Phelps, C. C. (2010) A longitudinal study of the influence of alliance network structure and composition on firm exploratory innovation. *Academy of Management Journal*, *53*(4), 890-913.

Pisano, G. (1989) Using equity participation to support exchange: Evidence from the Biotechnology industry. *Journal of Law, Economics, & Organization*, *5*(1), 109-126.

Pisano, G. P. (2006) *Science business: The promise, the reality, and the future of biotech*. Harvard Business Press.

Pisano, G. P. (2010) The evolution of science-based business: innovating how we innovate. *Industrial and Corporate Change*, *19*(2), 465-482.

Prahalad, C. K. & Hamel, G. (1990) *The core competence of the corporation*. Boston.

Prashantham, S. & Dhanaraj, C. (2010) The dynamic influence of social capital on the international growth of new ventures. *Journal of Management Studies*, *47*(6), 967-994.

Preacher, K. J. & Hayes, A. F. (2008) Asymptotic and resampling strategies for assessing and comparing indirect effects in multiple mediator models. *Behaviour Research Methods*, *40*(3), 879-891.

Prevezer, M. (1997) The dynamics of industrial clustering in biotechnology. *Small Business Economics*, *9*(3), 255-271.

Provan, K. G., Beyer, J. M., & Kruytbosch, C. (1980) Environmental linkages and power in resource-dependence relations between organizations. *Administrative Science Quarterly, 25*(2), 200-225.

Powell, W. W., Koput, K. W., & Smith-Doerr, L. (1996) Interorganizational collaboration and the locus of innovation: Networks of learning in biotechnology. *Administrative Science Quarterly, 41*(1), 116-145.

Powell, W. W. (1998) Knowledge and networks in the biotechnology and pharmaceutical industries. *California Management Review, 40*(3), 228-242.

Powell, W. W., Koput, K. W., Bowie, J. I., & Smith-Doerr, L. (2002) The spatial clustering of science and capital: Accounting for biotech firm-venture capital relationships. *Regional Studies*, *36*(3), 291-305.

Powell, W. W., & Snellman, K. (2004) The knowledge economy. *Annual Review of Sociology*, *30*, 199-220.

Powell, W. W., White, D. R., Koput, K. W. & Owen-Smith, J. (2005) Network dynamics and field evolution: The growth of inter-organizational collaboration in the life sciences. *American Journal of Sociology*, *11*(4), 1132-1205.

Quintana-García, C. & Benavides-Velasco, C. A. (2008) Innovative competence, exploration and exploitation: The influence of technological diversification. *Research Policy*, *37*(3), 492-507.

Rangone, A. (1999) A resource-based approach to strategy analysis in small-medium sized enterprise. *Small Business Economic*, *12*(3), 233-248.

Rauch, A., Wiklund, J., Lumpkin, G. T., & Frese, M. (2009) Entrepreneurial orientation and business performance: An assessment of past research and suggestions for the future. *Entrepreneurship Theory and Practice*, *33*(3), 761-787.

Reagans, R. & McEvily, B. (2008) Contradictory or compatible? Reconsidering the "trade-off" between brokerage and closure on knowledge sharing. *Advances in Strategic Management*, 25: 275-313.

Recombinant Capital (2010) *RECAP Database*, San Francisco: Delotti.

Reuer, J. J., Arino, A., & Mellewigt, T. (2006) Entrepreneurial alliances as contractual forms. *Journal of Business Venturing*, *21*(3), 306-325.

Reuer, J. J. & Ragozzino, R. (2006) Agency hazards and alliance portfolios. *Strategic Management Journal*, *27*(1), 27-43.

Reuer, J. J. & Tong, T. W. (2010) Discovering valuable growth opportunities: an analysis of equity alliances with IPO firms. *Organization Science*, *21*(1), 202-215.

Rindfleisch, A. & Moorman, C. (2001) The acquisition and utilization of information in new product alliances: A strength-of-ties perspective. *Journal of Marketing*, *65*(2), 1-18.

Roberts, E. B. & Hauptman, O. (1987) The financing threshold effect on success and failure of biomedical and pharmaceutical start-ups. *Management Science*, *33*(3), 381-394.

Rodan, S. & Galunic, C. (2004) More than network structure: how knowledge heterogeneity influences managerial performance and innovativeness. *Strategic Management Journal*, *25*(6), 541-562.

Romesburg, H. (1984) *Cluster analysis for researchers*. Lifetime learning publication, California.

Rosenkopf, L. & Schilling, M. A. (2007) Comparing alliance network structure across industries: Observations and explanations. *Strategic Entrepreneurship Journal*, *1*(3), 191-209.

Rost, K. (2011) The strength of strong ties in the creation of innovation. *Research Policy*, *40*(4), 588-604.

Rothaermel, F. T. (2001) Complementary assets, strategic alliances, and the incumbent's advantage: an empirical study of industry and firm effects in the biopharmaceutical industry. *Research Policy*, *30*(8), 1235-1251.

Rothaermel, F. T. (2002) Technological discontinuities and inter-firm cooperation: what determines a startup's attractiveness as alliance partner? *IEEE Transactions on Engineering Management*, *49*(4), 388-397.

Rothaermel, F. T. & Boeker, W. (2008) Old technology meets new technology: complementarities, similarities, and alliance formation. *Strategic Management Journal*, *29*(1), 47-77.

Rothaermel, F. T. & Deeds, D. L. (2004) Exploration and exploitation alliances in biotechnology: a system of new product development. *Strategic Management Journal*, *25*(3), 201-221.

Rothaermel, F. T. & Hess, A. M. (2007) Building dynamic capabilities: Innovation driven by individual-, firm-, and network-level effects. *Organization Science*, *18*(6), 898-921.

Rotheraermel, F. T. & Thursby, M. (2007) The nanotech vs. the biotech revolution: Sources of productivity in incumbent firm research. *Research Policy*, *36*(6), 832-849.

Roure, J. & Maidique, M. (1986) Linking prefunding factors and high-technology venture success: An exploratory study. *Journal of Business Venturing*, *1*(3), 295-306.

Roy, D. A. & Simpson, C. L. (1981) Export attitudes of business executives in the smaller manufacturing firm. *Journal of Small Business Management*, *19*(2), 16-22.

Ruef, M. (2002) Strong ties, weak ties and islands: structural and cultural predictors of organizational innovation. *Industrial and Corporate Change*, *11*(3), 427-449.

Rzakhanov, Z. (2004) Innovation, product development and market value: Evidence from the biotechnology industry innovation in biotechnology industry. *Economics of Innovation and New Technology*, *13*(8), 747-760.

Sampson, R. C. (2004) Organizational choice in R&D alliances: Knowledge-based and transaction cost perspectives. *Managerial and Decision Economics*, *25*(6), 421-436.

Sampson, R. C. (2007). R&D alliances and firm performance: the impact of technological diversity and alliance organization on innovation. *Academy of Management Journal*, *50*(2), 364-386.

Santoro, M. D. & McGill, J. P. (2005) The effect of uncertainty and asset co-specialization on governance in biotechnology alliances. *Strategic Management Journal*, *26*(13), 1261-1269.

Santos, F. M. & Eisenhardt, K. M. (2009) Constructing markets and shaping boundaries: Entrepreneurial power in nascent fields. *Academy of Management Journal*, *52*(4), 643-671.

Sarkar, M. B., Aulakh, P. S., & Madhok, A. (2009) Process capabilities and value generation in alliance portfolios. *Organization Science*, *20*(3), 583-600.

Sarkar, M. B., Echambadi, R. A. J., & Harrison, J. S. (2001) Alliance entrepreneurship and firm market performance. *Strategic Management Journal*, *22*(6), 701-711.

Schilling, M. A. & Phelps, C. C. (2007) Interfirm collaboration networks: The impact of large-scale network structure on firm innovation. *Management Science*, *53*(7), 1113-1126.

Schilke, O. & Goerzen, A. (2010) Alliance management capability: an investigation of the construct and its measurement. *Journal of Management*, *36*(5), 1192-1219.

Schoonhoven, C., Eisenhardt, K., & Lyman, K. (1990) Speeding products to market: Waiting time to first product introduction in new firms. *Administrative Science Quarterly, 35*(1), 177-207.

Shan, W. (1990) An empirical analysis of organizational strategies by entrepreneurial high-technology firms. *Strategic Management Journal*, *11*(2), 129-139.

Shan, W., Walker, G., & Kogut, B. (1994) Interfirm cooperation and startup innovation in the biotechnology industry. *Strategic Management Journal*, *15*(5), 387-394

Shane, S. (2000) Prior knowledge and the discovery of entrepreneurial opportunities. *Organization Science*, *11*(4), 448-469.

Shane, S. & Cable, D. (2002) Network ties, reputation, and the financing of new ventures. *Management Science*, *48*(3), 364-381.

Shane, S. & Venkataraman, S. (2000) The promise of entrepreneurship as a field of research. *Academy of Management Review, 25*(1), 217-226.

Shane, S. & Venkataraman, S. (2001) Entrepreneurship as a field of research. *Academy of Management Review, 26*(1), 13-16.

Shepherd, D. A., Douglas, E. J., & Shanley, M. (2000) New venture survival: Ignorance, external shocks, and risk reduction strategies. *Journal of Business Venturing*, *15*(5), 393-410.

Shrader, R. C. & Simon, M. (1997) Corporate versus independent new ventures: Resource, strategy and performance differences. *Journal of Business Venturing*, *12*(1), 47-66.

Shrout, P. E., & Bolger, N. (2002) Mediation in experimental and non-experimental studies: new procedures and recommendations. *Psychological Methods*, *7*(4), 422-445.

Sirmon, D. G., Hitt, M. A., & Ireland, R. D. (2007) Managing firm resources in dynamic environments to create value: Looking inside the black box. *Academy of Management Review*, *32*(1), 273-292.

Simsek, Z., Lubatkin, M. H., & Floyd, S. W. (2003) Inter-firm networks and entrepreneurial behavior: A structural embeddedness perspective. *Journal of Management, 29*(3), 427-442.

Silverman, B. & Baum, J. (2002) Alliance-based competitive dynamics. *Academy of Management Journal*, *45*(4), 791- 806.

Smith, W. K. & Tushman, M. L. (2005) Managing strategic contradictions: A top management model for managing innovation streams. *Organization Science*, *16*(5), 522-536.

Soh, P. H. (2003) The role of networking alliances in information acquisition and its implications for new product performance. *Journal of Business Venturing*, *18*(6), 727-744.

Srivastava, M. K. & Gnyawali, D. R. (2011) When do relational resources matter? Leveraging portfolio technological resources for breakthrough innovation. *Academy of Management Journal*, *54*(4), 797-810.

Stam, W. (2010) Industry event participation and network brokerage among entrepreneurial ventures. *Journal of Management Studies*, *47*(4), 625-652.

Stam, W. & Elfring, T. (2008) Entrepreneurial orientation and new venture performance: The moderating role of intra-and extra- industry social capital. *Academy of Management Journal*, *51*(1), 97-111.

Steensma, H.K., Marino, L., K., & Dickson, P. (2000) The influence of national culture on the formation of technology alliances by entrepreneurial firms. *Academy of Management Journal, 43*(5), 951-973.

Steier, L. & Greenwood, R. (2000) Entrepreneurship and the evolution of angel financial networks. *Organization Studies, 21*(1), 163-192.

Stevenson, H. & Jarillo, J.C. (1990) A paradigm of entrepreneurship: entrepreneurial management. *Strategic Management Journal*, *11*(5), 17-27.

Stinchcombe, A. L. (1965). Organizations and social structure. *Handbook of organizations*, *44*(2), 142-193.

Street, C. T. & Cameron, A. F. (2007) External relationships and the small business: A review of small business alliance and network research. *Journal of Small Business Management*, *45*(2), 239-266.

Stuart, T. E. (1999) A structural perspective on organizational innovation. *Industrial and Corporate Change*, *8*(4), 745-775.

Stuart, T.E. (2000) Inter-organizational alliances and the performance of firms: a study of growth and innovation rates in a high-technology industry. *Strategic Management Journal, 21*(8), 791-811.

Stuart, T. E., Hoang, H., & Hybels, R.C. (1999) Interorganizational endorsements and the performance of entrepreneurial ventures. *Administrative Science Quarterly, 44*(2), 315-349.

Stuart, T. E. & Podolny, J. M. (1996) Local search and the evolution of technological capabilities. *Strategic Management Journal*, *17*(1), 21-38.

Stuart, T. E., Ozdemir, S. Z., & Ding, W. W. (2007) Vertical alliance networks: The case of university–biotechnology–pharmaceutical alliance chains. *Research Policy*, *36*(4), 477-498.

Teece, D. J. (1992) Competition, cooperation, and innovation: Organizational arrangements for regimes of rapid technological progress. *Journal of Economic Behaviour & Organization*, *18*(1), 1-25.

Teece, D. J. (2000) *Managing intellectual capital: Organizational, strategic, and policy dimensions: organizational, strategic, and policy dimensions*. Oxford University Press.

Teece, D. J. (2007) Explicating dynamic capabilities: The nature and micro-foundations of (sustainable) enterprise performance. *Strategic Management Journal*, *28*(13), 1319-1350.

Teng, B. S. (2007) Corporate entrepreneurship activities through strategic alliances: A resource-based approach toward competitive advantage. *Journal of Management Studies*, *44*(1), 119-142.

Tihanyi, L., Ellstrand, A. E., Daily, C. M., & Dalton, D. R. (2000) Composition of the top management team and firm international diversification. *Journal of Management*, *26*(6), 1157-1177.

Tiwana, A. (2008) Do bridging ties complement strong ties? An empirical examination of alliance ambidexterity. *Strategic Management Journal*, *29*(3), 251-272.

Tsai, S. L., Ding, H. B., & Rice, M. P. (2008) The effectiveness of learning from strategic alliances: a case study of the Taiwanese textile industry. *International Journal of Technology Management*, *42*(3), 310-328.

Tsai, K. H. (2009) Collaborative networks and product innovation performance: Toward a contingency perspective. *Research Policy*, *38*(5), 765-778.

Tsai, W. & Ghoshal, S. (1998) Social capital and value creation: The role of intra-firm networks. *Academy of Management Journal*, *41*(4), 464-476.

Tushman, M. L. & Anderson, P. (1986) Technological discontinuities and organizational environments. *Administrative Science Quarterly*, *31*(3), 439-465.

Ucbasaran, D., Westhead, P., & Wright, M. (2001) The focus of entrepreneurial research: contextual and process issues. *Entrepreneurship Theory and Practice*, *25*(4), 57-80.

Uzzi, B. (1996) The sources and consequences of embeddedness for the economic performance of organizations: The network effect. *American Sociological Review*, 61: 674-698.

Uzzi, B. (1997) Social structure and competition in inter-firm networks: The paradox of embeddedness. *Administrative Science Quarterly*, *42*(1), 35-67.

Uzzi, B. (1999) Embeddedness in the making of financial capital: How social relations and networks benefit firms seeking financing. *American Sociological Review, 64*(4), 481-505.

Vandaie, R. & Zaheer, A. (2014) Surviving bear hugs: Firm capability, large partner alliances, and growth. *Strategic Management Journal*, *35*(4), 566-577.

Vanhaverbeke, W. & Noorderhaven, N. G. (2001) Competition between alliance blocks: The case of the RISC microprocessor technology. *Organization Studies*, *22*(1), 1-30.

Vassolo, R. S., Anand, J., & Folta, T. B. (2004) Non-additivity in portfolios of exploration activities: A real options-based analysis of equity alliances in biotechnology. *Strategic Management Journal*, *25*(11), 1045-1061.

Villanueva, J., Van de Ven, A. H., & Sapienza, H. J. (2012) Resource mobilization in entrepreneurial firms. *Journal of Business Venturing*, *27*(1), 19-30.

Walker, G., Kogut, B., & Shan, W. (1997) Social capital, structural holes and the formation of an industry network. *Organization Science, 17*(2), 109-125.

Wassmer, U. (2010) Alliance portfolios: A review and research agenda. *Journal of Management January, 36*(1), 141-171.

Weaver, K. M. & Dickson, P. H. (1998) Outcome quality of small-to medium-sized enterprise-based alliances: The role of perceived partner behaviours. *Journal of Business Venturing*, *13*(6), 505-522.

Westhead, P., Wright, M., & Ucbasaran, D. (2001) The internationalization of new and small firms: A resource-based view. *Journal of Business Venturing*, *16*(4), 333-358.

Wernerfelt, J. B. (1984) A resource-based view of the firm. *Strategic Management Journal, 5*(2), 171-180.

Williamson, O. E. (1975) *Markets and hierarchies*. New York: Free Press.

Williamson, O. E. (1985) *The economic institution of capitalism*. New York: Free Press.

Williamson, O. E. (1991) Comparative economic organizations: The analysis of discrete structural alternatives. *Administrative Science Quarterly*, *36*(2), 269-296.

Wiklund, J. & Shepherd, D. (2005) Entrepreneurial orientation and small business performance: A configurational approach. *Journal of Business Venturing*, *20*(1), 71-91.

Wratschko, K. (2009) *Strategic orientation and alliance portfolio configuration: The interdependence of strategy and alliance portfolio management*. Gabler edition wissenschaft.

Wu, W. Y., Chang, M. L., & Chen, C. W. (2008) Promoting innovation through the accumulation of intellectual capital, social capital, and entrepreneurial orientation. *R&D Management*, *38*(3), 265-277.

Wuyts, S., Dutta, S., & Stremersch, S. (2004) Portfolios of interfirm agreements in technology-intensive markets: consequences for innovation and profitability. *Journal of Marketing*, *68*(2), 88-100.

Wuyts, S. & Dutta, S. (2012) Benefiting from alliance portfolio diversity: The role of past internal knowledge creation strategy. *Journal of Management*, *23*(10), 110-143.

Xu, B., Magnan, M. L., & Andre, P. E. (2007) The stock market valuation of R&D information in biotech firms. *Contemporary Accounting Research*, *24*(4), 1291-1318.

Yamakawa, Y., Yang, H., & Lin, Z. J. (2011) Exploration versus exploitation in alliance portfolio: Performance implications of organizational, strategic, and environmental fit. *Research Policy*, *40*(2), 287-296.

Yasuda, H. (2005) Formation of strategic alliances in high-technology industries: Comparative study of the resource-based theory and the transaction-cost theory. *Technovation*, *25*(7), 763-770.

Yli-Renko, H., Autio, E., & Sapienza, H. J. (2001) Social capital, knowledge acquisition, and knowledge exploitation in young technology-based firms. *Strategic Management Journal*, *22*(6), 587-613.

Yli-Renko, H. & Janakiraman, R. (2008) How customer portfolio affects new product development in technology-based entrepreneurial firms. *Journal of Marketing*, *72*(5), 131-148.

Yu, J., Gilbert, B. A., & Oviatt, B. M. (2011) Effects of alliances, time, and network cohesion on the initiation of foreign sales by new ventures. *Strategic Management Journal*, *32*(4), 424-446.

Zaheer, S. (1995) Overcoming the liability of foreignness. *Academy of Management Journal*, *38*(2), 341-363.

Zahra, S. A. (1996) Technology strategy and new venture performance: A study of corporate-sponsored and independent biotechnology ventures. *Journal of Business Venturing*, *11*(4), 289-321.

Zahra, S. A., Hayton, J. C., Neubaum, D. O., Dibrell, C., & Craig, J. (2008) Culture of family commitment and strategic flexibility: The moderating effect of stewardship. *Entrepreneurship Theory and Practice*, *32*(6), 1035-1054.

Zhang, J., Baden-Fuller, C., & Mangematin, V. (2007) Technological knowledge base, R&D organization structure and alliance formation: Evidence from the biopharmaceutical industry. *Research Policy*, *36*(4), 515-528.

Zhang, J., Soh, P. H., & Wong, P. K. (2009) Effects of prior knowledge entrepreneurial resource acquisition through indirect ties: Compensatory. *Journal of Management, 36*(2), 511-536.

Zheng, Y., Liu, J., & George, G. (2009) The dynamic impact of innovation capability and inter-firm network valuation: A longitudinal study of biotechnology start-ups. *Journal of Business Venturing*, *25*(6), 593-609.

Zucker, L. G., Darby, M. R., & Armstrong, J. (1998) Geographically localized knowledge: Spillovers or markets? *Economic Inquiry*, *36*(1), 65-86.

Appendices

Appendix 1. Alliances of Aastrom Biosciences

Alliance Number	Name	Partner Name	Initiation Year month-year	Parties	Type	Equity Alliance = 1	$ Alliance capital (M)
1.	Aastrom Biosciences	University of Michigan	03-1992	University / Biotech	Research	1	2.5
2.	Aastrom Biosciences	Cobe Labs	10-1993	Drug/Biotech	Marketing	1	40
3.	Aastrom Biosciences	SeaMED	05-1994	Biotech/Biotech	Research	0	0
4.	Aastrom Biosciences	Ethox	11-1994	Biotech/Biotech	Research	0	0
5.	Aastrom Biosciences	Rhone-Poulenc Rorer	09-1995	Drug/Biotech	Research	1	30.9
6.	Aastrom Biosciences	University of Texas	04-1996	University / Biotech	Research	0	0.1
7.	Aastrom Biosciences	Immunex	04-1996	Biotech/Biotech	License	0	5.5
8.	Aastrom Biosciences	Loyola University	08-1996	University / Biotech	Research	0	0
9.	Aastrom Biosciences	Navidea Biopharmaceuticals	06-2001	Biotech/Biotech	Research	0	0
10.	Aastrom Biosciences	AUSL Ravenna	05-2002	Biotech / Biotech	Research	0	0
11.	Aastrom Biosciences	Stanford	10-2002	University / Biotech	Manufacturing	0	0
12.	Aastrom Biosciences	Stanford	05-2003	University / Biotech	Research	0	0
13.	Aastrom Biosciences	Orthovita	03-2006	Biotech / Biotech	Research	0	0
Total count		13				3	79

Appendix 2. Alliances of Acadia Pharmaceuticals

Alliance Number	Name	Partner Name	Initiation Year month-year	Parties	Type	Equity Alliance = 1	$ Alliance capital (M)
1.	Acadia Pharmaceuticals	Allergan	09-1997	Drug/Biotech	Research	1	75
2.	Acadia Pharmaceuticals	Allergan	07-1999	Drug / Biotech	Research	0	19
3.	Acadia Pharmaceuticals	ArQule	12-2000	Biotech / Biotech	Research	0	0
4.	Acadia Pharmaceuticals	Amgen	01-2002	Biotech / Biotech	Research	0	4.3
5.	Acadia Pharmaceuticals	Allergan	03-2003	Drug / Biotech	License	0	32
6.	Acadia Pharmaceuticals	Sunovion Pharmaceuticals	01-2005	Biotech / Biotech	Research	1	115
7.	Acadia Pharmaceuticals	Ipsen	11-2006	Drug/Biotech	Marketing	0	0
8.	Acadia Pharmaceuticals	Kingsbridge	08-2008	Biotech / Biotech	Marketing	1	60
Total Count		8				3	305.3