Global Knowledge Sourcing Activities: The Choice of Research and Development (R&D) Alliance Governance Modes in the Pharmaceutical Industry

By

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ABSTRACT OF THE DISSERTATION

Global Knowledge Sourcing Activities: The Choice of Research and Development (R&D) Alliance Governance Modes in the Pharmaceutical Industry

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The dissertation investigates factors affecting the choice of global R&D (Research and Development) alliance governance mode and successful alliance collaboration performance in one of knowledge intensive industries (i.e., Pharmaceuticals). In the first study, by identifying a variety of R&D alliance modes used in the Pharmaceuticals, and classifying them into four categories, I go beyond the traditional binary equity vs. non-equity alliance classification. This enriches the study of alliance governance structure and broadens the application of alliance modes in what is today a more complicated international R&D collaboration setting. And then, I explore the multi-specific factors (e.g., national, industry and firm) affecting the choice of an appropriate R&D alliance governance mode. Using a sample of 237 alliance deals announced in between 2000 and 2003, I found that the R&D alliance governance modal choice is not attributable to a single factor (e.g., exogenous country-specific factors), but is influenced by multiple factors. But those multiple factors have different impacts depending upon whether firms involve in R or D. Specifically, the likelihood of using a more-integrated alliance governance mode decreases as the gaps in culture and quality of human capital between nationalities of

partnering firms increase. On the other hand, national geographic distance and institutional environment difference are positively associated with the more-integrated governance mode. Furthermore, firms in the research stage are more likely to use a more-integrated governance mode, as opposed to firms in the development stage. These findings advance alliance governance structure research by opening the black box concealing the answers for paradoxical mixed-results on factors affecting the R&D alliance governance mode choice.

The second paper enhances the study of R&D alliance governance structure as well as Knowledge-Based View of alliance by examining the relationship between coordination and communication structure of alliances and successful alliance collaboration performance. Using data from a sample of biopharmaceuticals, I found that the probability of successful alliance performance depends on the degree of interaction and complexity of alliance deal; such lower degree leads to a better performance due to reduced communication and coordination costs. However, this negative relationship is moderated by partner's national diversity (i.e., domestic vs. foreign) and technological base complementarity in a way that alliances with less interactive and less complicated structure tend to have a better performance when the alliances are between domestic partners, and with similar technological bases. But when the alliances are more interactive and complex that increases coordination and communication costs, collaborating with foreign partners and partners with diverse technological bases contributes to a better performance even though the alliance governance structure incurs communication and coordination costs. The findings also provide insightful strategic implications to practitioners with regard to designing a suitable alliance governance structure for the better performance.

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CHAPTER 1

INTRODUCTION

1.1 Background of the Study

Knowledge has been described as one of the most important resources of the firm forming the valuable intangible organizational assets as well as capabilities (Grant, 1996; Grant and Baden-Fuller, 2004). Knowledge sourcing is regarded as a critical activity of the firm, because knowledge is a key determinant of firm competitiveness and growth (Kogut and Zander, 1993). However, because of technological complexity, rapidly changing technology, and increased cost of research and development (R&D), diversification of knowledge sourcing activities has become an important strategy of the firm. Today, firms are more likely to engage in geographically diversified R&D activities in order to access unique (technological) knowledge available in a specific region and to tap into foreign embedded knowledge for the sustainable growth (Cantwell, 1989; Chung and Alcacer, 2002). In this sense, the topic, global knowledge sourcing activities, has been paid much attention in the field of international business and management strategy.

Nevertheless, it is somewhat difficult to achieve acquisition of knowledge and technological innovation through global R&D activities without having a constructive strategy about where and how to source external knowledge. In this vein, there are at least two main research streams regarding the global knowledge sourcing activities: (1) Location Strategy and (2) Knowledge Sourcing Mode (i.e., Collaboration Mode). The dissertation is designed to address issues in location choice and alliance governance mode choice as a knowledge sourcing method. *First*, prior studies have focused on location-specific

advantages as determinants of global knowledge sourcing activities. Countries vary in the type and nature of innovation systems, and thus have different attractiveness for foreign firms. For instance, because of differences in education system (e.g., workforce) and technological background (i.e., availability of certain technologies), a country may have different levels of R&D activity as well as R&D productivity (Furman et al, 2002). And foreign firms may expand their R&D activities abroad to those countries where unique diverse technologies and highly productive labor forces are available (Kuemmerle, 1999). Others have emphasized liability of foreignness as the key factor affecting firms' internationalization (Hymer, 1960; Johanson and Vahlne, 1977). More specifically, distance defined to encompass cultural, geographic, institutional and economic dimensions affects internationalization of firms (Dow and Larimo, 2009; Lopez-Duarte and Vidal-Suarez, 2010). For instance, Gulati (1995) emphasized the importance of similarity in national culture and institutional environments between alliance partners in facilitating resource exchange and boosting inter-firm trust. In a similar vein, Steensma et al. (2000) found that because of differences in perceived uncertainty between alliance partners, national culture directly and indirectly affects the formation of technology alliances. As such, national level cultural and institutional distance has been recognized as one of critical determinants of international alliance formation.

However, as argued by Alcacer and Chung (2007), those location strategies assuming location as exogenous neglect firm heterogeneity such as firm capabilities and collaborative activities among firms. Location-specific advantages/disadvantages can be derived not only from the activities of local firms and institutions, but also from active interactions of foreign firms with local firms and institutions, and their knowledge

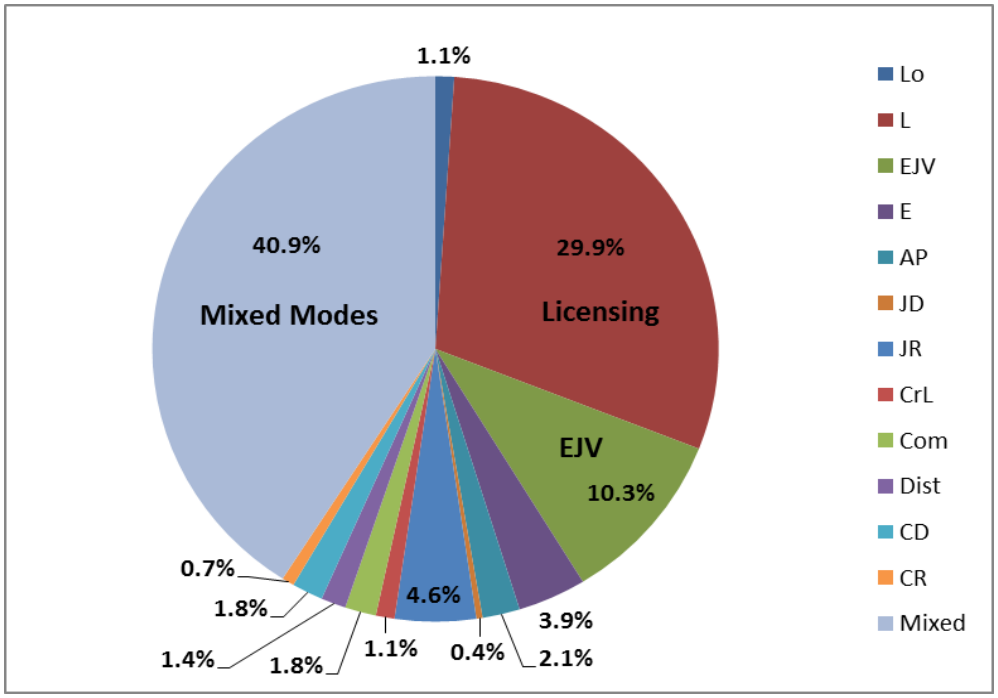
spillovers in industries of the country. Recently, Cantwell, Dunning and Lundan (2010) emphasized the importance of evolutionary subsidiary role. The subsidiary is an organization with its learning capability and ability to build networks with local firms as well as institutions. And subsidiaries involve in competence creating activities through collaboration with local firms and institutions. Given those, it is important for firms engaging in global knowledge sourcing activities to consider those national level exogenous factors (e.g., cultural, institutional and economic), as well as industry and firm-specific endogenous factors such as levels of technological development of the industry and the firm.

Second, another research stream in the study of global knowledge sourcing is the collaborative knowledge sourcing mode. Strategic alliance as the mode of collaboration has been widely used by firms in all industries. But particularly those in technology intensive industries such as telecommunication, semiconductors, computers and pharmaceuticals aggressively pursue inter-firm alliances. According to Contractor and Lorange (2002), there are at least seven motivations for strategic alliances: (1) Risk reduction, (2) Economies of scale, (3) Technology exchange, (4) Co-opting or blocking competition, (5) Overcoming government mandated trade or investment barriers, (6) Facilitating initial international expansion of inexperienced firms, and (7) Vertical quasi-integration advantages. However, the motives for establishing alliances have shifted as technological knowledge (or technology itself) in high-tech industries has become more complex and costly to develop. Mowery et al (1996), and Tapon and Thong (1999) emphasized the risk and cost side of motivation for inter-firm collaboration in R&D activities. Chung and Yeaple (2008), in a similar vein, found that firms involving in

international knowledge sourcing activities are more likely to use external knowledge as a springboard to reduce their next generation R&D costs. Accordingly, alliance governance modes used in the knowledge-intensive industry have become more diverse which goes beyond the traditional binary Equity vs. Non-equity based alliance modes described under TCE (Transaction Cost Economics). For instance, alliance modes used in the pharmaceutical industry (the research context of this dissertation) are highly diversified as illustrated in Fig. 1.1.

FIGURE 1.1

Example of Clauses in Alliance Agreements



Source: Recap Data: International pharmaceutical alliances 2000 ~ 2003. Loan (**Lo**): 1.1%; Licensing (**L**): 29.9%; Equity Joint Venture (**EJV**): 10.3%; Equity (**E**): 3.9%; Asset Purchasing (**AP**): 2.1%; Joint-Development (**JD**): 0.4%; Joint Research (**JR**): 4.6%; Cross-Licensing (**CrL**): 1.1%; Commercialization (**Com**): 1.8%; Distribution (**Dist**): 1.4%; Contract Development (**CD**): 1.8%; Contract Research (**CR**): 0.7%; Mixed modes (**Mixed**): 40.9%

As can be seen from Fig 1.1, it is common to use different types of alliance in the pharmaceuticals at least because of a couple of reasons. PhRMA (2009) showed increased

difficulty of developing new drugs; annual spending on R&D has been increasing during the year of 2000 through 2008, while the number of patent in the pharmaceutical industry has been decreasing 2005 afterwards. In addition, the number of new drugs approved by U.S. FDA (Food and Drug Administration) has been decreased as well. This phenomenon represents that new drug development has become more costly and risky. On top of this, increased industrial rivalry, increased difficulty of application of complementary technology, time consuming process of R&D (on average 10 to 15 years), and the patent expiration for top selling drugs makes pharma companies spend more money on research and development, but also makes them difficult to amortize their R&D spending. Given those facts, the dissertation is aiming to cover following research questions regarding the motivations for using diverse alliance governance modes in global R&D activities.

1.2 Research Questions and Goals of Dissertation

The dissertation examines four research questions regarding the determinants of international R&D alliance governance mode choice and the R&D alliance collaboration performance.

(1) *Using techniques such as cluster analysis, can we identify different classes of non-EJV (Equity Joint Venture) agreements and rank order them with increasing degree of inter-partner involvement?*

(2) *Along the continuum of international R&D alliances, with an EJV being the most integrated, can we identify the determinants of the governance modal choice, based on human capital, institutional, cultural and geographical differences between the home nations of each partner as well as industry and firm-specific technological base differences?*

(3) *How is the governance mode choice moderated by the types of activity – Research*

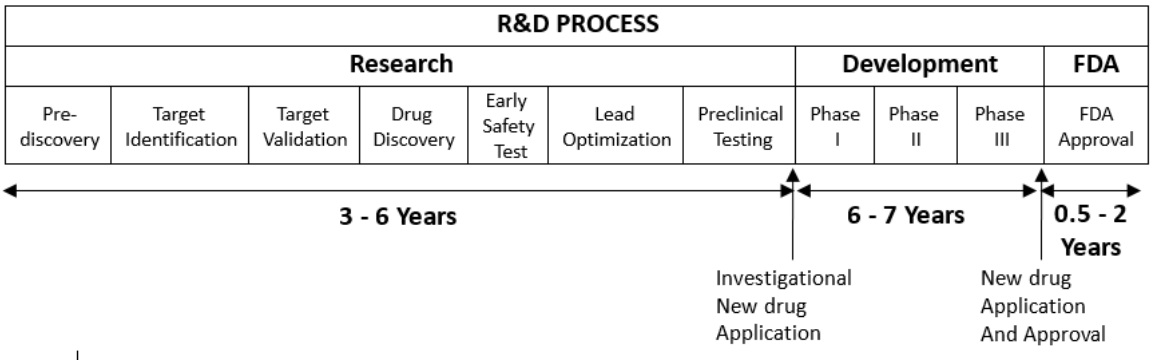
versus Development?

(4) *How does the alliance governance structure (i.e., interactive and coordinative structure) influence the success of alliance collaboration?*

The first study covers first three questions and focuses on the classification of different types of non-equity based alliances in order to be able to capture dynamism in R&D activities. And then, the study investigate factors affecting the choice of new alliance governance modes. Moreover, the first study describes how the choice of alliance governance mode is influenced by the stage of R&D; whether the alliance task is in basic research 'R', or in development 'D' phase. This unpacks activities uncomfortably lumped together into one rubric 'R&D' -- when actually the operations, strategic objectives, risks and rewards vary considerably between R and D (Figure 1.2 illustrates the distinction between R and D in the pharmaceutical industry; while basic research focuses on drug discovery and molecular science, development is associated with clinical field trials).

FIGURE 1.2

The Stages of Pharmaceutical R&D[1]



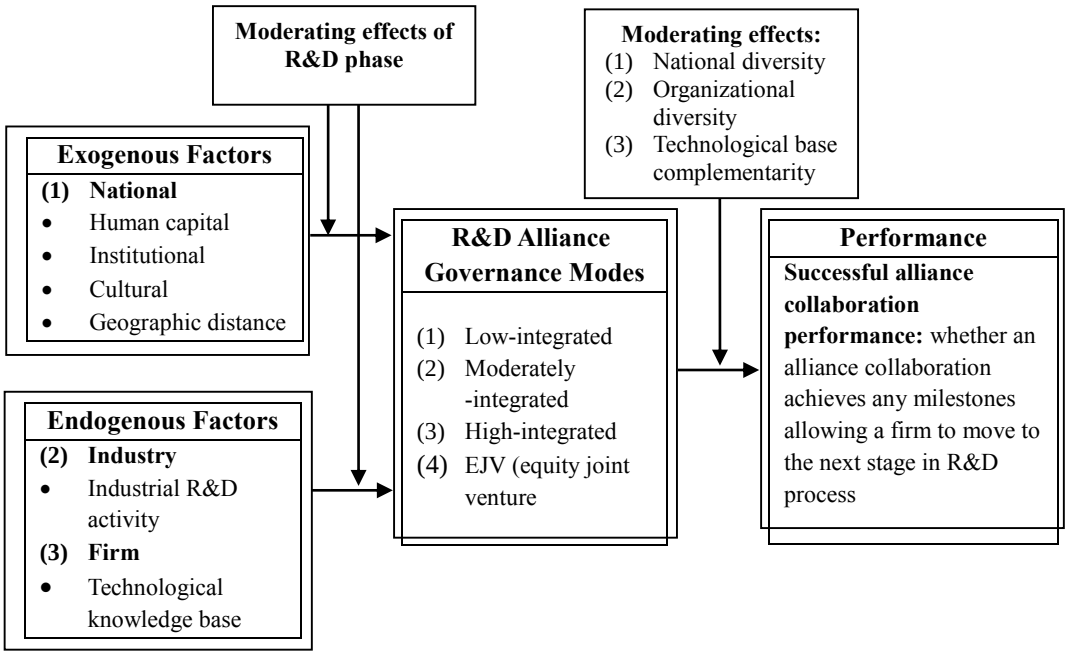
[1] Initially adapted from Rang (2006) and Sosa (2009), and reproduced by using PhRMA (Pharmac eutical Research and Manufacturers of America), 2007 and 2010 profile.

In the second study, I examine the relationship between the alliance governance structure and the alliance collaboration performance (i.e., Research question #4). And I particularly scrutinize coordination and communication mechanisms of alliance governance structure, and see the impact of such mechanisms on the collaboration performance. Not only does it enhances the study of alliance governance structure, but it also provides plausible explanations about the paradoxical phenomenon taken place in the pharmaceutical industry; as shown from the Fig. 1.1, an organizationally embedded alliance mode such as EJV is not always preferable although works drawing on Knowledge-Based View (KBV) have argued that a hierarchical alliance mode (e.g., EJV) is particularly effective due to its organizationally integrated communities that promote tacit or complex knowledge share and transfer activity (Kogut, 1988; Kogut and Zander, 1992; Sampson, 2004; Macher, 2006). Then, I further investigated the moderating roles of partner diversity in terms of nationality (foreign vs. domestic), organizational types (universities, research institutes and firms), and technological base on the alliance governance structure-performance relationship.

Fig. 1.3 presents the outline of dissertation.

FIGURE 1.3

Outline of Dissertation



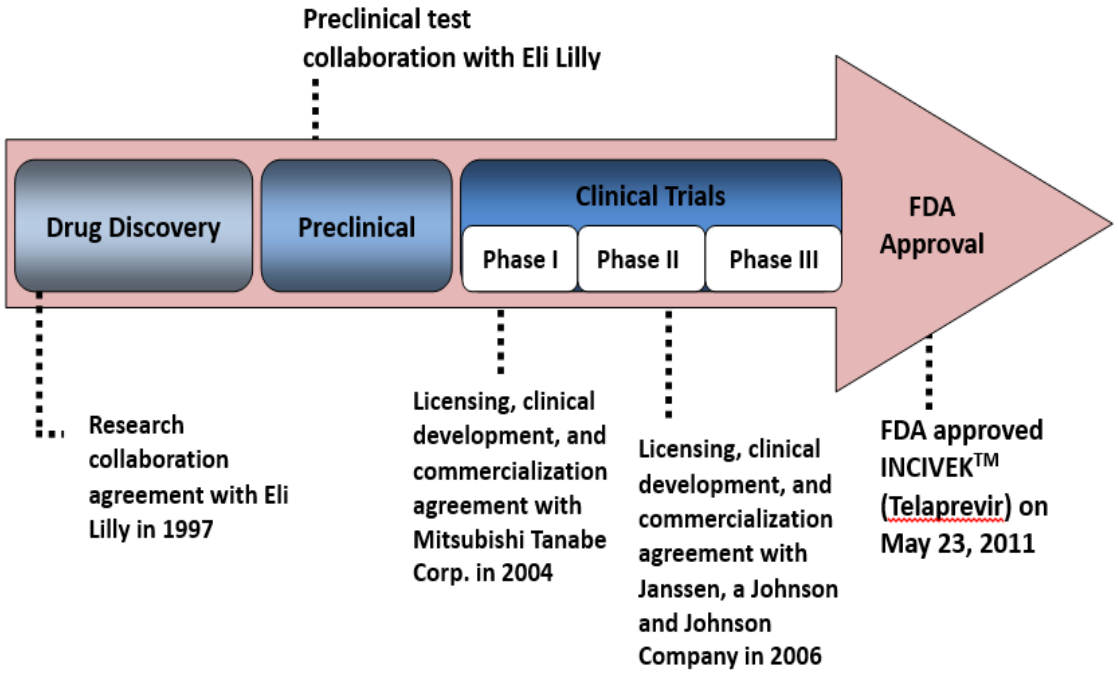
1.3 Research Setting

The dissertation investigates the determinants of R&D alliance governance mode choice, and examines the relationship between alliance governance structure and alliance collaboration performance in the pharmaceutical industry. There are a couple of reasons why pharmaceutical industry provides a good research context for this study. *First*, pharmaceutical industry is a knowledge intensive industry where many firms engage in strategic alliances allowing this study to capture the dynamism of inter-firm R&D activity. *Second*, because of significant distinction between research and development in the pharmaceutical industry, the study setting provides a better context in analyzing diversity and dynamism of inter-firm alliances. As described in Fig. 1.2, there is a significant distinction between research and development in the pharmaceutical industry; while

research activity focuses on drug discovery, development is associated with the clinical trials. This may also mean that factors affecting the alliance governance mode choice paly a different role depending upon different stages of R&D. For instance, due to the difficulties in dealing with tacit knowledge in the early research stage, firms are more likely to use a more hierarchical alliance mode (Santoro and McGill, 2005). Hence, the study setting separating research from development allows me to examine the different role of factors in different stages. *Finally*, complexity of R vs. D in the pharmaceutical industry allows me to capture stage-by-stage alliance collaboration performance. As illustrated in Fig. 1.4, firms can get involved in multiple alliances to develop only one drug product. This may dilute the definition of alliance collaboration performance; the alliance in the early drug discovery stage does not have to be an unsuccessful alliance even if its drug product/compound is not ultimately approved by FDA nor commercialized in the market.

FIGURE 1.4

Illustration of Alliance Activities: Commercialization of One Drug Product



But then, the dependent variable of second part of dissertation, the *Successful Alliance Collaboration Performance*, measuring the success of alliance collaboration whether an alliance collaboration achieves any milestones that allow a firm to move to the next stage in R&D process, provides a clearer definition of alliance collaboration performance.

1.4 Overall Methodology

The major contributions of this dissertation is to identify a variety of alliance types used in one of R&D intensive industries and to classify them into different categories. In order to be able to do these, it is critical to actually reading the real alliance contracts. Prior dichotomous alliance classification seems to overlook a variety of agreement-based alliances used in many industries such as pharmaceuticals, electronics and information technology. This is probably because actual details of the alliance agreement held confidentially by each firm were then not available. Recently, the actual text of alliance agreements has become available in data bases such as ReCap and SDC. I used a unique data source, *Current Agreements Database*, which covers details on global alliance agreements in the bio-pharmaceutical sector (U.S. SIC 2833 through 2836) ranging from equity joint ventures to technology licenses, joint research/developments, loans, and passive equity purchases. The database contains the alliance deal announcement date, alliance partners (e.g., nationality and address), actual contract documents (actual contract and/or financial information is sometimes not disclosed), alliance deal components (i.e., types of alliance- licensing, development, and so on), and stages of development ranging from discovery to phase III clinical trial. In addition to this, I used a variety of publically

available data sources to measure independent variables: OECD library data to measure human capital and industrial factors, Worldbank Governance Indicators for institutional environment variables, Hofstede's Cultural index for cultural differences, CIA World Factbook for physical geographic distance, the latest version of IMS Health's USC 5 (The Uniform System of Classification) for technological base differences, and 10-K annual reports for firm-level data (e.g., size and age). Since the dependent variable of first study, "*Degree of Overall Integration*": The categorization of alliance governance modes, is rank ordered, I used Ordinal Logistic Regression.

I used the same database (i.e., Current Agreement) for the second study. And I especially investigated companies' annual report to see if their alliances actually move towards the next stage in the R&D process, and thus to measure the successful alliance collaboration performance. The dependent variable of second study takes the form of '0' and '1' ('1' denoted the successful alliance collaboration), I performed the Logistic Regression.

CHAPTER 2

LITERATURE REVIEW

2.1 Review of Collaborative Research and Development and its Modes

In this chapter, I will review literatures on collaborative R&D alliance modes. Some important terms will be defined first, and then I will review and point out some gaps in the literatures.

2.1.1 Definition of Collaboration, and Research and Development

Inter-firm collaboration has been highlighted as an important strategy for more than two decades in the field of business management. Collaboration can be defined as pursuing mutual interests and common benefits. Within this paradigm, the business world is composed of a network of inter-partner relationships developed and fostered through strategic cooperation with the goal of achieving mutual benefits (e.g., Miles & Snow, 1986; Thorelli, 1986; Borys & Jemison, 1989). Firms can also collaborate in the context of R&D. However, although there is a significant distinction between research and development, the term R&D has been used without clear distinction. It is critical to define research and development before we go into more details.

According to National Science Foundation, research can be classified into two; basic research and applied research. *Basic research is described as the pursuit of new scientific knowledge or understanding that does not have immediate commercial purposes, while applied research describes application of the findings of basic research or other existing knowledge toward discovering new scientific knowledge.* On the contrary, *development describes the systematic use of the knowledge or understanding gained from research or*

practical experience directed toward the production or significant improvement of useful products, services, processes or methods… In order words, research is more theoretical in nature and creates knowledge, and also can be reported as a scientific research papers while development is based on a synthetic knowledge (Asheim and Coenen, 2005), and is directed to the introduction of new or improved products (Dwyer, 2008). Based on these definitions, it is important to identify which activity in the R&D a firm is actually involved (research, development or both R&D), because firms in some technology-based industries such as computing, communications and transportation tend to focus on development activities rather than research (Narin and Olivastro, 1992).

The distinction between research and development is relatively clear in the pharmaceutical industry. As can be seen from Fig. 1.2, R&D process is comprised of drug discovery- Research and clinical trials-Development. Brief description of drug development process is as follows (PhRMA, 2011)[2].

- **Basic Research (including preclinical)**

This is a starting point of drug development. Scientists in a laboratory, academic institutions, biopharmaceutical companies, work to understand the disease to be treated. Once scientists/researchers understand the underlying cause of a disease, they select a "target" which is usually a molecule related to the disease. And then they test the target whether it is really related to the disease being studied. Among many targets, they choose a promising lead compound that could become a drug. By having this lead compound they initially test for safety, toxicity and so on, and optimize (i.e., altering the compound for

[2] PhRMA Profile, 2011

better safety and effectiveness) the compound before testing it to animal at the preclinical stage. Finally, they can have animal-based clinical trial called ‘Preclinical’ to determine whether it is testable for human. Thus, the research in the pharmaceutical industry focuses on science-oriented knowledge creation (e.g., finding new compound) through application or combination with other relevant field of researches such as biology and chemistry.

- **Development (Phase I ~ III Clinical Trials)**

Once researchers pass the preclinical, and before they start human-based clinical trials, they must file an Investigational New Drug (IND) application with the FDA. After the FDA approves the drug for human test, pharmaceutical companies, sometimes in collaboration with clinical laboratories, universities and Contract Research Organization (CRO), can start Phase I clinical trial. In Phase I trial, safety, drug metabolism, and drug interaction can be tested and should be passed to the next Phase II clinical trial. In Phase II trial, drug developers test efficacy and examine the possible side effects as well as risk associated with the drug. Once the potential drug passes Phase I and II clinical trials, it goes through the most costly and time consuming Phase III clinical trial with a large group of patients in order to test efficacy, safety and the overall benefit-and-risk relationship of the drug. In the case of successful Phase III trial, companies can finally file their drug candidate to the FDA for approval and commercialization. Hence, development in the pharmaceutical industry is about testing new drugs through clinical trials.

2.2 Motivations for Alliance Formation

As mentioned in the introduction part, there are various motives for forming alliances (Contractor and Lorange, 2002; Inkpen, 2008); for instance, gaining economies of scale by

pooling diverse resources from each alliance firm, minimizing risk while promoting stability, and gaining access to partner firm's knowledge/technologies. Because of these various motives for alliance formation, there is no general definition for alliance. Nevertheless, alliance or strategic alliance can be defined as "*a relatively enduring inter-firm cooperative arrangement that utilizes resources and/or governance structures from autonomous organizations*" (Inkpen, 1998). And strategic alliances include joint ventures (JVs), licensing agreements, distribution and supply agreements, research and development partnerships, co-production agreements, franchising, and technical exchanges (Tsang, 1998; Inkpen, 1998). Because of complexity and diversity in the usage of strategic alliance, a single theory may not be able to explain dynamics of alliance formation and the evolution of types of alliance. Given the fact, the theoretical background of alliance formations can be derived from at least those following theories/perspectives; *Transaction Cost Economics, Resource-based view, Knowledge-based view and Organizational Learning perspective*. *First*, the Transaction Cost Economics (TCE) describes inter-firm alliance as a hybrid form of organization in between the hierarchical transactions within the firm and arm's length transactions in the market place (Williamson, 1991). In other words, firms can choose a hybrid mode (i.e., alliance) when the contracts through market relationship are too expensive and when complete integration is considered too costly and risky. Firms can reduce costs of uncertainty, transaction and coordination of arms-length market transactions through alliances (Dunning, 1995). For instance, two different forms of transactional uncertainty such as environmental and behavioral uncertainty (Rindfleisch and Heide, 1997)[3] can be reduced through an alliance with a better control and monitoring

[3] Environmental uncertainty: search and negotiation costs in identifying and contracting with an outsourcing alliance partner. Behavioral uncertainty: opportunistic behaviors of transaction partner

mechanism (Belderbos et al. 2004). *Second*, unlike TCE, Resource-based view (RBV) emphasizes the internal resources and capabilities of the firm and argues that those resources and capabilities can be the basis of competitive advantage (Wernerfelt, 1984; Barney, 1991; Conner, 1991; Amit and Schoemaker, 1993; Peteraf, 1993). And here resources, according to Amit and Schoemaker (1993), can be defined as: *Stocks of available factors that are owned or controlled by the firm in the form of know-how (e.g., patents and licenses), financial or physical assets (e.g., property, plant and equipment), human capital and so on. And capabilities refer to as a firm's capability to deploy resources through information-based, tangible or intangible processes that are firm-specific and are developed overtime through complex interactions among the firm's resources.* From RBV perspective, firms can maximize their value by effectively combining the resources of the partner firms in a cooperative relationship (Kogut, 1988; Hagedoorn et al., 2000). By forming alliances firms can access, share and/or exchange valuable resources with partnering firms, particularly when those resources cannot be efficiently obtained through market transactions (Das and Teng, 2000). *Third,* another perspective that addresses the motivations for alliance formations is Organizational Learning (OL) perspective. Organizational learning focuses on the interaction of firms' organizational environment with other organizations. The important feature of organizational learning is a process of imitating the behavior of other organization and accepting their routines (Hedberg, 1981). In this sense, organizational learning perspective is different from those two theoretical perspectives mentioned above; OL focuses more on the evolutionary perspective of alliance that emphasizes post-alliance value creation activities such as accessing, transferring, learning and creating knowledge, whereas TCE

and RBV focus on ex-ante alliance motivations. Hence, from the OL perspective, alliances can be formed as a vehicle for organizational learning and knowledge sharing (Inkpen, 2008). *Fourth*, Knowledge-based view (KBV) has been regarded as a theoretical framework for examining the boundary of firms since knowledge recognized as a critical resource of the firms (Kogut and Zander, 1992; Grant, 1996; Spender, 1996). KBV is viewed as an extension of RBV in that knowledge including intangible resources such as reputation, a customer database, a new technology, or a consulting company's service offering (Fey and Birkinshaw, 2005), is a basic resource of competitive advantage (Conner and Prahalad, 1996). And KBV examines the exploitation of existing firm resources. However, the difference between RBV and KBV is that KBV further examines the firm's ability to develop new capabilities and access knowledge beyond firm boundaries (Grant and Baden-Fuller, 2004). Thus, the motivation/goal of alliance formation, under the KBV, is to acquire external knowledge through organizational learning (Hamel, 1991; Mody, 1993).

Although the motivations for alliance formations can be approached by multiple theories, in this dissertation, I will focus on TCE and KBV because these theories better explain the modes of collaboration in international R&D activities, and thus better suited to this study context. Moreover, KBV is particularly useful, because KBV not only emphasizes knowledge accessing and acquiring activities of the firm, but it also entails inter-organizational knowledge transferring through organizational learning and appropriate alliance modal choice. Hence, it captures dynamism of international R&D alliance activities, and provides a richer understanding in the study of alliance governance mode choice.

2.3 Alliance Governance Modes under TCE and KBV

Due to asymmetric resources contributed by each partnering firm, opportunistic behaviors such as learning, using resources for one's own interest or appropriating a partner's critical resources may occur in a collaborative relationship (Das & Teng, 1998). In order to minimize alliance partner firm's opportunistic behaviors yet facilitate organizational learning and knowledge transfer, choosing an appropriate alliance governance mode is critical. As presented in Table 2.1, different types of alliance ranging from non-equity based alliances to equity based alliances have been identified in the previous researches. Equity-based alliances are categorized into two; Equity Joint Venture (EJV) and Minority Investments/holdings (Passive equity purchase). And the difference between Equity joint venture and Minority investment is that the former creates a new entity with relatively well organized control and decision making mechanism, while the latter takes a minority equity position without creating a new entity. On the other hand, non-equity based alliances take many different forms, from unilateral agreement such as licensing to bilateral agreements such as joint contracts, joint development agreement and cross-licensing.

TABLE 2.1

A Typology of Alliances

Studies	Types of Alliance	
	Equity Mode	**Non-Equity Modes (Contractual agreements)**
Mowery et al., 1996	Equity Joint Venture (**EJV**)	R&D contract, Licensing, Joint Development Agreement, Cross-licensing & tech. sharing, Customer-Supplier partnership, Mixed (Licensing and Equity exchange)
Steensma, 1996	**EJV**, Equity acquisition, Minority investment	Research Contract, Licensing
Coopers and Lybrand, 1997		Joint marketing/promotion, Joint selling/distribution, Joint Production, Joint design, Licensing, R&D contract, Outsourcing
Gulati and Singh, 1998	**EJV**, Minority Investment	Contractual alliances- Licensing, Second-sourcing, Distribution agreements, Joint Contracts and Technology exchange agreements
Das and Teng, 2000	**EJV**, Minority equity alliances	Bilateral and Unilateral contract-based alliances
Contractor and Lorange, 2002	**EJV**	Technical training/start-up assistance agreements, Production/assembly/buyback agreements, Licensing, Franchising, Management/marketing service agreement, Cooperative agreement (in exploration, research and development/co-production)
Odagiri, 2003		Joint research, Commissioned research, Technology acquisition, Outsourcing
Narula and Duysters, 2004	**EJV**; -Research corporation -Minority holding and Cross-holding	-Joint R&D agreement (Joint research pact and Joint development agreement) -Customer-Supplier relationship (R&D contract, Co-production/marketing) -Bilateral technology flows (Cross-licensing, technology sharing, mutual second sourcing) -Unilateral technology flows (Licensing, Second sourcing agreement)
Santoro and Mcgill, 2005	**EJV,** Minority equity	One-way licensing, Cross licensing, Bilateral agreement
Todeva and Knoke, 2005	**EJV,** Majority/minority holdings	Cooperative agreements, R&D consortia, Strategic cooperative agreement, Cartels, Franchising, Licensing, Subcontractor networks, Industry standard groups, Action sets
Vrande et al., 2009	**EJV,** Minority holdings	Non-equity technology alliances, Corporate venture capital (CVC) investments

From TCE perspective, an alliance is viewed as a hybrid governance mode lying between market and hierarchy (i.e., firm). And firms can utilize incentive alignments to reduce partner firm's behavioral uncertainty (i.e., opportunism) by adopting different

alliance governance modes (using bilateral/reciprocal agreements rather than unilateral agreements). Although TCE provides a good theoretical lens in the study of alliance governance mode choice, it has been criticized by researchers because it fails to account for strategic objectives of alliance mode choice (Fosfuri, 2006). For instance, according to TCE, unilateral agreement such as technology licensing can be chosen when the transaction costs for searching partners and appropriation of key technology are relatively low. However, licensing might not take place because of licensor's profit dissipation effects[4] even though the market transaction costs are low.

In this vein, there are a couple of limitations of the TCE in application to knowledge-intensive industries. *First,* although transaction cost is high, strategic alliance is a preferred mode to hierarchical modes in certain technology driven industries such as IT (information technology). Hagedoorn and Duysters (2002) found that firms in industries facing with increasing technology intensity and radically changing technology preferred more flexible organizational structure in order to learn through loosely structured agreements. *Second,* due to high risks, costs and difficulties of research and development, transaction costs are very high in knowledge-intensive industries. Nevertheless, as can be seen from Fig. 1.1, companies in pharmaceutical industry prefer non-equity based alliances to equity-based alliance (i.e., EJV). Probably, it partly reflects that firms in the pharmaceutical industry tend to choose non-hierarchical modes of collaboration for strategic purposes. *Third,* TCE does not fully take into account the coordination mechanism as a way to control and monitor partner relationship. Under traditional Transaction Cost Economics, alliance types

[4] Profit dissipation effect refers to as reducing profits due to increased competition; licensee can be a direct competitor of licensor in case the licensee, by acquiring licensor's technology, produces similar products and launches them in the licensor's market.

(unilateral contract-based alliances and equity-based joint venture) lie on the organizational continuum between market and hierarchy (Williamson, 1991; Oxley, 1997). And each alliance governance structure is conceptualized based on levels of hierarchical controls as part of incentive alignments. In this sense, equity joint venture, where ownership is shared by the partner firms, and coordination of the collaborative activities is governed and monitored by a well-established control mechanism (i.e., joint board), is regarded as the most hierarchical mode of alliance. And thus this kind of organizational embeddedness promotes collaboration and knowledge sharing in the EJV while reducing opportunism in the organization (Oxley and Wada, 2009). However, due to the increased complexity of R&D in high-tech industries such as pharmaceuticals, electronics and information technology, firms use diverse alliance governance modes that are not covered by TCE (Mowery et al., 1996; Hagedoorn et al., 2008). For instance, mixed modes (e.g., joint research plus licensing agreement) are widely used in the pharmaceuticals. And mixed modes that contain multiple provisions can be used as incentive alignments for a better monitoring and control of partners.

Another approach, Knowledge Based View (KBV), argues that due to organizationally embedded communities that facilitate tacit or complex knowledge share and transfer, EJV is an ideal mode of collaboration (Kogut, 1988; Kogut and Zander, 1992; Sampson, 2004; Macher, 2006; Oxley and Wada, 2009). However, it is not necessary for firms to form long-term based EJVs. As shown in Fig. 1.1, firms in the pharmaceutical industry are more likely to use non-equity based alliances than equity-based alliance (EJV) for R&D activities even though EJV, under KBV, is an ideal mode for knowledge sharing, learning and transferring activities. This is because sometimes short-term contract based alliances such as licensing,

bilateral research collaboration agreement or combination of these two provide safer and more flexible options in the case of alliance failure. By using more flexible alliance modes (e.g., short-term contract based), firms have more options to reverse their contracts/agreements when they see negative outcomes in the process of R and D. As such, the study of alliance governance mode under KBV focuses on knowledge sharing activities yet neglects risk and cost side of R&D collaboration that affects the choice of alliance governance modes. Hence, in this dissertation I incorporate those mixed modes to enhance TCE and KBV of alliance governance structure.

2.4 Globalization of Research and Development

Previously I reviewed the motivations for alliance formation and the alliance governance modes from TCE and KBV perspectives, and pointed out some limitations. In this chapter, I will review the motives for R&D globalization from TCE and KBV perspective, and will investigate the determinants of international R&D activities.

According to Patel and Vega (1999), and Bas and Sierra (2002), there are four different motivations for international R&D activities; *(1) Technology-seeking, (2) Home-based Exploiting, (3) Home-based Augmenting, (4) Market-seeking R&D*. And the studies classified those four motives for international R&D activities based upon a matrix of a firm's strengths and weaknesses of technological activities in its home country as well as host countries' technological profile. Among the motivations, technology-seeking and home-based augmenting motives are worth highlighting for this dissertation setting, because those two motives have been emphasized as key factors and as competitive advantages for the growth of the firms, and reflected the increasing recent trends in

knowledge-seeking activities (Dunning and Narula, 1995; Archibugi and Iammarino, 2002). Foreign R&D is no longer merely opened for product adaptations for local tastes and preferences. But rather, firms engage in R&D internationalization for competence-creating purpose and for seeking and monitoring new technological opportunity (Cantwell and Mudambi, 2005). As such, R&D globalization has regarded as technology exploration and development opportunities, as opposed to exploitation and adaptation of home country based technologies.

As is the case, many researchers including Cantwell and Mudambi (2005) have explored the new paradigm of R&D internationalization by emphasizing the technology seeking and learning motive of international R&D activity. Under KBV, firms geographically diversify their R&D activity to gain access to the wider range of resources such as new skills and technologies available internationally (Almeida, 1996; Singh, 2007). In addition, because of path-dependency of technological development (Redding, 2002), and differences in innovation system across nations (e.g., intellectual property, educational system, university-industry relationship, and level of concentration of R&D agencies), some technologies are available only in a specific region/nation attracting foreign R&D activities (Furman et al., 2002). In a similar vein, others have found international R&D spillover effects, and suggested that international R&D allows firms to access complementary scientific knowledge and thus to increase innovative capabilities by integrating internal technology with external new technologies (Teece, 1986; Penner-Hahn and Shaver, 2005). *Second*, there is also a cost-side of benefit in international R&D activities. Because of the competitive pressure of developing new technology as well as increased R&D costs in, firms are more likely to collaborate with cross-border research alliances (Dunning, 1994).

Firms look for opportunity for international R&D alliance in order to reduce their fixed R&D costs by supplementing their internal R&D activity with new knowledge sourced externally (Chung and Yeaple, 2008). Also, firms can reduce such costs associated with innovation by accessing inexpensive sources such as labor, land, capital and technological resources (Kotabe et al, 2002; Gassmann and Han, 2004).

In sum, international R&D activities have been highlighted as an important strategy for the growth of firms in the field of international business. As has been shown from prior researches, knowledge-seeking as well as costs and risks reduction motives have become more critical for the sustainable growth of companies. However, due to differences in the level of technological development and availability of technologies, location-specific advantages vary across countries. Given the fact, the location choice strategy has also become one of the most important strategies of firms for maximizing their benefits while minimizing cost and risk of R&D. In the following section, I will review the importance of location choice strategy, address some important relationship between location choice and entry mode strategies, and finally revisit the determinants of R&D alliance governance mode choice. And some theoretical gaps in the literatures will be discussed in the conclusion part.

2.5 Determinants of International R&D Alliances

One of research streams in the study of internationalization is ‘Entry mode choice’. Firms cannot take the location-specific advantages without an appropriate entry mode because of the cost of foreignness. Liability of foreignness has been regarded as the key factor affecting the internationalization of firms over the past few decades. According to

Hymer (1960), liability of foreignness increases with the distance between the host and home country. And others specified that unfamiliarity rising from the host country environments such as cultural, institutional and economic differences hinders the flow of information and increases the cost of international operation (Johanson and Vahlne, 1977). In this sense, the concept of distance has been paid much attention as the determinant of location and entry mode choice, and as one of the core topics in the field of international business. And the concept distance has been conceptualized in multidimensional terms such as geographic, institutional, cultural, economic, and psychic (Ghemawat, 2001; Berry et al., 2010). Prior studies have focused primarily on the impact of distance (e.g., cultural, institutional, geographic, psychic, and economic distance) on the international expansion of firms. However, despite the richness of researches, the study of distance has shown inconsistent results and has critical limitations. While some showed that cultural and geographic distance negatively affect the international expansion of firms (Ojala and Tryvainen, 2007; Malhotra et al., 2009), others have shown relatively low or no impact of geographic distance on the international expansion (Ambos and Schlegelmilch, 2004; Nachum and Zaheer, 2005; Ojala, 2009). This paradox, indeed, addresses many limitations of the study of distance on the internationalization of firms, and can possibly be explained in several ways. *First*, the cause of this paradoxical phenomenon lies in the strategic objectives of the firms. Firms in knowledge intensive industries and with the knowledge-seeking motive may have stronger willingness to diversify their geographic scope in order to be able to accessing diverse knowledge. Then cultural or geographic distance would not be a critical factor for the location choice. However, if firms have other than knowledge-seeking motive such as market-seeking, then culturally as well as geographically proximate

locations would be better for accessing new market customers. *Second*, majority of distance studies focus only on national level distance. And they fail to account for industry and firm-specific factors that may also affect internationalization of firms. A multi-level approach is important, because firms can still expand their operation to multiple countries or geographically dispersed locations for strategic motives (e.g., technology access and acquisition, and risk and cost share) even though there exists a lot of national level differences such as culture, institution and economics.

These arguments are also applicable to the context of this dissertation; factors affecting the international R&D alliance mode choice. Multi-level factors still matter for the formation of international alliance, because alliance partners can be defined in terms of their nationality, national industry and their firm characteristics. For instance, Gulati (1995) emphasized the importance of similarity in national culture and institutional environments between alliance partners for promoting resource exchange and enhancing inter-firm trust. In a similar vein, Steensma et al. (2000) found that because of differences in perceived uncertainty between alliance partners, national culture directly and indirectly affects the formation of technology alliances. Physical or geographical distance also affects the formation of international alliances. Because of tacit nature of knowledge as well as difficulties in transferring knowledge, firms are more likely to partnering and collaborating with geographically proximate partner firms (Hitt et al., 1997; Hagedoorn, 2002; Picci, 2010). As such, cultural, institutional and geographical proximity have been regarded as important determinants of international alliance formation. Nevertheless, similar to the arguments above, the study of national difference on the formation of international alliances has several weaknesses. *First*, prior studies have shown mixed results. While

some showed that cultural and geographical distance impedes the formation of international alliances and the further development of inter-organizational relationship (Lyles and Salk, 1996; Mowery et al., 1996), others have found non-significant impact of those cultural and geographical distance on the international alliance formation (Glaister and Buckley, 1996; Nielsen, 2003). As argued above, endogenous factors (e.g., industry and firm-specific factors) in the location should be considered to possibly provide some explanations for this paradoxical phenomenon. Recently, Cantwell and Mudambi (2011) emphasized firms' strategic perspective on location choice as well as industry-specific technological sourcing activities by mentioning that when knowledge accumulation involves complex forms of combination from diverse sources across industries, then firms are more likely to involve in geographically dispersed wider range of network. Given those, the dissertation investigates multi-level factors affecting the choice of international R&D alliance mode.

2.6 Conclusion

This intensive yet extensive literature review provides some insightful suggestions to the future research, and contributes to the extant literatures. *First*, both TCE and KBV failed to account for strategic objectives of firms in the choice of alliance mode. Although transaction cost is high in knowledge-intensive industries, firms might not choose a hierarchical mode because of strategic objectives that outweigh the benefits of such hierarchical alliance mode. In addition, unlike what KBV suggested, firms in the knowledge intensive industry where accessing, learning and acquiring external knowledge is paramount, may prefer more flexible alliance governance modes to the hierarchical

alliance mode (e.g., EJV) in order to be remained flexible in the case of alliance failure. *Second*, TCE does not fully take into account the coordination mechanism as a way to control and monitor partner relationship. Firms oftentimes might not simply take hierarchical modes to control and monitor alliance partner relationship. But rather, they can reinforce their activities by adding other provisions in the original agreement (e.g., mixed modes: Licensing plus Joint research and/or Joint development). *Third*, in the study of international alliance, the concept of distance is very important as a determinant of location choice. However, prior researches tend to focus on national level distance and neglect endogenous industry and firm-specific factors. That is why prior researches tend to focus on the study of "Mode of Entry" rather than the study of "Mode of Collaboration". Firms choose ideal locations not simply for a single purpose (e.g., technology-seeking), but for multiple purposes such as seeking knowledge while minimizing risks and costs of R&D or production. And then firms try to maximize their benefits by balancing among costs, risks and benefits of inter-firm alliance. Since Dunning's OLI paradigm, researches focusing on the motivation and pattern of internationalization have evolved overtime in a way that the study focuses changed from the ownership and internalization to the location. Unfortunately, no theory or framework explains alliance dynamism. The dissertation is specially designed to bolster the study of "Mode of Collaboration" and to provide insightful theoretical lens in explaining those paradoxical phenomena described earlier as well as dynamism of international alliance activities in the era of globalization.

CHAPTER 3

INDUSTRY REVIEW

Drug Discovery and Development Activities in the Biopharmaceuticals

3.1 Historical Characteristics of U.S. Pharmaceutical R&D

Inter-firm R&D collaboration is not a new phenomenon in the pharmaceutical industry. As partly mentioned in the introduction part, there are many different value chain activities in R&D in the biopharmaceuticals, from new drug discovery to the FDA approval (See FIG. 1.2). And it takes on average 10 to 15 years to develop a new drug. No firms in this industry want to develop a new drug by taking all risks, uncertainties, and costs on their own. Or simply because of lack of drug discovery and development capabilities, a firm may not be able to develop a drug on its own. As just described, developing a new drug is costly, risky and time-consuming work. And because of these characteristics, inter-firm R&D collaboration has been pervasive in the pharmaceutical industry. To be more specific and to assess the reason for this difficult and complex drug development process, it is important to analyze the evolution of pharmaceutical industry structure.

Before 1980: Until 1980, the pharmaceutical industry was dominated by big-size firms. And the big-size firms have focused entirely on in-house research and development activities since the value chain activities are vertically integrated, from drug discovery to clinical development, regulatory affairs, manufacturing and marketing. And the firms amortize their R&D through a combination of patenting, know-how, technology licensing, and brands. The pattern of pharmaceutical R&D is also illustrated by Gambardella (1992)'s case study concluding that U.S. pharmaceutical companies with better in-house scientific

capabilities have achieved innovative performances. And the study emphasizes the importance of in-house R&D activities as competitive advantages. As such, competitive advantages were driven by firms' ability to manage product market interactions with regulators and consumers, and their ability to develop drugs through internal R&D (Cockburn, 2004). With those capabilities, firms have developed a new drug by relying largely on serendipity in the drug discovery stage. In other words, firms have used so called a 'shotgun' approach as they randomly screened chemical compounds from huge numbers of compounds (Mittra, 2007). Only when a chemical shows interesting biological activity, then scientists go back and figure out composition of the chemical. Thus, firms tended to focus on making one or two million compounds with relatively less chemical diversity, because firms did not much have methodologies for synthesizing libraries of compounds.

Beyond 1980: In the mid-1980s, the emergence of new life science-based technologies (e.g., increased ability to create monoclonal antibodies, opened up new areas of research, and gene splicing) for discovery research coupled with rapid developments in molecular biology as well as technological improvements in screening and synthetic chemistry promoted pharmaceutical firms to have increased drug discovery rate of new molecular entities, and thus to restructure internal R&D processes (Mittra, 2007). Pharmaceutical firms began to look for more scalable approaches to drug discovery using synthetic chemistry libraries, combinatorial libraries and high-throughput screening. However, because of new life science technologies (e.g., synthetic chemistry), it has increased the chemical diversity made drug discovery more science-intensive and made it more difficult for firms to synthesize libraries of compounds. As such, it became more costly and difficult to discover new compound which in turn made pharmaceutical firms emphasize more on

deep understanding of physiology at the molecular level. Due to increased complexity and difficulty, traditional pharmaceutical firms were not able to fully exploit the potential of the life sciences without diversifying their knowledge sourcing strategies. More recently, automated synthesis and high-throughput screening enabled pharmaceutical firms to synthesize, test and maintain millions of compound. Nevertheless, increased size of compound library itself takes more time and cost, and discovering a creative compound among diverse compound collections has become a more arduous work making firms a slave rather than a creative and innovative one. Each firm has different compound library and synthesis methodology so that it creates opportunity to share their firm-specific capabilities (e.g., methodology and libraries) with other firms. Finally, it promoted firms to engage more in inter-firm collaborative activities such as licensing or other types of strategic alliance in order to exploit those external technologies (Cockburn, 2004).

The description provides explanations of increased costs and risks of drug discovery process, and dynamism of pharmaceutical R&D activities. Given this background, next, I will describe stylized facts about the increased R&D costs in the drug discovery (R) and clinical trial (D). Right after this, I will see the trends of alliance activities in the industry, and discuss about the relationship between increased R&D costs and risks, and inter-firm R&D alliances.

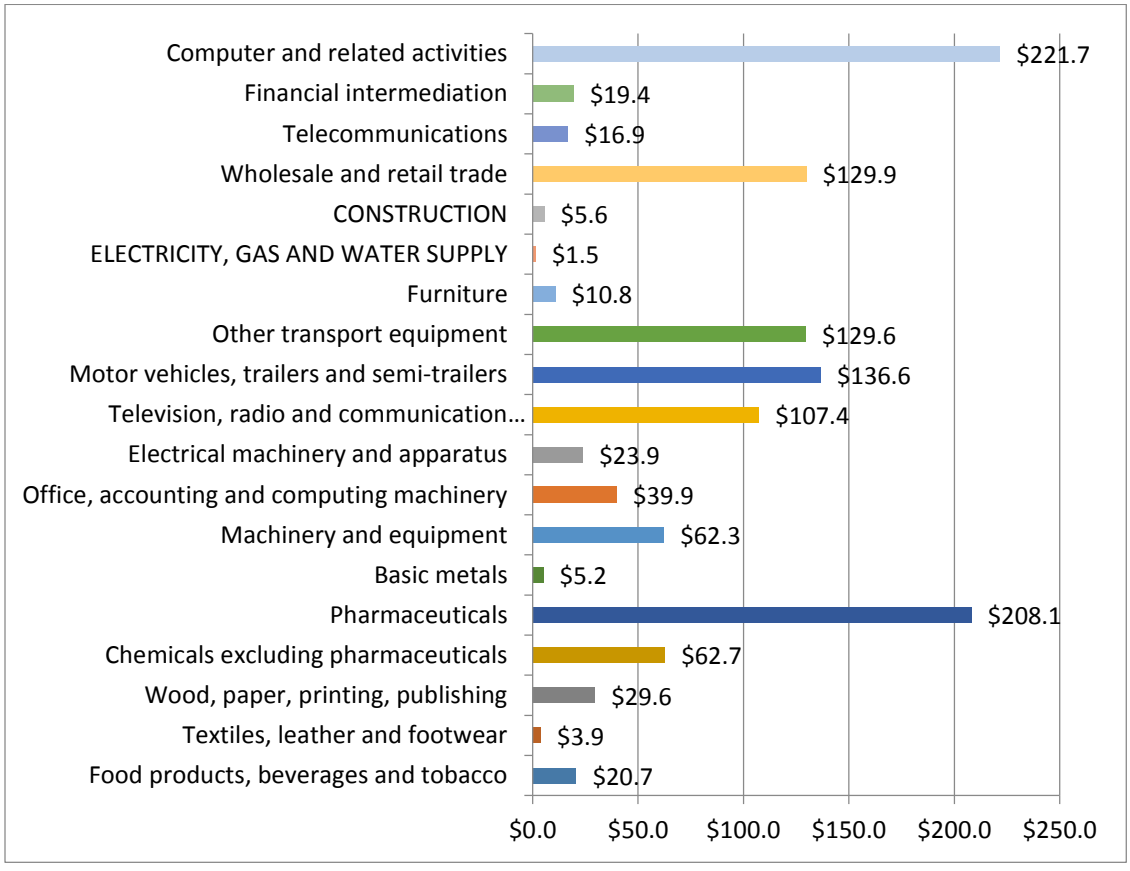
3.2 Increased R&D Costs for New Drug Development

Fig. 3.1 shows Business Enterprise R&D expenditures by industry and sector in the U.S. And the pharmaceutical is one of the most R&D intensive industries in the country. The

cost of R&D represents at least two things; (1) the level of intensity of activity (2) the level of difficulty of drug development. For instance, *first*, there must be many pharmaceutical/ biotech firms competing with each other in order to develop new drugs. Because of industry rivalry and pressure to develop new drugs (i.e., product diversification), pharma and biotech firms invest into R&D activities. *Second*, it is difficult to develop new drugs partly because of complexity and diversity of development process as well as technology used for the new drug development.

FIGURE 3.1

R&D Expenditures by Industry and Sector in the U.S. 2000 ~ 2007[5]



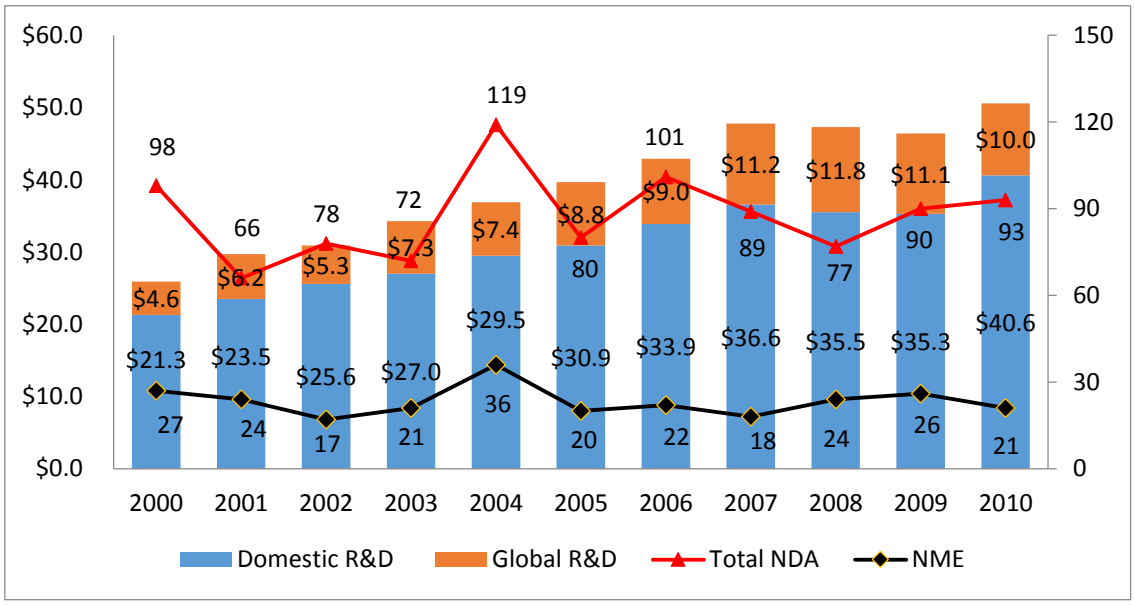
Unit: Billions of Dollars

[5] **Source:** OECD stat- Business Enterprise R&D Expenditure by Industry, 2000 ~ 2007

But if we consider the input and output relationship, it may bring more than two implications. Fig. 3.2 shows a trend in pharmaceutical industry R&D expenditure in the U.S. as well as the number of new drugs approved by the FDA. Total R&D expenditure which is comprised of domestic and global R&D activities has been increased continuously since 2000. In addition, it has shown an increasing trend in global R&D activities meaning that it has become more important to engage in international R&D activities for developing new drugs. However, the output (i.e., NDA- number of new drugs approved by the FDA) has not been commensurate with its investment; NDA has been diminished especially since 2006. In addition, the average number of NME (New Molecular Entity) is relatively low during 2006 to 2010 compared to those of previous 5 years. NME, according to the FDA, is defined as an active ingredient that has never been marketed in the U.S. in any form. In other words, it is totally new in terms of its chemical structure, and is not modified by using compounds that are already on the market. Indeed, more than half of drugs approved by the FDA in the 1990s were new formulations or new combinations of compounds that are already approved (DiMasi and Paquette, 2004). As such, NME is different from NDA and should be classified differently when it comes to output/ productivity.

FIGURE 3.2

Pharmaceutical R&D Expenditure, and the number of NDA & NME in the U.S.[6]



Units: Billions of Dollars (Left) and Number (Right)

As just mentioned, input and output relationship provides several environmental challenges against why R&D costs increased while productivity declined. According to DiMasi et al., (2003) and Congressional Budget Office (2006), there are at least three reasons why it has shown the continuing growth in R&D costs for developing new drugs. *First*, scientific advancements affect the cost of R&D. As partly discussed in the beginning of this chapter, the emergence of new life science-based technologies for discovery research coupled with technological improvements in screening and synthetic chemistry has contributed to increased learning costs. Also, while automated synthesis and high-throughput screening technologies enabled pharmaceutical firms to synthesize and test

[6] **Source:** Pharma R&D Expenditure- PhRMA 2012 Profile; NDA (New Drug Application) and NME (New Molecular Entity)- CDER (Center for Drug Evaluation and Research) by USFDA (U.S. Food and Drug Administration)

scalable compound, increasing the compound libraries itself has become an uncontrollable burdensome work to the firms (Cockburn, 2004). Nevertheless, pharmaceutical firms tend to put ample money on increasing the size of compound library in order to increase the possibility to find new formulations or combinations, and create new drugs. *Second*, increased industry rivalry plays a major role for the skyrocketed R&D costs (Dickson and Gagnon, 2004). For instance, uncountable number of firms are involved in therapeutic competition. Developing a NME is so costly that many firms are actually chasing the same target in the therapeutic classification. Although the chemical compounds are different and thus patentable, the drugs end up being classified into the same therapeutic area. And those drugs have only few differences with regard to the efficacy and may have better treatments as they reduce side-effects. *Finally*, if those drugs are launched on the same market, then firms will suffer from the reduced market share and thus the profitability. So this makes firms to diversify their therapeutic class inducing them to put more investment into R&D. On top of this, competition from generic[7] drugs is rising throughout the world. Expiring their patents of top selling prescription drugs is always a concern of pharmaceutical firms. And there will be many lower priced generic drugs available as the brand name drugs' patent expires which in turn make firms to invest vast of money on R&D activities. Table 3.1 presents an example of top brand name drugs with their patent expirations in between 2012 and 2013.

[7] Generic drug is the same as the brand name drug in terms of dose, safety, strength, how it is taken, quality, performance, and intended use. –FDA-

TABLE 3.1

Top Brand Name Drugs with Patent Expiration in 2012 and 2013[8]

Brand	Generic Name	Manufacturer	Expected Availability
Actos	Pioglitazone	Takeda	August, 2012
Detrol	Tolterodine	Pfizer	September, 2012
Diovan	Valsartan	Novartis	September 2012
Diovan HCT	Valsartan/HCTZ	Novartis	September 2012
Focalin XR	Dexmethylphenidate	Novartis	October 2012
Lunesta	Eszopiclone	Sepracor	June 2012
Tricor	Fenofibrate	Abbott	July 2012
Aciphex	Rabeprazole	Eisai	May 2013
Cymbalta	Duloxetine	Lilly	June 2013
Niaspan	Niacin Extended-Release Tablet	Abbott	September 2013
Opana ER	Oxymorphone Extended-Release Tablet	Endo	January 2013
OxyContin	Oxycodone Extended-Release Tablet	Purdue Pharma	April 2013

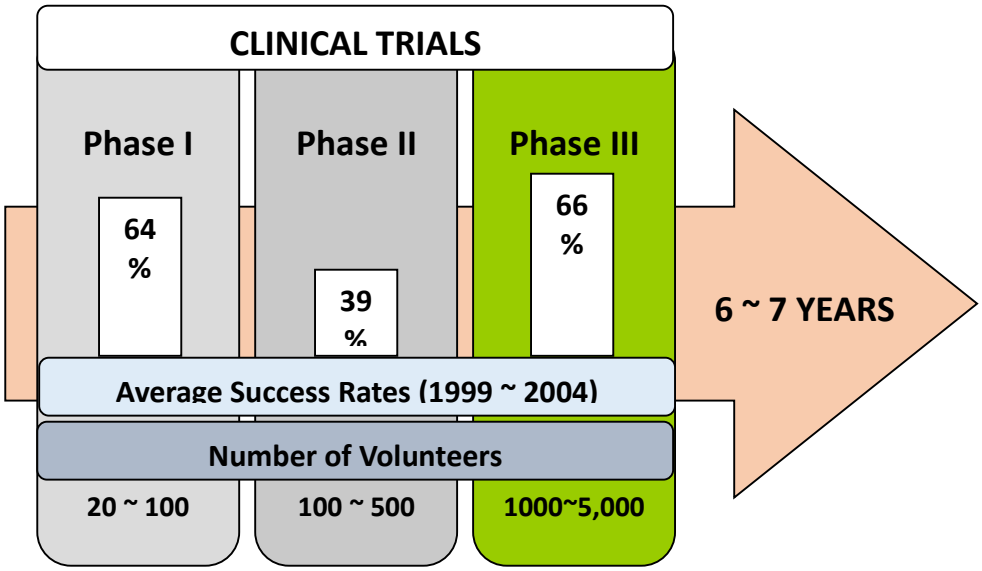
Last but not least, one of major reasons for uprising R&D costs lies in the clinical trials (i.e., development). The percentage of drug projects that failed in clinical trials during 1999-2004 comparing to those during 1993-1998 has been increased (Dimasi et al., 2010). Also, according to Dimasi et al., (2010), approximately one in six drugs that enter the clinical trials can eventually obtain approval for marketing in the U.S. In order to increase the success rate, probably firms have to reinforce their trial-and-error basis research activities. To illustrate this, Fig. 3.3 shows risky, costly and time-consuming process of

[8] **Source:** *Pharmacist's Letter/ Prescriber's Letter, 2012* http://pharmacistsletter.therapeuticresearch.com

clinical trials.

FIGURE 3.3

Clinical Trials and Success Rates[9]



And the followings describe characteristics of each clinical trial (i.e., Phase I through III). First of all, each clinical trial requires different number of participants for its own purpose. In phase I, relatively small number of volunteer is required to test drug safety, toxicity and to see mechanism of actions. If it turns out that the drug is safe, then it goes through Phase II trial. In phase II trial, drug efficacy will be tested to see if the drug is really effective for treating specific diseases, and to examine whether there are any side-effects of the drug. Phase III clinical trial is the most expensive and time-consuming experiment since it requires multiple tests for drug safety, long-term efficacy of drugs and overall benefits and risks relationship for a large number of people. As such, these three clinical trials in total take, on average, 6 to 7 years, but the length of each phase of trials

[9] **Source:** PhRMA, 2011. Average Success Rates: DiMasi et al., 2010. P. 274.

may vary depending upon the size, complexity and difficulty of protocol. For instance, clinical trials for chronic diseases, defined by WHO (World Health Organization) as diseases of long duration and generally slow progression, take longer to achieve measurable results because the disease requires bigger and more expensive clinical trials (Congressional Budget Office, 2006). The examples of chronic diseases are heart disease, cancer, stroke, diabetes, allergy, and so on. Also, since drugs for chronic diseases are meant to be taken for a long time period, it has to be tested for any side-effects that might cause during the long-term medication. Therefore, more time-consuming, risky and costly clinical trials for those chronic diseases could have contributed to the uprising R&D costs. Plus, the size, length and complexity of study is positively related to the cost of clinical trials since the bigger the size of clinical trials the more the volunteers are required, and the lengthier the clinical trials the more money is required for volunteers for their reward. The following example illustrates the complexity of such clinical trial of Vertex pharmaceuticals. The company designed two separated Phase I clinical trial for different patient groups with hepatitis C virus (HCV): Phase I (a) for healthy volunteers and Phase I (b) for HCV-infected volunteers. Similarly, Vertex also had two separated Phase II trial based on the types of patients: Phase 2 (a) for patients with genotype 1 HCV infection and Phase 2 (b) for patients with genotype 2 and 3 HCV infection. Besides above examples, clinical trial itself has its difficulties in terms of implementation of human experiments. It is sometimes difficult to find volunteers as well as those with specific diseases (e.g., rare disease) for clinical trials. That is partly the reason why many firms outsource their clinical trials to other international test centers or global CROs (contract research organizations) where many participants/volunteers are available (Azoulay, 2004).

In sum, increased R&D expenditures in the U.S. pharmaceutical industry has been attributed to the following factors.

- **Scientific advancements:** The emergence of life science-based technologies
- **Increased industry rivalry:** Competition in market shares: (1) pharmaceutical firms are chasing the same target diseases, and (2) patent expiration of top selling drugs encourages the emergence of generic drugs in the market
- **Risky, lengthy and costly clinical trials:** (1) Low success rates, and (2) Lengthy and complex clinical trials in the case of chronic disease, and (3) Increased difficulty in clinical trial volunteer enrollments

The growth of R&D expenditure is not a phenomenon that can be seen only in the U.S. but is a worldwide phenomenon. As shown in Fig. 3.4, European Union also showed an uprising pattern on R&D expenditures during 2000 ~ 2010. Although Japan and other East Asian countries are not shown from the graph (lack of data), it is known that R&D costs in those Asian countries are also continuously increasing. Given the fact, reducing R&D costs has become a major concern and an important strategy for pharmaceutical firms in the world. But then the question is how to reduce R&D costs. The answer probably lies in the R&D collaboration.

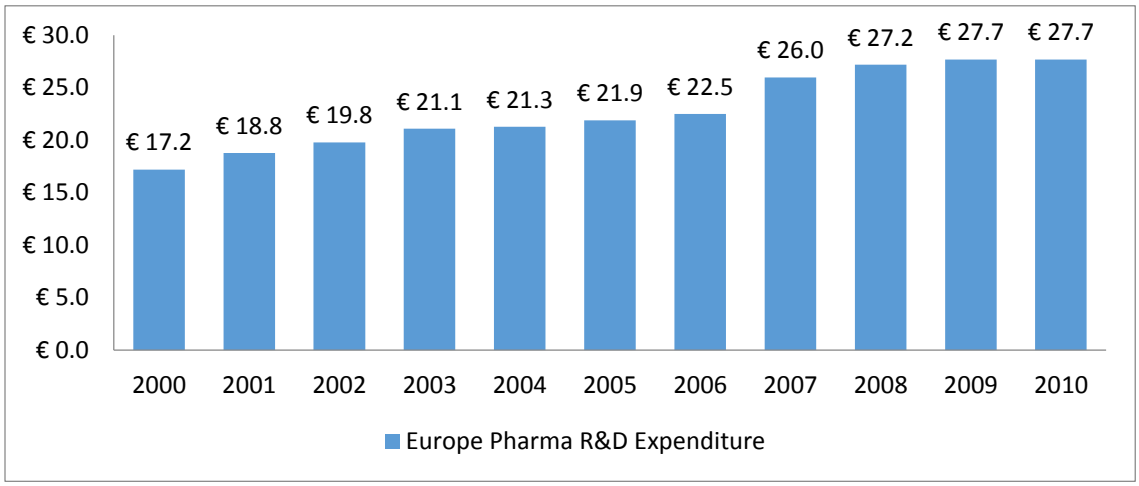
3.3 Trends in R&D Collaboration

According to Roijakkers and Hagedoorn (2006), the historical data (MERIT-CATI) on inter-firm R&D partnering in the pharmaceutical and biotechnology industries reveals an overall growth pattern in the number of newly established R&D partnerships since the mid-

1970s.

FIGURE 3.4

Pharmaceutical R&D Expenditure in the European Union[10]



Unit: Billions of Euros

In the high-tech sector such as pharmaceutical, high costs of R&D imply that many firms are indeed unable to follow up the latest technological development by counting solely on their in-house R&D efforts (Roijakkers and Hagedoorn, 2006). That is why firms mainly look for a collaboration to keep up with costly research (OECD, 2008). And it has shown the pattern of R&D partnerships that non-equity R&D alliances as well as their share in the total number of partnerships far exceed those of equity alliances because of a high degree of flexibility enabling the firms to switch from research in one technological field to another (Hagedoorn, 2002; Roijakkers and Hagedoorn, 2006). As such, research collaboration, defined as "*any activity where two or more partners contribute resources and technological know-how to agreed complementary aims*" (Tyler and Steensma, 1995) can be used to diffuse R&D costs while firms under such an agreement are pooling

[10] **Source:** EFPIA (European Federation of Pharmaceutical Industries and Associations) Annual R eport 2003, 2007, 2009 and 2011

technological know-how for the research activities. Hence, the rationale common to all pharmaceutical R&D collaborations is that firms in an agreement can access and share technological knowledge as well as financial resources (e.g., funds) of partner firms for developing new technologies while reducing costs of R&D.

Alliances continue to proliferate because of the emergence of life science-based technologies, the diversity of research and technology platforms, as well as risky, lengthy and costly clinical trials. Needless to say, all pharmaceutical firms require massive long-term investments in R&D in order to make sure their long-term sustainability and profitability. Many pharmaceutical firms continuously try to build and diversify R&D networks through alliance agreements not simply to share R&D costs, but also to spread high-level of uncertainty and risk factors embedded in the R&D process. The followings specifically describe the risk and cost sharing motivations for R&D alliance collaboration in the pharmaceutical industry. *First*, as mentioned before, basic research is typically a very risky project because of its unpredictable outcome and productivity. Firms are uncertain about the method they use for discovering new compounds. Given the fact that the firms have different methodologies in synthesizing the libraries of compounds, it will be better to engage in research collaboration activities, and share complementary skills and technologies in order to reduce uncertainty and risk of failure (Tapon and Thong, 1999). *Second*, another uncertainty and risk lies in the pharmaceutical research and development is failure/discontinuation in clinical trials (DiMasi, 2010). Although pharmaceutical firms found new compounds, those compounds may not lead to a successful return unless it passes through all clinical trials and finally receives FDA approval. In order to avoid this risk in the development (i.e., clinical trials) stage, firms, for instance, can use a more

flexible contract-based alliance agreement such as licensing; in-license a compound developed by the licensor and test it for clinical trials. This is a good strategy because these compounds may have already been undergone some screening or tested prior to licensing, and thus may have some screening effects that reduce failure of further clinical trials (DiMasi, 2010). *Third*, commercial risk is somehow a critical risk for pharmaceutical firms since it is unpredictable to establish a new market for a new drug and its financial returns from market sales (Mittra, 2007). However, this is not directly associated with research and development activities, but related to after FDA approval marketing activities of the firms. In sum, many firms engage in collaborative research and development activities to share complementary technological knowledge, and diffuse R&D costs, risks and uncertainties in new drug development.

Moreover, as shown in Fig. 3.2, it is obvious that international R&D activities of U.S. pharmaceuticals have been increasing since 2000. Once again, new life science technologies increasing the chemical diversity and complexity, and thus the difficulty of drug discovery have also triggered the R&D internationalization. And this new paradigm encourages the firms to build broader and more diverse R&D networks with global pharmaceutical firms for the sake of knowledge-seeking as well as risk and cost share in R&D. In this sense, prior researches have addressed the rising importance of R&D internationalization of firms (Henderson, 1994; Gassmann and Reepmeyer, 2005), and emphasized the positive role of global R&D activities on the innovative outcome (e.g., New Molecular Entity) (Halliday et al., 1997). Not only is the research collaboration a recent trend in the pharmaceutical industry (Tapon and Thong, 1999), but also drug development activities (i.e., clinical trials) have become more internationalized due to

increased difficulties in conducting in-house and domestic clinical trials; clinical trials are known as a time-consuming and expensive work because of inherent difficulties in finding volunteers and sites for the experiment (Shah, 2003; Ernst and Young, 2011).

As the international R&D alliance increases in the industry, it has become more important issues for pharmaceutical firms to choose right locations, partners, and collaborative alliance modes for R&D activities. Despite of this increasing trend and importance, the researches on the location, alliance partner, and alliance governance mode choice has not been developed well in the field of international business. The two parts of empirical studies of this dissertation which will be in Chapter 4 and 5 will provide theoretical and practical implications to the study of international R&D alliance mode, location choice and the success of alliance collaboration performance by examining the multi-level determinants on the international R&D alliance governance mode choice, and factors (i.e., coordination and communication structure of a specific alliance) affecting the success of alliance collaboration.

CHAPTER 4

DETERMINANTS OF INTERNATIONAL R&D ALLIANCE GOVERNANCE MODE CHOICE

4.1 Introduction

The first study of this dissertation makes three principal contributions. It illustrates in detail, how international Research and Development (R&D) alliance agreements need to be classified into a wider spectrum of governance modes, rather than into overly-broad categories, such as 'equity versus non-equity', as a dependent variable. The reality is far more nuanced. Agreement-based R&D collaborations (without forming a separate equity joint venture (EJV) company), may include several auxiliary provisions such as passive equity investments, real options triggers, and other clauses that ameliorate, to some extent, the market failure concerns of Transaction Cost Economics (TCE). EJVs are described by both TCE and the knowledge-based view of the firm as preferable when transaction and knowledge transfer costs are high. However EJVs are often not pure equity investments but include side agreements that may supersede the equity power balance between the allies. Going beyond the "market versus hierarchy" dichotomy, this paper provides a more detailed and nuanced classification, along a continuum of alliance governance modes, as the dependent variable. *Second*, the paper explores the determinants of the governance choice, as a function of the institutional, cultural and geographical 'distances' between the home nations of the alliance partners. *Third*, we describe how the choice of alliance governance mode is also influenced by whether the alliance task is in basic research 'R',

or in development ‘D’. This unpacks activities uncomfortably lumped together into one rubric ‘R&D’ -- when actually the operations, strategic objectives, risks and rewards vary considerably between R and D.

International strategic alliances are increasingly used a means of widening the sources of technological knowledge and sharing risk and cost of R&D (Mowery et al., 1996; Contractor and Lorange, 2002; Narula and Duysters, 2004; Chung and Yeaple, 2008). Offshore R&D locations provide lower cost human resources (Huggins et al., 2007; Lewin et al., 2009; Demirbag and Glaister, 2010) and unique technological resources. Choosing an appropriate alliance governance mode can avoid unintended leakage of technologies while maximizing the benefits of joint research (Oxley, 1997; Oxley and Sampson, 2004). Due to the increased complexity of R&D in high-tech industries such as pharmaceuticals, electronics and information technology, firms have a variety of options in using an appropriate alliance governance mode (Mowery et al., 1996; Hagedoorn et al., 2008).

Early studies such as Gulati and Singh (1998) were content to use an “equity (EJV) versus non-equity (agreement only)” type of dichotomy to classify alliance governance types because actual details of the alliance agreement, held confidentially by each firm were then not available. Recently, the actual text of alliance agreements has become available in data bases such as ReCap and SDC. This has surfaced agreement complexities not treated by academics before, enabling scholars such as Contractor and Reuer (2014), Santoro and McGill (2005); Vrande et al. (2009); and Reuer and Ariño (2007) to classify agreement governance over a wider spectrum of categories. These can range from “low integration” modes such as pure patent licensing which does not involve extensive interaction between the allies, to “moderate integration” involving an agreement package

that includes a license agreement, milestone triggers, and coordinated work by the scientist of the two firms, to "high integration" governance modes which, in the extreme, result in the allies constituting a new EJV company to undertake the research activities.

Alliances are not only hybrid modes, but each agreement -- depending on its mission and negotiation – can include a heterogeneous mix of provisions, financing, as well as specifying the rights, obligations, costs, risks and rewards devolving on each partner. Figure 1.1 (earlier in the dissertation) illustrates the situation in pharmaceutical R&D alliances – the focus of this empirical study -- where over a dozen distinct agreement provisions can be incorporated by negotiators in mixed governance modes in order to find the right balance between maximizing the benefits from the alliance (e.g., transferring, exchanging and creating technological knowledge, and monetary reward from royalties or return on equity) while minimizing the environmental uncertainty, risks of technological leakage, and the partner's opportunistic behaviors.

Given these complexities, and the fact that each alliance agreement is a unique goulash of disparate elements, the traditional certitudes of older theories need to be modified. For instance, Transaction Cost Economics (TCE) suggests that when transaction costs (e.g., complexity and uncertainty) are great, hierarchical alliance modes such as equity joint ventures (EJVs) that "align the incentives" of the partner are preferable (Dyer & Singh, 1998). EJVs are also supposed to minimize partner opportunism (Williamson, 1985; Mudambi and Tallman, 2010). Because of high investment compared to agreement based alliance modes, termination is a more onerous decision and therefore held to be less likely. However, perhaps because EJVs also involve higher risk, resource commitment, sunk costs and have lower reversibility, the most hierarchical alliance mode (i.e., an EJV) is preferred

only in a small minority of cases (See Figure 1.1). In a similar vein, the Knowledge-based view (KBV) suggests that EJVs should be an ideal mode of collaboration because knowledge transfer is best effected when the personnel of the partners work together under one EJV organization (Kogut and Zander, 1992; Sampson, 2004; Macher, 2006; Oxley and Wada, 2009). However, firms in the pharmaceutical as well as other industries are today more likely to use non-equity or contractual alliances than EJVs for their R&D activities, using mixed or complex alliance governance modes such as a licensing plus joint research agreement (Mowery et al., 1996; Hagedoorn et al., 2008). Since the majority of recent R&D alliances are agreement based, their drawbacks under TCE and KBV theories appear to be increasingly overcome by complex provisions that protect the interest of both partners. The research questions treated in this part of dissertation are:

(1) *Using techniques such as cluster analysis, can we identify different classes of non-EJV (Equity Joint Venture) agreements and rank order them with increasing degree of inter-partner involvement?*

(2) *Along the continuum of international R&D alliances, with an EJV being the most integrated, can we identify the determinants of the governance modal choice, based on human capital, institutional, cultural and geographical differences between the home nations of each partner as well as industry and firm-specific technological base differences?*

(3) *How is the governance mode choice moderated by the types of activity – Research versus Development?*

The last research question is detailed in Figure 1.2 for pharmaceuticals. While basic research focuses on drug discovery and molecular science, development is associated with

clinical field trials. Factors affecting the R&D alliance governance mode choice have different impacts in different stages of R&D. Basic research deals with tacit knowledge, especially in the early research stage, and firms are more likely to use a more hierarchical alliance mode (Santoro and McGill, 2005). The development stage in clinical trials involves somewhat more explicit or codified information which is partially standardized although a trial in a foreign setting entails communication and knowledge transfer difficulties.

4.2 Identification and Classification of Alliance Governance Modes

A wide spectrum of alliance governance modes is available to pharmaceutical firms -- along a continuum between arms-length transactions and a fully integrated mode (i.e., EJV) (Gulati and Singh, 1998; Contractor and Lorange, 2002; Narula and Duysters, 2004; Santoro and Mcgill, 2005; Vrande et al., 2009). An optimum choice minimizes uncertainties and maximizes benefits. Below, we identify diverse agreement based governance modes used in the international pharmaceutical industry and rank order them into distinct categories with ascending inter-partner integration. In a subsequent section of this paper, we add EJVs to the right hand side of the spectrum, and then explore the determinants of the governance choice in each international alliance.

4.2.1 Classifying Alliance Governance Types Using Cluster Analysis

The empirical study of the first part of dissertation constructs a dependent variable labeled as the "Degree of Overall Integration" in the governance of the alliance. Using cluster analysis, I, first, provide a classification of alliance governance modes, because the hypotheses development are based on this classification as the dependent variable.

In constructing and negotiating international alliance R&D agreements in the pharmaceutical sector, I identified different types of tasks and provisions that constitute the overall bundle of an agreement. These include[11]

I. Asset Purchase (AP)

II. Contract Development (CD)

III. Contract Research (CR)

IV. Cross-Licensing (CrL)

V. Passive Equity Purchase (E)

VI. Joint Development (JD)

VII. Joint Research (JR)

VIII. License (L)

IX. Loan (Lo)

X. Manufacturing (M)

XI. Supply(S)

XII. Equity Joint Venture (EJV)

Depending on the mix of the above twelve provisions or "ingredients" chosen for an alliance, we then classified non-EJV alliances (approximately 88 percent of the sample cases) along two dimensions (which were then used for the cluster analysis).

[11] Further details (definitions) of these provisions are available in the appendix

Dimension 1: Degree of Interaction: The degree of workflow/task interdependence between alliance partners (i.e., No-way, one-way, and two-way interaction), after Thompson (1967):

- **Pooled task:** Tasks that are performed independently but the allies are interdependent in in economic or financial terms; examples are Loan and Passive Equity Purchase; no-way interaction
- **Sequential task:** The output of one task is an input for the other partner. In other words, the interaction between the partners is unilateral (i.e., one way); examples are licensing, contract research and contract development; one-way interaction
- **Reciprocal task:** The output of a task is inputted simultaneously to both allies or is a jointly performed task. The interaction between the partners is therefore bilateral or joint; examples are cross-licensing and joint research/development agreement; two-way interaction

Dimension 2: Degree of Complexity: The degree of alliance contract complexity that stipulates resource allocation, adjustment and adaptation of ongoing tasks (i.e., Number of alliance components in an alliance, and the number of pages of alliance agreement)

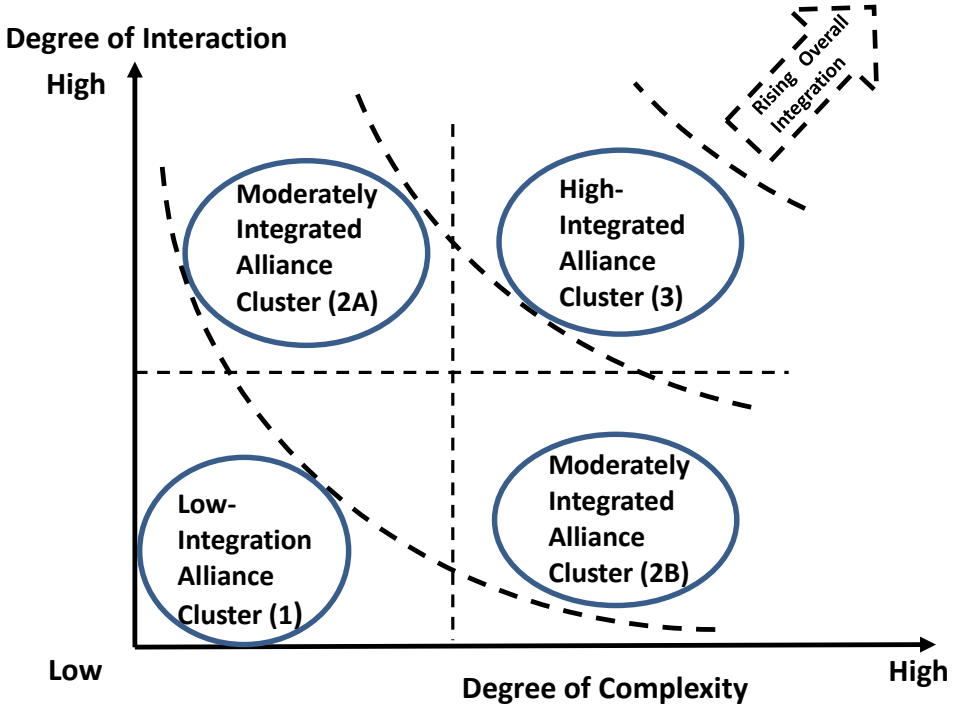
The Degree of Complexity of an R&D alliance deal can be measured by the number of deal components in an alliance. For example, an agreement that includes licensing plus joint research can be coded with a value of two. In addition, we also consider the number of pages to capture the complexity of an alliance deal, following Hagedoorn and Hesen (2009). The number of pages is a crude index but has been used in previous studies because there is a presumed correlation between contract complexity and the number of pages. For

example, if we compare a pure licensing agreement with a licensing plus option agreement, the latter is more complex and contains more details. A licensing plus option contains not only royalties but an additional contingent future financial reward which could be a lump-sum or a claim on future earnings. Thus it will tend to have more pages in the agreement.

Putting the above two dimensions together, non-equity based alliance governance modes can be classified into three clusters; (1), (2) (A and B), and (3) using the "K-Means Clustering Procedure" whose technical details are mentioned immediately below. Figure 4.1 illustrates the increasing degree of overall integration rising from Cluster (1) to (2) to (3).

FIGURE 4.1

Cluster Analysis for the Dependent Variable: "Degree of Overall Integration"



4.2.2 Cluster Analysis

A. Coding of Alliance Types (By Degree of Interaction)

Based on these 12 different types of alliance, we scored the degree of interaction where no-way is coded as 1, one-way as 2, and two-way as 3.

- **No-way (1):** Agreements that include Asset Purchasing, Loan and Passive Equity Purchase
- **One-way (2):** Agreements that include Manufacturing, Supply, License, Contract Research, and Contract Development
- **Two-way (3):** Agreements that include Joint Research, Joint Development, and Cross-licensing

If an alliance agreement contains multiple components such as license as well as joint research, then we summed the interaction score between license (2) and joint research (3) to make a total degree of interaction. It makes sense because each individual component includes different activities such as license-technology transfer, and joint research-exploitation of that technological knowledge.

B. Coding of Alliance Types (By Complexity of Agreement)

We coded the degree of complexity by counting the number of alliance components in each alliance agreement (e.g., if an alliance agreement that contains three different components such as equity, license and joint research is coded as "3"), and the number of pages of alliance agreement (Hagedoorn and Hesen, 2009). As mentioned earlier, the number of pages is not affected too much by contractor's writing style. For instance, although it is titled as license agreement on the actual contract for both pure technology license and licensing plus option agreement, licensing is significantly different from the

licensing plus option agreement in a sense that licensing is simply transferring licensor's technology to licensee whereas licensing plus option agreement is much more complicated since it contains specified options such as royalty payment upon technology/product development.

C. Cluster Analysis (for classifying non-EJV alliances) in Terms of Rising Level of Overall Integration between Partners

For the cluster analysis, I used the same sample that I use for the empirical test (details about data and sample are described in the methodology part later in this chapter). Of 237 alliances, in the sample, 208 are non-EJV while 29 are equity joint ventures. The cluster analysis was restricted to those 208 non-EJV alliances. The objective was to see if these 208 alliances could be grouped into categories with a rising degree of overall integration between the partners of the alliance. Based on three items (i.e., the degree of interaction, the number of alliance components and the number of pages), I performed a K-means cluster analysis since it allows us to minimize the variance within each cluster, and this is more robust than any other hierarchical method in terms of presence outliers and errors in the distance measures (Slater and Olson, 2001). *First*, I selected four clusters as a starting point. But later since the "overall degree of integration" rises generally in the 'northeasterly' direction in Figure 4.1, I combined two clusters labeled 2A and 2B into one cluster as representing a moderately-integrated alliance governance mode. And then I checked correlation among items. However, I found that there is a very high correlation (i.e., 0.90) between the degree of complexity measured by the number of alliance components and the degree of interaction. This is possible because alliance partners are

more likely to interact as the number of alliance deal components increases. Given this fact, I decided not to use the number of alliance deal components as one of dimensions of cluster analysis.

Table 4.1 provides ANOVA statistics. And the followings show the number of cases in each cluster.

Cluster 1 (Low-Integration): 92

Cluster 2 (Moderately-Integrated: 2A and 2B): 102

Cluster 3 (Highly Integrated): 14

Total: 208

TABLE 4.1

ANOVA Statistics

	Cluster		Error		F	Sig.
	Mean Square	Df	Mean Square	Df		
Standardized score for ***the number of pages***	43.674	3	.372	204	117.263	.000
Standardized score for ***the degree of interaction***	60.690	3	.122	204	496.643	.000

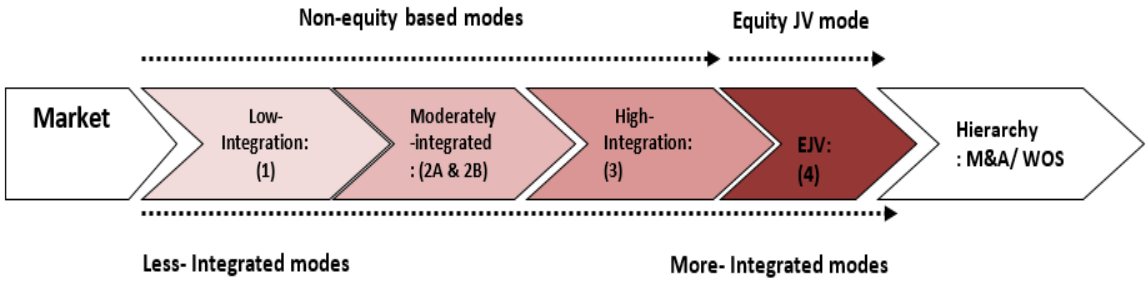
D. Final Rank Ordering of Alliances by "Degree of Overall Integration" (Figure 4.2)

Having rank ordered the 208 non-EJV alliances into three categories using the clustering procedure, I then added EJVs on the extreme right hand side of Figure 4.2 as the most highly integrated type of alliance. This is because an EJV typically involves the highest commitment of (financial, personnel and technological) resources by partners; the scientists, technicians and other staffs from the partners work together on a daily basis; and this type of alliance is the least reversible because of sunk costs of the investment thus leading, generally, to a high degree of commitment to success.

Recall that the cluster analysis was done only on the non-EJV, or agreement-based, alliance subsample (around 90 percent of cases). This resulted in three groups of non-EJV alliances, for the dependent variable "Degree of Overall Integration" (1) Low-Integrated, (2) Moderately-Integrated, (3) High-Integrated. To this, on the right hand side of Figure 4.2 we add a fourth group, namely (4) EJVs. This conforms three decades of alliance studies concluding that when the partners create a separate JV firm, jointly staffed and operated with personnel from both partners, and often with a more substantial financial commitment than a contractual alliance, the degree of overall integration is the highest.

FIGURE 4.2

A continuum of alliance governance modes: Rising Degree of Overall Integration



4.3 Hypotheses Development

What factors influence or determine the selection of one of the governance choices in Figure 4.2? I detail below hypotheses based on (1) country-specific factors such as human capital, culture, institutional and geographic differences between the nations of the alliance

partners, (2) industry-specific factors (e.g., industry-specific R&D intensity), and (3) firm-specific factor such as type of research depending on the therapeutic area.

4.3.1 Country-Specific Factors

Differences in the Quality of Human Capital (Between the Home Nations of the Allies)

Prior studies have analyzed the acceleration in offshore R&D (Huggins et al., 2007; Atkinson, 2007; Demirbag and Glaister, 2010) driven, in part, by the availability of low-cost yet skilled technicians and scientists. But besides cost, the quality of human resources in a partner firm (i.e., skilled and educated workers) plays a critical role in international collaborations as well as the economic growth of a nation, in general (Benhabib and Spiegel, 1994; Furman et al., 2002). Skill levels and absorptive capacity are essential elements for knowledge transfer in R&D activities (Minbaeva, 2007). A greater difference in the quality of human capital between the countries of the partnering firms increases uncertainty and, ceteris paribus, reduces the likelihood of joint R&D activity.

When firms consider an R&D alliance in a country where they can find and liaise with skilled and educated workers, they may prefer to use more organizationally integrated alliance governance modes such as joint research and/or a combined mode (i.e., licensing plus joint research collaboration) in order to enhance knowledge transfer and learning between collaborating firms. On the other hand, if partner firms are from countries with widely different levels of human resource skills, it would not be prudent for them to increase their resource commitment in a more-integrated R&D alliance mode. Instead, they are likely to choose less-complicated R&D activities requiring lower level of resource

commitment, and choose a less-integrated alliance governance mode such as pure licensing (e.g., simply license-out old technology to a partner as licensee).

Moreover, the choice of an alliance governance mode will depend upon whether the task is in the research or development phase. Research activities in pharmaceutical industry focus on the drug design where molecules are developed from theories (Tapon and Thong, 1999). Because of the nature of basic research, pharmaceutical firms undertake this with educated scientists in laboratories. Research collaboration requires collaborating firms to closely communicate and exchange technological. By contrast, development activities involve field trials on human subjects (See Figure 1.2) and clinical experimentation is done under routines and "templates" supplied by one alliance partner to the other for their nation's trials. In short, the "R" part of pharmaceutical research requires considerable creativity, tacit knowledge and molecular scientific skills, whereas the "D" part of R&D is much less tacit and can be outsourced to independent physicians and test sites for the coordination and supervision of clinical trials (Azoulay, 2004). Clinical trials are increasingly done by independent clinical test centers in Asian countries (under the supervision of the local partner) in order to minimize cost and time of clinical trials (Wong, 2009). This can be regarded as a less-integrated alliance governance mode, also known as a CRO (Contract Research Organization). A more-integrated alliance mode can still be used by firms in the research phase for better communication and knowledge transfer between the allies. On the other hand, firms in the development phase use and transfer knowledge which is more explicit, and codified, and requires less interaction and communication. In this case, the alliance will likely choose a less-integrated alliance mode. Thus,

H1: *The greater the difference in the quality of human capital of the home nations of the allies, the lower the likelihood of using a more integrated alliance mode. Moreover, this negative relationship will be even stronger when the R&D is in the development phase rather than the research phase.*

Differences in Institutional Factors Such as the Rule of Law (Between the Home Nations of the Allies)

Scott (1995) identified three pillars of institutions: Cognitive, Regulative and Normative. The cognitive aspect refers to how members of a society view their economic environment (Xu and Shenkar, 2002) and the beliefs and value system of their society (DiMaggio a lnd Powell, 1983). The regulative aspect concerns the setting, monitoring and enforcement of rules and regulations. And the normative aspect prescribes desirable goals and the appropriate means of attaining the goals (Xu and Shenkar, 2002). However, because of their similarity, normative and cognitive aspects of institutions have been combined into one concept by some scholars (Gaur and Lu, 2007; Chao and Kumar, 2010) and used as a determinant for the location and governance modal choice of multinational firms.

The greater the differences in the institutional environment between host and home countries (or alliance partner nations), the greater the need on the part of the foreign investor or alliance partner to adapt and be more responsive (Kostova and Roth, 2002). In addition, a greater institutional difference increases uncertainty in terms of monitoring and judging whether the transfer of practices and strategies is illegal in the host country (Eden and Miller, 2004; Xu and Shenkar, 2002) – or in the pharmaceutical sector, whether the

local FDA will approve. In this sense, institutional environment is one of critical determinants of the location and alliance governance mode choice for firms involving in R&D.

For joint R&D conducted with a foreign partner there is one institutional criterion which is particularly crucial: Rule-of-law . Firms in knowledge intensive industries (like pharmaceuticals where patents are key strategic assets) are concerned about protecting their intellectual property when they license-out or transfer those technologies. Other things being equal, they are more likely to use low-integration alliance modes involving arm's length contracts (e.g., license) only when countries provide strong contract laws, regulations and an intellectual property protection regime.

On the other hand, when the Rule-of-law is weak, firms with valuable proprietary technologies in the form of patents (or 'knowhow' which is even more difficult to legally defend) are more likely to use higher-integration alliance governance modes (Klein et al., 1990; Gulati and Singh, 1998; Pan and Tse, 2000). There are three reasons for this hypothesis. First, more integrated alliance modes (and especially an EJV) enables the technology providing partner superior monitoring ability. Second, more integrated alliance modes also entail greater resource commitment by both partners, making easy dissolution of the alliance more difficult. This tempers opportunism. For example, termination of distant arms-length license agreement has a much lower consequence, or cost, compared with the termination of an EJV where both allies have sunk millions into the project. Third, appropriation of a reasonable share of alliance returns is better effected and more assured in nations with weak rule-of-law through more integrated alliance modes (Contractor & Reuer, forthcoming; Oxley & Wada, 2009). As such, when the difference in institutional

environment (i.e., rule-of-law) between countries of the partnering firms is high, firms will be more likely choose a more-integrated alliance governance mode.

However, the above hypothesis will be moderated, depending upon the stage of R&D. The drug development process (i.e., clinical trials) is highly regulated, firms are required to follow strict standards and procedures to ensure good clinical practice (Rowberg, 2001), and the risks are high since human subjects are involved. According to the US FDA (United States Food & Drug Administration), new drugs developed by foreign firms cannot be sold in the U.S. if the clinical trials were not conducted under stricter U.S. investigational new drug application rules. In alliance partner countries with relatively weak legal standards and regulations, the focal partner is even more zealous to carefully monitor, support, and have control over the clinical trials. For this reason, firms in the development phase are likely to choose a more-integrated alliance mode in nations where the rule of law is weaker. Hence,

H2: *As the difference between the nations of the allies increases, in terms of institutional factors such as the rule of law, there will be a greater likelihood of using a more integrated alliance mode. And this positive relationship will be even stronger when the R&D is in the development phase rather than the research phase.*

Cultural Factors

Cultural differences between partnering firms increase the level of uncertainty (Richards and Yang, 2007) and this is especially pertinent in R&D. Recent studies suggest that the different dimensions of culture (such as power distance, uncertainty avoidance,

individualism, masculinity and long-term orientation used by Hofstede) have different effect on the organizational modal choice and each should be examined separately (Barkema and Vermeulen, 1997; Tse et al., 1997; Richards and Yang, 2007; Delerue and Simon, 2009). Here we focus specifically on power distance and long-term orientation as determinants of the alliance governance mode.

Prior studies have shown a positive relationship between high power distance and the choice of an equity-based mode (i.e., hierarchical mode). Firms from high power distance countries accepting inequality and hierarchy of power in the organization prefer to have greater control in inter-organizational relationships, and seek more integrated modes towards the right hand side in Figure 4.2. Firms from low power distance countries are more open and willing to work as a group or a team for a certain project without formally integrating rules or hierarchies (Tse et al., 1997; Pangarkar and Klein, 2001; Richards and Yang, 2007; Schwens et al., 2011). With greater power distance, partners one or both allies may also prefer more integrated modes in order to reduce opportunistic behaviors.

However, other studies have made a counter argument that a similar culture facilitates the formation of equity joint ventures (Buckley and Casson, 1996) and more integrated relationships between partners. In addition, cultural differences are said to increase alliance conflict (Lane and Beamish, 1990), collaboration problems in technology R&D alliance activity (Mowery et al., 1996) and knowledge transfer problems (Hamel, 1991). Since the study context lies in R&D alliances, we need to follow the latter point of view. As mentioned earlier, R&D activity requires intensive collaboration accompanying the close communication and coordination between partners. A greater power distance increases the cost of communication and coordination in more integrated alliance modes. In this case,

firms may prefer to choose a more flexible, lower-integration governance mode in uncertain organizational environments (Schwens et al., 2011).

Long term orientation also fits into this study since R&D in the pharmaceutical industry is long-term and time consuming. If a company from a long-term orientation culture that focus more on future interactions and rewards, and perceives more clearly the shadow of the future (Das and Teng, 2000; Delerue and Simon, 2009), allies with a short-term oriented organization, this may increase the possibility of opportunism, and reduce inter-firm trust in an alliance. Hence, we hypothesize that with greater long term orientation differences, partner firms will prefer a less-integrated alliance governance mode where consequences of opportunism are less onerous (compared with say the dissolution of an EJV). Less-integrated modes are in that sense more reversible, or can be terminated with lower costs or consequences under a more flexible governance structure.

The perceived uncertainty of the R&D project is much higher in the early research phase compared to the later development (or clinical trial) phase (Rothaermel, 2001). In the early discovery stage of basic research, the efficacy of compounds is highly uncertain and researchers do not know whether the compound will progress further through additional development stages or not. On the other hand, a drug that has completed Phase II, and awaits the large scale human trials in Phase III is a safer bet. In the Phase III development, or "D" stage, in pharmaceutical R&D there is greater certainty as well as greater scientific understanding and codification of knowledge. Phase III trials involve more standardized templates where even large cultural differences can be transcended and a culturally distant partner can follow procedures, even remotely. Therefore we hypothesize that the impact of

cultural differences is reduced in the later stage of drug development, and that collaboration with partners can occur through less-integrated alliance governance modes:

H3A: *As cultural difference in power distance between partnering firms increases, the likelihood of using a more-integrated alliance mode will decrease. Moreover, this negative relationship will be stronger for R&D in the development phase rather than in the research phase.*

H3B: *As cultural difference in long-term orientation between partnering firms increases, the likelihood of using a more-integrated alliance mode will decrease. Moreover, this negative relationship will be stronger for R&D in the development phase rather than in the research phase.*

National Geographic Distance between Nations of the Allies

Geographic distance has been used as a proxy in empirical studies. R&D, by nature, is a knowledge intensive activity requiring collaborating firms to closely interact through face-to-face communication for a better exchange of technological knowledge. As geographic distance increases, the cost and complexity of knowledge search and communication increases (Daft and Lengel, 1986), and communication intensity decreases (Katz and Allen, 1982) making R&D units more difficult to create collaborative environments and build close relationships (De Meyer, 1991; Westney, 1990). In addition, geographic distance limits the effectiveness of knowledge transfer (Hansen and Lovas, 2004; Shenkar, 2001). Different time zones and long transmission channels between R&D

units limit knowledge transfer effectiveness (Ambos and Ambos, 2009). By contrast, close geographic proximity facilitates a firm's face-to-face as well as other means of contact with scientists which fosters cooperative environments (Ganesan et al., 2005).

The right choice of alliance governance mode plays a critical role, especially when firms collaborate with geographically distant partners. As emphasized by the TCE and KBV perspective, firms need a more interactive (i.e., bilateral interaction) or organizationally embedded modes such as EJVs in order to facilitate knowledge sharing activity, and broaden the scope of inter-firm interaction and collaboration. Given the fact, the use of more-integrated alliance governance modes can transcend the geographical distance obstacle and reduce the barriers of coordination and communication in the alliance. And this will particularly be salient for firms in more complex joint operations such as basic research.

On the other hand, alliances in the development (clinical trial) phase are more likely to use a less-integrated alliance mode, even when partner firms are in geographically distant locations. Recent years have seen a greater geographical dispersion of clinical trials using contractual partners (e.g., CROs: contract research organizations who handle locally the collection of volunteers in a timely manner and feed data back to the other partner) in each nation. Where trials were once restricted to just the US, Europe and Japan, a new drug may today be simultaneously tested in a Phase III trial in 20 nations. The formerly small markets in emerging nations have become substantial in their own right, their FDAs now demand or suggest that local approval will be smoother if local trials are conducted, and the local medical establishment in each nation is also more favorably inclined to adopt the drug after approval if trials were conducted in their own hospitals and clinics. By engaging in several

simultaneous geographically dispersed clinical trials over patient pools in several nations, data on how the human physiology reacts can be more speedily assembled, and costs of drug development are lowered because of the lower fees paid to emerging nation volunteers, doctors and hospitals. More specifically, the logic of collaboration in the clinical trial stage is that firms in-license compounds that have been discovered and tested by other firms, and the firms (licensee) then conducts clinical trials in their nation (DiMasi et al., 2010). Or they can simply outsource clinical trials to the geographically dispersed CROs by having a clinical development contract which usually requires relatively lower interaction between outsourcing firms and the CROs. In addition, by using this kind of less-integrated alliance mode, firms have more options to reverse their contracts/agreements when they see negative outcomes from clinical trials in some nations. Hence, we hypothesize that,

H4: *As geographic distance between partner firms increases, the likelihood of using a more-integrated alliance mode is increased. And this positive relationship will be stronger for R&D in the research phase rather than in the development phase.*

4.3.2 Industry-Specific Factors

According to Alcacer and Chung (2007), knowledge spillovers are not exogenous events resulting from the prevailing geographic configuration of economic actors, but are the result of firm activity through interactions with diverse actors. We hypothesize here that when the alliance partners are based in more similar industry contexts, in terms of *(1) Industrial R&D intensity*, and *(2) industrial technology specialization*, that increases the

likelihood of more-integrated alliances. Or, to put it equivalently, when there is a gap or asymmetry between the R&D intensity and technological specialization of the partner industries, there is a greater likelihood of looser, and less-integrated alliances.

A large gap or difference in the level of R&D intensity between the host and home country industry is said to depict a gap in absorptive capacity, and this can create high costs in international knowledge transfer (Teece, 1981; Oxley, 1997). Firms in a knowledge intensive industry with a knowledge-seeking motive tend to locate their R&D activity in countries with similar levels of industrial technology development. The same logic can be applied to R&D alliance activity. By allying with a partner firm in the industry with a similar level of R&D intensity to that of the home country, and by increasing resource-commitment through a more-integrated governance mode, they can promote learning, exchange of technological knowledge, and create better fruits from their R&D program. However, firms in high (low) R&D intensive industry involved in an R&D alliance in a country with low (high) industrial R&D intensity can choose a less-integrated governance mode; firms can license out (in) their old (new) technologies to (from) partners in the country with a low (high)-level of R&D intensity. And then both partners may reduce uncertainty in searching and monitoring external technological knowledge while protecting core technologies.

Second, industrial technology specialization is another important industrial factor affecting the choice of R&D alliance governance mode. Industrial technology specialization, measured by concentration of patent filings in certain areas, imply that the trajectory of the industry is moving towards certain types of technology. If an industry is

highly specialized in certain sub-fields of technology, that increases uncertainty in monitoring, learning and absorbing new technologies in other sub-fields. Therefore, when the industry of one partner is more specialized than the other, firms will more likely choose less-integrated alliance modes that are closer to arm's length market transactions (e.g., licensing, towards the left side of Figure 4.2) in order to reduce commitment in the face of technological uncertainties (Vanhaverbeke et al., 2002). Contractual alliance modes towards the left side of Figure 4.2, involve lower resource commitment (in terms of personnel and finance), are more reversible (i.e., the consequences of termination are less onerous than let us say winding up an EJV), and thereby provide greater flexibility in case an incorrect R&D decision or strategy move has been made.

This desire for lower commitment, reversibility and flexibility will, we hypothesize, be even stronger in the development phase. The conduct of clinical trials is far more codified and monitorable than basic research (because human physiology does not vary dramatically across nations and standardized testing procedures and data reporting templates can be used). This facilitates the adoption of contracts with CROs. At the same time flexibility and reversibility in clinical trials is a virtue. If one approach in a clinical trial fails, firms can try another test with different protocols. And firms will be able to do this over again through a more flexible governance mode by simply changing terms of the alliance contract. Hence, a less-integrated alliance governance mode will more likely be used by firms in development phase. We propose the following hypotheses.

H5A: *As the gap between allies in Industrial R&D intensity increases, the likelihood of using a more-integrated alliance mode will decrease. And this negative relationship will be stronger for joint work in the development phase rather than in the research phase.*

H5B: *As the gap between allies in Industrial technology specialization increases, the likelihood of using a more-integrated alliance mode will decrease. And this negative relationship will be stronger for joint work in the development phase rather than in the research phase.*

4.3.3 Firm-Specific Factor

Firms concentrate on different disease areas depending upon their technological background and/or specialty. One may have strengths in oncology, while another may focus its research and patenting on heart disease. Therapeutic area difference refers to the dissimilarities between therapeutic area concentrations of two partnering firms which can be measured by the patent profile of each. How do therapeutic area differences affect the alliance governance choice? The literature provides some contrary suggestions which I summarize below and then adopt one as a hypothesis.

Prior studies have emphasized the critical role of complementarities of technological knowledge. One view is that new product and new processes comes not from the combination of similar technologies but from the combination of different technologies or complementarities (Breschi et al., 2003). However, accessing, learning and absorbing complementary technologies are not easy tasks, but require absorptive capacity in related technology areas (Girma, 2005). Accordingly, firms need to choose a right knowledge

sourcing mode in order to be able to generate benefits from the unique complementary technologies. Some prior studies conclude from the knowledge based view (KBV), that collaborating firms choose more integrated/ hierarchical alliance modes in order to facilitate understanding, learning and transferring complementary technologies (Mowery et al., 1996; Gulati and Singh, 1998; Sampson, 2004). In a similar vein, Transaction Cost Economics (TCE) also argues that when partnering firms have greater technological distance, due to the emergence of information asymmetries leading directly to adverse selection, firms can choose more integrated alliance modes to minimize relationship-specific uncertainty.

However, a contrary can be found in other studies -- that firms are more likely to choose less-integrated or more flexible governance modes when firms focus on different sub-fields because then technological uncertainty is high. In such a case, the desire for flexibility and lower commitment prevails over the need for a stronger administrative control to avoid partner's opportunism (Folta, 1998; Hagedoorn and Duysters, 2002; Colombo, 2003; Van de Vrande et al., 2009). In this study, I follow the arguments of the latter view since the context of this study, where it is strategically more important for firms under highly uncertain environments to remain flexible in the case of adverse selection.

Finally, alliances in the development phase will have a greater desire to choose contractual modes because of a greater desire, and ability to remain flexible. The desire for flexibility comes from the need to adapt clinical test procedures in the face of negative and unsuccessful results. Contract clauses allow this flexibility. Under a loosely structured governance mode, the alliance can adopt an abandon or try-it-again approach. By contrast and EJV entails a heavy commitment that is not easily reversible. Hence,

H6: *As the Therapeutic Area Difference between partnering firms increases, the likelihood of using a more-integrated alliance mode will decrease. And this negative relationship will be stronger in the development phase than in the research phase.*

4.4 Methodology

Data and Sample

The unit of analysis of this study is the alliance agreement. I used a unique data source, *Current Agreements Database*, which covers details on global alliance agreements in the bio-pharmaceutical sector (U.S. SIC 2833 through 2836) ranging from equity joint ventures to technology licenses, joint research/developments, loans, and passive equity purchases. The database contains the alliance deal announcement date, alliance partners (e.g., nationality and address), actual contract documents (actual contract and/or financial information is sometimes not disclosed), alliance deal components (i.e., types of alliance-licensing, development, and so on), and stages of development ranging from discovery to phase III clinical trial. (Figure 1.2). Because of the need for complete agreement detail, cases lacking details on all variables had to be eliminated and the final sample size was 237 alliances.

In addition to this, I used a variety of publically available data sources to measure independent variables: OECD library data to measure economic and industrial factors, Worldbank Governance Indicators for institutional environment variabless, Hofstede's Cultural index for cultural differences, CIA World Factbook for physical geographic

distance, the latest version of IMS Health's USC 5 (The Uniform System of Classification) for therapeutic area differences, and 10-K annual reports for firm-level data (e.g., size and age).

Dependent Variable

The dependent variable, as shown in Figure 4.2, is 'Degree of Overall Integration' which can also as a categorization of alliance governance modes. TCE logic implies that alliance governance modes can be defined along a market-hierarchy continuum (Williamson, 1985; Oxley, 1997). Here I used a new continuum of alliance governance modes that I labeled "Degree of Overall Integration" based on two dimensions (i.e., the degree of interaction and the degree of complexity of the alliance deal). This allows me to capture more diverse yet complex alliance governance structures that have not yet been explored. The dependent variable is coded on an ordered basis as follows: Low-integrated alliance modes= '1', Moderately-integrated modes= '2', High-integrated modes= '3', and EJV= '4'. The ranking order goes from 'Less (1) to the most (4) integrated alliance governance mode'.

Independent Variables

Several explanatory variables have to do with the differences between the home nations of the alliance companies, in terms of the countries' human capital indicators, rule of law rankings, culture and geography. For each of these, the differences (or 'distances') between the home nations of the allies was calculated thus

$$\sum_{i=1}^{4}\{(\mathrm{Index_{iX}} - \mathrm{Index_{iY}})^2 / \mathrm{V_i}\} / 4$$

where Index ix (iY) stands for the score of country X (or Y) in ith year and Vi stands for the variance of ith year. And I averaged the 4-year period scores (i.e., 2000 through 2003), since the scores vary with each year in each country.

Quality of Human Capital (HUMAN). To measure the availability of skilled/ well-educated labor, participation rates in tertiary education (i.e., percentage of population that enrolls in tertiary education) were used.

Institutional Factor*: Rule-of-law*. I used World Bank's Governance Indicators (Kaufmann et al., 2005; Dikova, 2009) which provide a score for each nation (on items such as contract enforcement, intellectual property rights, the police, and the courts, as well as the likelihood of crime and violence).

Cultural factors: *(A) Power Distance (POWER DIST.) and (B) Long-term Orientation (LONG-TERM)*. I measured those two dimensions of national culture by using Hofstede's cultural index, and used the same calculation formula as shown above. These two cultural attributes were chosen (over others such as masculinity/femininity since they are more closely related to alliance and joint venture governance).

National Geographic Distance *(GD)*. Previously, the geographic coordinates of countries (i.e., latitude and longitude figures that determine the geographic center of the country are widely used to measure the geographic distance between the geographic centers of two countries (Berry et al., 2010). However, it is not a precise measurement because in many cases geographic distance between two cities of countries (e.g., between western part

of U.S. and eastern part of Canada) is much larger (or smaller) than the geographic distance from the geographic centers of two countries. Thus, I use the physical address/location of alliance partners to precisely measure the geographic distance between two geographic points. And the great circle distance formula was used to calculate the geographic distance between two points.

Industry Factors: Alliance partner companies vary in terms of their *(A) R&D intensity (RDINT), and (B) technology specialization (TECHSP).* Industrial R&D intensity was measured by pharmaceutical industry R&D expenditure as a percentage of GDP of the country. Industrial technology specialization was measured by the patent concentration in the pharmaceutical industry of a nation relative to the total patent concentration of the pharmaceutical industry in the entire world. It is important to distinguish R&D intensity for a particular sector, from national R&D intensity in general for a nation. Each has different a different signaling effect. For instance, firms in the pharmaceutical industry may seek a partner in a country they believe attractive due to its high national R&D expenditure, in general. However, the pharmaceutical industry in that nation may have a relatively low R&D expenditure compared to that of other industries in the nation. Hence, an industry-specific measurement for R&D intensity and technology specialization allows us to capture unbiased endogenous firm heterogeneity in the industry. I used the following formula.

Industrial technology Specialization = $\dfrac{P_{ijX} / \sum_a P_{iX}}{\sum_j P_{iw} / \sum_a P_{iw}}$, where P_{ijX} stands for the number of patents in ith year in the pharmaceutical industry (j) of country X. $\sum_a P_{iX}$ represents the total number of patents in ith year in the all industry (a) of country X. $\sum_j P_{iw}$ is the total number of patents in ith year in the pharmaceutical industry (j) of the world (w).

And finally, $\sum_a P_{iw}$ is the total number of patents in ith year in the all industry (a) of the world (w). And then I used the above formula to calculate the gap in the alliance partners' industrial R&D intensity and technology specializations.

Firm Factor: *Therapeutic Area Difference* (TAD). Different biotech and pharmaceutical firms specialize in different disease (therapeutic) areas. To measure the technological knowledge base gap or difference between partnering firms, I used a product-related technology measurement (i.e., each firm's therapeutic classification of commercialized drugs through the IMS health-USC code, approved by either the US FDA (Food and Drug administration) or European Medicines Agency which uses WHO (World Health Organization)'s ATC (Anatomical Therapeutic Chemical) Classification code. I made drug lists of each firm. Finally, in order to calculate therapeutic area difference between partnering firms, I tabulated the 3-digit USC therapeutic classification to which each drug belongs, and then I used the following calculation method (after Jaffe, 1986; Sampson, 2004 and 2007; Van de Vrande et al., 2009).

$$\textit{Therapeutic Area Difference} = 1 - \frac{T_i T_j'}{\sqrt{(T_i T_i')\,(T_j T_j')}}$$

Where Ti (j) represents the distribution of firm i (j)'s number of drugs across therapeutic classification. This creates a multidimensional vector. For instance if Ti= (1, 4, 5, 6) in therapeutic class A, B, C and D while Tj = (0, 3, 2, 0). Then, the therapeutic area difference will have a value from 0 to 1 -- with a value of 1 indicating the greatest possible therapeutic area difference between two partnering firms; in this example, the therapeutic area

difference between firm i and j is 0.309.

Control Variables

I employed several control variables that may affect the alliance governance mode choice. I controlled for '*firm size'* because a larger firm, due to its greater capability to cope with uncertain environments, may feel less susceptible to external environment fluctuations and partner opportunism (Aulakh et al., 2013). In order to measure size, I used the number of employees of each firm, or in the case of a university, the number of faculty in a specific department (e.g., medical center and biology department). '*Firm age'* controls for capability to conduct research and development, because older firms, due to experience, are more likely to perform better (Rothaermel and Deeds, 2004). Since the unit of analysis of this study is a dyad, or an alliance deal, I calculated the size and age difference between two partnering organizations (whether they be firms, universities or research institutes) by using the basic difference calculation formula. In order to control for the effect of prior alliancing experience (path dependent tendencies) on the choice of alliance governance mode, I employed '*prior alliance experience'* (Rothaermel and Deeds, 2006; Van de Vrande et al., 2009), measured by the number of prior alliance ties with the same firms, universities or R&D institutes. Finally, I introduced a dummy variable as a control for *'university, or R&D institute',* since universities and R&D institutes are not direct competitors of firms, and thus may be more cooperative and have low opportunistic tendencies. I code this as '1', if a firm formed an alliance with university or R&D institute, and '0' otherwise.

Statistical Model

Since the dependent variable, *Degree of Overall Integration (aka. Alliance governance modes),* is rank ordered (Low Overall Integration…1…2…3…4…High Overall Integration), I use an *ordinal logistic regression* (Menard, 2002; Santoro and McGill, 2005; Yamin and Golesorkhi, 2010). This is an appropriate methodology even with independent variables that are a combination of categorical (e.g., universities and R&D institutes) and continuous measures (e.g., geographic distance). The ordinal logistic regression model is as follows:

$$\text{Ln}\,[P(Y=j)] = \text{Ln}\left[\frac{P(Y=j)}{1-P(Y=j)}\right] = \alpha_j + \beta_{j1}x_1 + \cdots + \beta_{jk}x_k$$

Where P(Y=j) is the probability of the event (Y=j) for the *j*th case. α_j is the *j* intercept parameter, and β is the vector of independent variables.

4.5 Results

Table 4.2 provides descriptive statistics and the correlation matrix for the variables used in this empirical analysis. The correlation matrix, prima facie, raises the question of multi-collinearity between say geographic distance and quality of human capital. However, those seemingly correlation is mainly because of the same difference measurement between countries using the distance calculation formula indicated earlier. Nevertheless, although a multi-collinearity test -- for example for geographic distance and quality of human capital -- showed VIF (Variance Inflation Factor) scores of 3.24 and 2.27 respectively, these scores are lower than 10 (Neter, Wasserman and Kutner, 1985). Thus, it does not seem to have multi-collinearity problems among the variables. In order to make sure this, I further check

condition index and variance proportions. The condition indices for both geographic distance and human resource availability show very low values of 3.00 for these two. In addition to this, values on variance proportions for geographic distance and quality of human capital show 0.00 for almost all variables -- meaning that all other variables are not independently influenced by these two variables.

TABLE 4.2

Descriptive Statistics and Correlation Matrix (Pearson Coefficients)

	Variables	MEAN	S.D.	VIF	1	2	3	4
1	AGE	2.602	5.753	1.45	1.000			
2	SIZE	2.331	4.275	1.33	0.001	1.000		
3	ALLIANCE EXP	0.092	0.305	1.05	-0.044	0.154	1.000	
4	UNIVERSITY	0.088	0.284	1.58	0.532**	-0.170**	-0.046	
5	RESEARCH INST.	0.097	0.296	1.13	-0.029	-0.108	-0.053	1.000
6	Log GD	7.769	1.462	3.24	-0.110	0.097	-0.005	-0.102
7	RULE-OF-LAW	0.174	0.752	2.84	-0.049	-0.034	-0.038	-0.210**
8	HUMAN	3.694	5.024	2.27	-0.091	0.239**	0.098	-0.057
9	POWER DIST.	0.26	0.706	1.76	-0.085	0.090	0.009	-0.193**
10	LONG-TERM	0.509	1.525	2.41	-0.021	-0.073	-0.086	-0.075
11	RDINT	1.058	2.231	1.64	-0.026	0.384**	0.071	-0.104
12	TECHSP	0.258	0.869	1.74	-0.031	0.040	-0.020	-0.144*
13	TAD (USC3)	0.951	0.114	1.10	0.083	-0.168**	-0.060	-0.091

	5	6	7	8	9	10
5	1.000					
6	0.036	1.000				
7	0.137*	0.336**	1.000			
8	0.044	0.682**	0.080	1.000		
9	0.055	0.445**	0.551**	0.244**	1.000	
10	0.038	0.469**	0.618**	0.142*	0.443**	1.000
11	-0.102	0.385**	0.030	0.449**	-0.015	-0.053
12	-0.039	0.340**	0.534**	0.135*	0.367**	0.171**
13	0.140**	0.117	0.044	0.081	0.035	0.073

	11	12	13
11	1.000		
12	0.135*	1.000	
13	-0.045	0.023	1.000

*Correlation is significant at the 0.05 level

**Correlation is significant at the 0.01 level (two-tailed)

Tables 4.3 and 4.4 present the estimation results for the ordinal logistic regression models on the factors affecting the likelihood (or choice) of R&D alliance governance mode choice. Table 4.3 shows the results for the full sample while Table 4.4 shows separate subsamples for alliances involving basic research "R" versus alliances covering development "D". This is similar to Rothaermel and Deeds (2006). Activities in research phase are significantly different from those in development phase and may, as I hypothesized, produce different results with regard to the choice of alliance governance mode.

In Table 4.3, Model 1 shows the fixed effect of control variables only. Model 2 presents the effects of country-specific factors such as geographic distance, culture, institution and economic environment. Model 3 adds the effects of industrial factors including industrial R&D intensity and industrial technology specialization. Model 4 as the full model, is about the additional effect of the differences between each alliance partner's technological base (i.e., Therapeutic Area Difference) on the choice of R&D alliance governance mode.

Among the controls, only 'university' shows a strong negative relationship with the dependent variable in all models except Model 6. This indicates that when firms form R&D alliances with universities, there is a greater likelihood of choosing less-integrated alliance modes such as licensing.

TABLE 4.3

Ordinal Logistic Regression:

Degree of Overall Integration as the dependent variable, and full sample used (Sample A)

Variables	Model 1 (Sample A)	Model 2 (Sample A)	Model 3 (Sample A)	Model 4 (Sample A)
AGE	0.373 (.031)	0.038 (.032)	0.034 (.032)	0.036 (.032)
SIZE	0.017 (.028)	0.026 (.031)	0.014 (.033)	0.010 (.034)
Alliance Experience	-0.376 (.396)	-0.377 (.423)	-0.349 (.424)	-0.354 (.424)
University	-3.540 (.992)***	-3.544 (1.00)***	-3.432 (.999)***	-3.374 (1.00)***
Research Institute	-0.504 (.438)	-0.597 (.433)	-0.472 (.443)	-0.411 (.446)
Quality of Human Capital		-0.071 (.037)*	-0.078 (.038)**	-0.076 (.039)**
Rule-of-Law		0.415 (.251)*	0.193 (.317)	0.190 (.317)
Power Distance		-0.519 (.268)**	-0.449 (.263)*	-0.451 (.265)*
Long-Term Orientation		-0.257 (.117)**	-0.179 (.131)	-0.180 (.131)
Geographic Distance		0.002 (.000)***	0.001 (.000)**	0.001 (.000)**
Industrial R&D intensity			0.078 (.071)	0.075 (.072)
Industrial Technology Specialization			0.237 (.228)	0.232 (.225)
Therapeutic Area Difference				-1.067 (1.126)
-2 Log likelihood	511.121	500.656	498.021	497.025
Chi-square	31.98***	46.27***	48.91***	49.91***
Cox and Snell R-square	0.126	0.177	0.186	0.190
Number of observations	237	237	237	237

All tests two-tailed; standard errors in parentheses
*P < .10 ; **P < .05 ; ***P< .01

TABLE 4.4

Moderating Effects of R&D phase

Ordinal Logistic Regression:

Samples in Research Phase (Sample B) vs. Samples in Development Phase (Sample C)

Variables	Model 5 (Sample B)	Model 6 (Sample C)
AGE	0.020 (.035)	0.274 (.117)**
SIZE	0.040 (.045)	-0.025 (.061)
Alliance Experience	-0.442 (.488)	-0.374 (.939)
University	-2.974 (.981)***	-21.661 (.000)
Research Institute	-0.574 (.521)	0.686 (.100)
Quality of Human Capital	-0.071 (.046)*	-0.068 (.100)
Rule-of-Law	-0.330 (.685)	3.134 (1.465)**
Power Distance	-0.491 (.300)	-1.373 (.658)**
Long-Term Orientation	-0.058 (.179)	-0.232 (.253)
Geographic Distance	0.001 (.000)**	-0.000 (.000)
Industrial R&D intensity	0.024 (.095)	0.024 (.145)
Industrial Technology Specialization	0.652 (.430)	-1.372 (.679)**
Therapeutic Area Difference	0.175 (1.437)	-3.206 (1.835)*
-2 Log likelihood	320.894	151.679
Chi-square	43.39***	21.83**
Cox and Snell R-square	0.224	0.250
Number of observations	161	76

All tests two-tailed; standard errors in parentheses
*P < .10 ; **P < .05 ; ***P< .01

But this is highly significant only in the research "R" phase (in Model 5; β= -2.974, p<0.01) as opposed to development "D". This is not a surprise because universities do not commercialize drugs, and are not direct competitors of firms. Secondly, universities patent

their discoveries and typically license the patent rights to partner firms, without undue fears of competition or opportunism. Hence such alliances use a relatively low integration type of alliance as their choice of governance mode (such as licensing).

Hypothesis 1 is about the effect of difference in the Quality of Human Capital between the home nations of the partners with respect to the choice of R&D alliance governance mode. This is significant at 10 % level (Model 2). A larger difference or gap in the availability of skilled/educated labor between the countries of partner firms decreases the likelihood of using more-integrated alliance governance modes. However, unlike the hypotheses, when the sample is partitioned into alliances tackling basic research "R" versus development, "D", I found that it is in alliances tackling basic research that the significant negative effect is more accentuated (Model 5).

Hypotheses 2 is about the effect of national institutional differences (i.e., rule-of-law) on the choice of R&D alliance governance modes. The empirical result provides significant support for Hypothesis 2 (Model 2; $\beta = 0.418$, $p<0.1$). In addition, as can be seen from model 6, rule-of-law differences provide an even more marked effect on alliance governance mode, but only for firms in the development phase. According to Gulati and Singh (1998), and Pan and Tse (2000), firms respond to uncertainty in institutional environments, and minimize intellectual assets appropriation risk through more hierarchical governance modes. The finding is consistent with their arguments. In the pharmaceutical development stage, with risky clinical trials on thousands of subjects, and

the need for tighter control and supervision, there is a greater likelihood of choosing a more-integrated alliance mode for better monitoring and supporting development activity.

Hypothesis 3 tests the impact of cultural differences on the alliance governance mode choice. The greater the gap or difference in the countries' power distance and long-term orientation scores, the lower the likelihood of using a more-integrated alliance mode. In model 2, the results are negative and significant for both power distance and long-term orientation at 5% level. The result suggests that cultural differences in power distance and long-term orientation increases partner uncertainty, can hinder the flow of knowledge sharing activity and communication, and therefore ceteris paribus, the partners choose a more-flexible, less integrated, alliance mode. When the sample is partitioned the results for each sub-sample are weak. It is only in the development phase that allies are more likely to choose a less-integrated alliance mode, and that too only for power distance differences. In general, there is strong support for hypothesis 3A, and only partial support for hypothesis 3B (no moderating effect). This result supports the arguments of Buckley and Casson (1996); Mowery et al., (1996); and Hamel (1991).

Geographic distance has been used as a proxy variable in several studies. The result supports the idea that, other things being equal, a greater geographic separation between alliance partners increases the likelihood of more-integrated R&D alliance governance modes. The result is strongly supported at 1% level (Model 2; $\beta = 0.001$, $p<0.01$). In addition, the likelihood of using a more-integrated alliance mode is stronger for firms

involved in research phase rather than for firms in development phase (Model 5). Hypothesis 4 is strongly supported.

Unfortunately, there were no significant results for industrial and firm-level factor differences on the R&D alliance governance mode choice in general, although as seen in Model 6, when there is high level of difference in industrial technology specialization, the likelihood of using a less-integrated alliance mode is stronger for firms in development phase. This provides partial support for the hypothesis 5B.

Finally, when partnering firms have previous experience in very different therapeutic areas, the likelihood of using a less-integrated alliance governance mode is stronger for firms in development phase – providing partial support for hypothesis 6. Allies in the development phase may want to remain flexible by choosing relatively less-integrated alliance modes, especially when one partner has weaker expertise than the other in the therapeutic area undergoing trials.

4.6 Additional Test

As mentioned in the introduction, the applicability of TCE and KBV is more limited when these theories attempt to differentiate between various hybrid modes. In the traditional distinction between "non-equity versus equity" modes TCE and KBVs prescriptions are clearer. However, in many industries, especially in the pharmaceutical sector, non-equity alliances (of various types) predominate, as seen in Figure 1.1. In this dissertation, I have three different varieties of non-equity alliances, plus EJVs as a fourth alliance type, with rising levels of inter-partner integration Dependent Variable category 1 through DV 4). In Table 4.5, I see the marginal effects of ordinal logistic regression, rather than simply computing and comparing the odds ratio of variables. This allows me to assess

the probability of each category against the others. Table 4.5 provides marginal probability effects of ordinal logistic regression for the full sample, but focuses only on those variables with supported hypotheses.

TABLE 4.5

Marginal Probability Effects of Ordinal Logistic Regression (supported hypotheses only)

Full Sample (Sample A)			
DV	**Variable**	**Coefficient**	**S.E.**
Low-Integrated (1)	University	0.615***	0.068
	Geographic Distance	-0.033**	0.015
	Quality of Human Capital	0.019*	0.012
	Rule of law	-0.099	0.062
	Power Distance	0.138**	0.068
	Long-term orientation	0.049*	0.028
Moderately-Integrated (2)	University	-0.430***	0.059
	Geographic Distance	0.015**	0.007
	Quality of Human Capital	-0.009*	0.006
	Rule of law	0.047	0.031
	Power Distance	-0.065*	0.036
	Long-term orientation	-0.023*	0.015
High-Integrated (3)	University	-0.062***	0.017
	Geographic Distance	0.005*	0.003
	Quality of Human Capital	-0.003*	0.002
	Rule of law	0.016	0.011
	Power Distance	-0.022**	0.012
	Long-term orientation	-0.008*	0.005
EJV (4)	University	-0.122***	0.023
	Geographic Distance	0.012**	0.005
	Quality of Human Capital	-0.007*	0.004
	Rule of law	0.036	0.023
	Power Distance	-0.050**	0.025
	Long-term orientation	-0.017*	0.010

*P < .10 ; **P < .05 ; ***P< .01

In this additional check – of testing each of the four dependent variable categories against the others together -- the results are generally consistent with the earlier findings and hypotheses, with the exception that "rule of law" loses explanatory significance. To be more specific, when there is a gap in Quality of Human Capital between two countries of partnering firms, the likelihood of using a low-integrated mode (i.e., DV1) increases by 1.9%, while DV2, 3 and 4 decreases by 0.9, 0.3 and 0.7%, respectively; the probability of alliance mode usage is as follows, DV1> DV3> DV4 > DV2. And the likelihood of using the low-integrated alliance mode is high, particularly when partnering firms have different perception in power distance; the probability of using DV1 is increased by 13.8 %. However, the probability of using DV 2, 3 and 4 is decreased by 6.5%, 2.2% and 5.0%, respectively (i.e., DV1> DV3> DV4> DV2). Similarly, the probability of using DV1 is high in the face of cultural difference in the dimension of long-term orientation (i.e., DV1: increased by 4.9%). But the likelihood of using DV2, 3 and 4 is decreased by 2.3%, 0.8% and 1.7%, respectively (i.e., DV1> DV3> DV4> DV2). Finally, as mentioned earlier, geographic distance between partnering firms may increase costs of coordination and communication in knowledge sharing activity. In order to minimize the risk of coordination and communication while maximizing the inter-firm collaboration, the more-integrated alliance mode will be a better option. More specifically, firms are more likely to use a moderately-integrated alliance mode rather than to use a low or high-integrated alliance mode; the probability of using DV 2, DV 3 and DV 4 is increased by 1.5%, 0.5% and 1.2% respectively, while DV 1 is decreased by 3.3% (i.e., DV 2 > DV 4 > DV 3 > DV1).

In sum, the marginal test clearly presents the likelihood of each alliance governance mode choice, and explains the paradoxical phenomenon (e.g., why the usage of non-equity

based alliances rather than EJVs is predominant) taken place in one of knowledge intensive industry, pharmaceuticals.

4.7 Discussion and Conclusion

This study advances the academic understanding of alliance governance by going beyond the overly broad, traditional categories of "equity vs. non-equity" alliances. In several sectors, especially pharmaceuticals, contractual alliances greatly outnumber equity joint ventures (EJVs). And therefore probing the distinctions between the varieties of non-equity alliances is essential to understanding the complexities of alliance formation and governance.

In this study, the dependent variable comprises four rank-ordered alliance governance categories (three contractual 1, 2, 3…plus one EJV variety 4) with rising levels of inter-partner integration. What I label "inter-partner integration" is a composite construct built from two salient building blocks, or concerns, in alliance formation (i) the extent of inter-partner interaction (depending on the incidence of pooled, sequential and/or reciprocal joint activities), and (ii) the degree of complexity of the task undertaken by the alliance (based on the number of deal components in the agreement as well as its length). The domain of this study is pharmaceutical R&D and I additionally make the necessary distinction between basic research "R" and development "D" to assess the extent to which the alliance governance type is influenced by whether the alliance's purview is R versus D.

This paper is also differentiated from the mass of alliance empirical studies by extracting raw data from an actual reading of 237 alliance agreements. Although some scholars such as Zhou, Poppo and Yang (2008) or Reuer and Arino (2007) have begun to

probe the details of actual agreements, most previous studies only used broad classifications drawn from synopses published by news abstracts like SDC (Securities Data Corporation). Without probing the anatomy of alliance agreements, a study is akin to practicing medicine without dissection. In this study, each agreement was read and scored for the inclusion of 12 elements ranging from licensing, to asset purchase, to the partial (passive) acquisition of partner shares, to milestone triggers (real options), to manufacturing or supply chain links between the partners, loans, and finally the creation of a separate EJV company (Please see Appendix). From these components, I calculated the 'degree of complexity' of the alliance which, together with the 'degree of integration' created an overall index, rank-ordered into four categories with a rising "overall degree of integration" (Contractor and Reuer, 2014).

An ordinal logistic regression procedure then assessed the accuracy of classification for each alliance (in terms of its governance mode in the four categories) based on the differences between the home nations of the allies and their sub-sectoral specialization (i.e., which areas each pharmaceutical partner company has worked in the past).

The main conclusion is the R&D alliance governance modal choice is not attributable to a single factor (e.g., exogenous country-specific factors), but rather influenced by multiple factors, both country-specific or exogenous (differences in institutions, human factors, culture and geography between the home nations) as well as sectoral and therapeutical area differences.

This enriches the foundations of KBV and TCE theories, while at the same time introducing additional factors that allow scholars to distinguish between the varieties of non-equity or contractual alliances in a complex global business environment. For instance,

under the KBV, a hierarchical alliance mode (i.e., EJV) is deemed preferable, because it promotes collaboration and knowledge sharing activity, and minimizes partner opportunism (Oxley and Wada, 2009). Furthermore, due to organizationally embedded communities that facilitate tacit or complex knowledge share and transfer, EJVs are said to be an ideal mode of collaboration (Kogut, 1988; Kogut and Zander, 1992; Sampson, 2004; Macher, 2006; Oxley and Wada, 2009). However, this study supports the argument that firms in industries facing with increasing technology intensity and radically changing technology prefer more flexible alliances such as agreements that provide a less-integrated and flexible or reversible arrangements (Hagedoorn and Duysters, 2002). Sometimes it is too risky to use an EJV as a knowledge sourcing mode, because technological uncertainties such as failure of drug discovery and clinical trials may actually lead to an adverse selection problem. Rather, firms can diffuse those risks by using, for instance, a moderately-integrated alliance mode that lies in between a license (more akin to an arm's length contract) and an organizationally fully embedded mode such as EJV. The moderately-integrated contractual mode (i.e., DV = 2 in this study) provides a more flexible organizational structure than an EJV since it allows partners to more easily change or modify their research and development contracts in the face of technological uncertainties and changes in regulatory or R&D environment.

Another critical issue that the framework of this study addresses is that firms can strategically choose an alliance governance modes for different stages of R&D. Research is obviously different from development in the sense that research requires more frequent and closer interaction between partners, as opposed to development which (for the

pharmaceutical clinical trials) often entails a more formalized/standardized field trial environment. This study reveals that the likelihood of using a more-integrated governance mode is stronger for firms in the research phase especially when partners are located in geographically distant places. This is reasonable, because research alliances are exposed to the difficulty of coordinating and transferring tacit knowledge across organizational boundary (Lane and Lubatkin, 1998; Rothaermel and Deeds, 2004), and thus are more likely to choose a more-integrated mode to facilitate knowledge sharing activity. On the other hand, firms in development phase are more likely to use less-integrated modes in the face of uncertainties rising from cultural, institutional, industrial technology specialization and therapeutic area differences between partnering firms.

The dependent variable construct of this study, identification of 12 salient agreement provisions (see Appendix), as well as its conclusions about how country and sectoral differences influence the structure of alliances, also provides rich insights for managers. Firms can diversify their risks and the location of their R&D activity by using different alliance governance modes, thus leading to better crafted agreements.

CHAPTER 5

R&D ALLLIANCE GOVERNANCE STRUCTURE AND THE SUCCESSFUL ALLLIANCE COLLABORATION PERFORMANCE: THE EFFECTS OF PARTNER DIVERISTY AND TECHNOLOGICAL BASE COMPLEMENTARITY

5.1 Introduction

In this chapter, I try to answer the fourth research question *"How does the alliance governance structure (i.e., interactive and coordinative structure) influence the success of alliance collaboration?"*

Strategic alliances allow firms to gaining access to external resources, and create new resources (Mowery et al., 1996; Mitchell et al., 2002). In addition, alliances are strategically important particularly when firms involve in Research & Development (R&D) and external technological knowledge sourcing activity. To achieve a successful knowledge share and creation, firms must be able to access external technological knowledge, and integrate and apply those knowledge through an effective alliance governance mode (Oxley and Wada, 2009; Hoetker and Mellewigt, 2009). In this vein, work drawing on Knowledge-Based View (KBV) has argued that a more organizationally embedded alliance mode such as equity joint venture (EJV) is particularly effective due to its organizationally integrated communities that promote tacit or complex knowledge share and transfer activity (Kogut, 1988; Kogut and Zander, 1992; Sampson, 2004; Macher,

2006). And an equity-based alliance has been positively associated with knowledge transfer and creation performance (Chen, 2004; Oxley and Wada, 2009).

However, this positive relationship might not always be seen in all knowledge intensive industries. For instance, the most hierarchical alliance mode (i.e., EJV) is not always preferable for firms in the pharmaceutical industry even though their R&D alliance is highly knowledge intensive activity (Figure 1.1). This paradoxical phenomenon may imply that it is not simply a matter of types of alliance, but the matter of effective alliance governance mechanisms (e.g., interaction, control and coordination) that affects the alliance performance. In addition, this addresses two important issues that might have been uncovered. *First*, prior studies tend to focus on types of alliance and their impacts on the amount of knowledge transfer (Oxley and Wada, 2009) and knowledge creation performance (Lin et al., 2012). And relatively little attention has been paid to the alliance structure and its impact on the successful alliance collaboration performance (i.e., successful alliance collaboration outcome: milestone achievement). Since the alliance structure used in certain technology/knowledge intensive industries such as telecommunication and pharmaceuticals has become more complicated which also goes beyond the dichotomous alliance classification (i.e., non-equity vs. equity based alliance), it became a critical strategy for firms to effectively govern alliance structure in order to achieve a better performance. In response to this importance, Mowery et al. (1996) identified different types of alliance and found that bilateral contract-based alliances (e.g., cross-licensing and technology sharing) as opposed to unilateral alliances are positively associated with knowledge transfer performance. Furthermore, Hagedoorn et al. (2008) emphasized the role of sophisticated technology and its impact on the choice of even more

complicated alliance types/structures (e.g., licensing plus any types of partnership such as joint research collaboration). *Second*, it is critical to capture the success of alliance collaboration as a consequence of successful management of alliance structure through which alliance partners interact, coordinate and communicate in the course of research and development. Simple knowledge transfer and creation performance measurement such as the number of patent granted cannot be applicable particularly when alliances involve in non-patentable R&D collaboration (e.g., product candidate experiment: Clinical trials in the pharmaceutical industry).

In this study, I examine the relationship between R&D alliance governance structure and alliance collaboration performance. And then I argue that overall alliance collaboration performance depends upon the effective coordination and communication mechanisms through which the degree of interaction and the degree of complexity of alliance is governed. But this relationship is contingent upon the degree of alliance partner diversity or complementarity. Using alliance deal data in the pharmaceutical industry, I test the alliance governance structure and collaboration performance linkage, as well as moderating effects of alliance partner diversity and technological base complementarity of partners. Pharmaceutical industry is suitable to this study setting since alliance activity is dominant throughout the research and development process. In addition, a variety in types of alliance used in the industry reflects the importance of strategic usage of alliance governance structure. Empirical findings support the argument that certain degree of coordination and communication costs derived from increased interaction and complicated alliance structure has a negative impact on the alliance collaboration performance. However, this negative relationship varied depending upon whether firms collaborate with foreign or domestic

partners, and partners with a diverse or similar technological base. Specifically, it is better for firms to govern an alliance with a more organizationally integrated structure (e.g., EJV) when they collaborate with foreign partners as well as partners with diverse technological bases.

By introducing a new coordination and communication mechanism in the alliance, the study framework and the alliance governance structure developed in this study contributes to the study of KBV of strategic alliance as well as alliance characteristics. In addition, the findings provide some insightful explanations about the paradoxical phenomenon and future study opportunities to revisit the relationship between alliance governance structure and collaboration/innovation performance.

5.2 Coordination and Communication Mechanism in Alliances

In order to achieve a better collaboration performance, firms should be able to utilize a coordination and communication mechanism (Poppo and Zenger, 2002; Lee and Cavusgil, 2006; Jiang and Li, 2009), and balance between partner diversity and complementarity in alliances (Saxton, 1997; Teng and Das, 2008; Lin et al., 2009). However, alliance governance mechanism (i.e., relational vs. contractual-based governance) mentioned in prior studies might not be applicable to the more complex alliance structure, because firms in certain knowledge intensive industries, for instance, use a combined/mixed alliance structure as described in Hagedoorn et al. (2008): A combination of contractual and relational governance (e.g., licensing plus joint collaboration agreement). To address this issue I already identified different types of alliance including those combined modes, then classified them into four different categories (Figure 4.1 and 4.2).

Prior research, on the one hand, has identified and classified the alliance governance structures based upon the degree of interaction/interdependence between the partnering firms, and ranked them between arms-length transactions and a fully integrated mode (i.e., EJV) (Gulati and Singh, 1998; Contractor and Lorange, 2002; Narula and Duysters, 2004; Santoro and Mcgill, 2005; Vrande et al., 2009). On the other hand, others have used 'Personal vs. Depersonalized exchange mechanism' to characterize alliance governance structure: Relational vs. Contractual-based (aka. formal) governance mechanisms (Poppo and Zenger, 2002; Hoetker and Mellewigt, 2009). In this study, I basically utilize common elements used in the prior alliance classification system in order to be able to fully capture diverse alliance structures. 12 different types of R&D alliance mode were identified, and then 4 types of alliance mode were classified based on two dimensions. Based on this, this study scrutinizes the coordination and communication mechanism of such alliance modes.

One of dimensions, the degree of interaction, not only represents the directionality of workflow but it also reflects the amount of communication between alliance partners (e.g., give and take of technological knowledge or information). For instance, since the direction of knowledge flow is one-way in a pure licensing agreement, the amount of communication is absolutely less than that of cross-licensing agreement. Moreover, if the alliance deal contains multiple deal components such as licensing plus joint development, it increases the degree of interaction of two independent activities (e.g., one-way plus two-way interaction), and thus the communication difficulty between two partners. Given those, I define the communication cost as the communication difficulty rises from the increased interactions between partners due to multiple alliance deal components. The second dimension of governance structure was the degree of complexity representing the

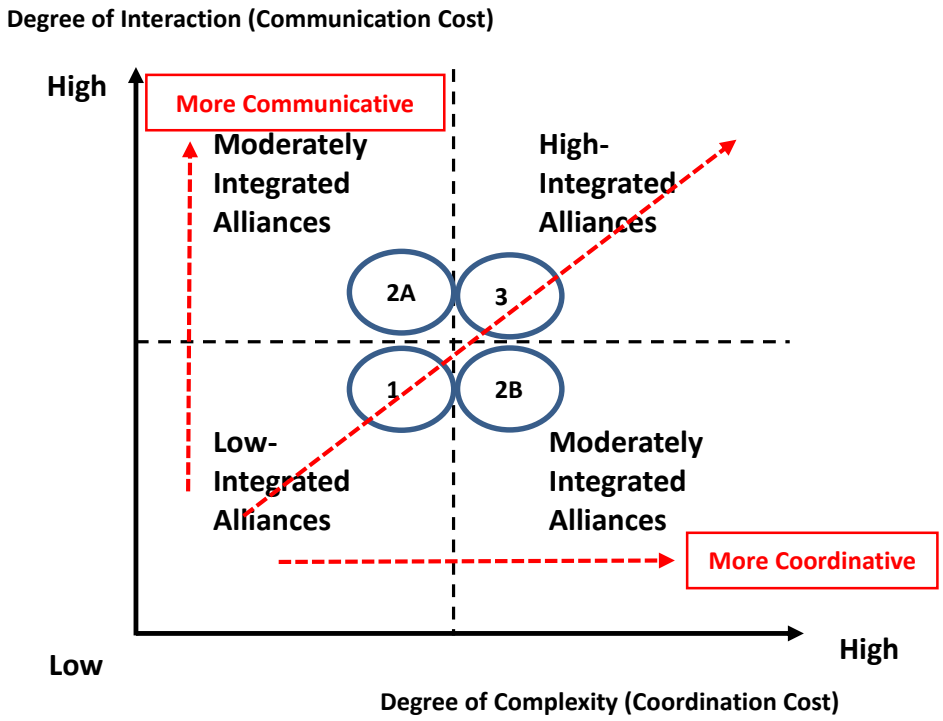
complexity of R&D alliance deal. The number of deal components as well as number of pages of an alliance were used as a proxy for the complexity of alliance structure. For example, the degree of complexity of licensing plus joint research agreement can be coded as two since one alliance deal is actually a combination of two different alliance deal components. This captures a coordination mechanism of an alliance; if the alliance contract has become more complicated due to the number of deal components (e.g., again, in case of 3: licensing, joint research and joint development agreement), partners need to coordinate multiple tasks for the better resource allocation, adjustment and adaptation of tasks involved. Hence, I define coordination costs as organizational complexity of decomposing, adapting and adjusting tasks between partners.

5.2.1 Discriminant Analysis for the Communication and Coordination Structure of Alliances

Previously in Chapter 4, I performed the K-means cluster analysis to classify and illustrate alliance governance modes and to see "Overall Degree of Integration" of a specific alliance. Unlike the previous study in Chapter 4, this study focuses on the communication and coordination mechanism of a specific alliance. As can be seen in Figure 5.1, those classified in 2A of the quadrant are actually more interactive than coordinative, and thus the communication costs are much higher than those classified in 2B of the quadrant.

FIGURE 5.1

Communication and Coordination Mechanism in Non-Equity Alliances



Since the degree of communication and coordination of a specific alliance is known, I decided to conduct a discriminant analysis. Using two dimensions (i.e., the degree of interaction and the degree of complexity) and the mean value of each dimension, I coded four governance modes, because the classification contains type 1, 2A, 2B and 3 non-equity based alliance governance modes; (1) Mean of degree of interaction= 4, and (2) Mean of degree of complexity=33 (See Figure 5.2). I used those 208 non-equity alliances excluding 29 equity joint ventures since I added EJVs (same as what I have done in Chapter 4) and coded it as "4" indicating the most coordinative and interactive alliance structure.

FIGURE 5.2

Scatter Plot of Degree of Interaction and Complexity

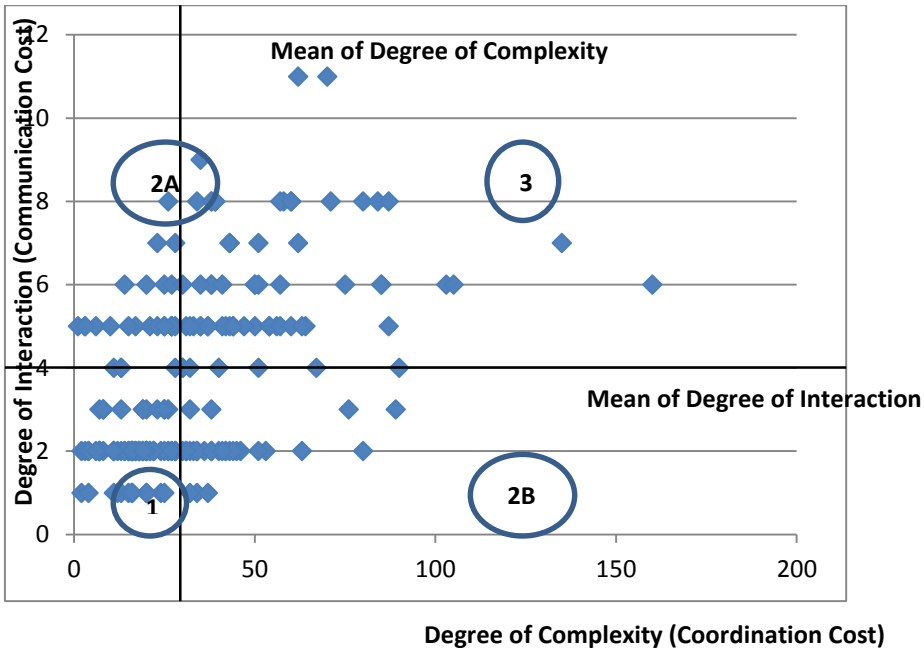


Table 5.1 presents the classification result. And it shows statistically very significant classifications meaning also that it is well-classified; eigenvalue of function 1 is high representing that it is significantly discriminant from function 2, and canonical correlations for both functions are high (close to 1) meaning that these two functions are very important to classify the coordination and communication of four different alliance structures. And Table 5.2 presents classification results that the discriminant analysis classifies the coordination and communication of four non-equity based alliance governance structures as follows:

(1) Low-Integrated (Least communicative yet coordinative alliances): 109 alliance deals

(2A) Moderately-Integrated (More communicative alliances): 17

(2B) Moderately-Integrated (More coordinative alliances): 23

(3) High-Integrated (High communicative and coordinative alliances): 59.

TABLE 5.1

Canonical Discriminant Analysis (N=208)

Function	Eigenvalue	% of Variance	Cumulative %	Canonical Correlation	Wilk's Lambda	Chi-square	d.f.	Sig.
1	3.149	87.3	87.3	.871	.165	367.242	6	.000
2	.458	12.7	100.0	.561	.686	76.981	2	.000

TABLE 5.2

Classification Results

		Governance Modes	Predicted Group Membership				Total
			1	2A	2B	3	
Original	Count	1	93	13	3	0	109
		2A	0	17	0	0	17
		2B	0	0	23	0	23
		3	0	16	1	42	59
	%	1	85.3	11.9	2.8	.0	100.0
		2A	.0	100.0	.0	.0	100.0
		2B	.0	.0	100.0	.0	100.0
		3	.0	27.1	1.7	71.2	100.0

5.3 Hypotheses Development

Based on the classification results from the discriminant analysis, I develop the hypotheses.

5.3.1 Coordination and Communication Costs of R&D Alliance Structure and Collaboration Performance

Firms engage in alliance activities at any time in the research and development process,

and utilize the alliance governance structure as a vehicle to achieve goals such as sourcing and creating new technological knowledge, and sharing risk and cost of R&D (Mowery et al., 1996; Dyer et al., 2007). However, as mentioned earlier in the introduction part, innovation performance achieved by knowledge transfer and creation might not fully capture the performance of all R&D alliance activities, because R&D may also contain other than transferring and creating technological knowledge. In this study, successful alliance collaboration performance measuring whether an alliance collaboration achieves any successful milestones reflects the quality of alliance performance. For instance, successful licensing agreement can be defined not as the receipt of right to use licensor's technology, but as the internalization and assimilation of such complex technological knowledge which enables the licensee to utilize the technology for further R&D activities. Then the question is how alliance partners can achieve a successful alliance collaboration performance.

The usage of effective communication and coordination mechanism in an alliance can positively affect the performance (Gulati and Singh, 1998; Poppo and Zenger, 2002). This is particularly salient in technology intensive R&D alliances. R&D activity is highly knowledge intensive dealing with tacit technological knowledge, and thus entails close communication and interaction for learning and transferring knowledge (Dyer et al., 2007; Jiang and Li, 2009). However, according to organization design scholars (Galbraith, 1977; McCann and Galbraith, 1981), increased interaction and coordination between partners can actually increase information processing costs. In addition, increased information processing costs can cause conflict and communication failure, and may have a negative impact on performance (Pondy, 1970). More specifically, the degree of communication

costs varies depending upon workflow of ongoing task; in the case of pure licensing, knowledge flow is one way transferring it from a licensor to a licensee, and thus they can interact at the minimum level which also lowers the possibility of partner conflict and information processing costs. In contrast, the workflow of cross-licensing is two-way since both partners transfer and share their proprietary technologies simultaneously. Then the communication costs can be doubled compared to that of single pure licensing.

The coordination cost, on the other hand, arises from the complexity of decomposed alliance tasks to be completed jointly or individually across organizations in a given alliance. For instance, the coordination cost of cross-licensing plus joint research collaboration, as opposed to that of just cross-licensing, is much higher because both alliance partners involve in two separate tasks which increase the difficulties associated with organizing tasks and adjusting their particular needs. The coordination and communication costs can be more increased in equity joint ventures, because firms pursuing multiple R&D activities that require high-levels of task coordination and partner communication tend to form EJV rather than contractual alliances (Pisano, 1989). Although the communication and coordination costs are high in EJV, EJV is particularly useful and effective since it provides a more organizationally integrated control (Gulati and Singh, 1998) as well as both formal and informal communication mechanisms (Kale et al., 2000; Lee and Cavusgil, 2006). Nevertheless, increased information processing costs and the likelihood of miscommunication may make the venture more difficult to achieve a better collaboration performance.

Putting all things together, increased coordination and communication costs in a given alliance may lead to a decline in performance. But, this negative relationship can be more

significant when alliance partners try to achieve a more challenging goal (i.e., successful alliance collaboration performance) than simple goals such as transferring and creating technological knowledge. In the R&D process, going through the next stage to develop a new product requires more challenging activities (e.g., application and examination of newly created technology) that go beyond knowledge transfer and creation activity. Hence, I propose the following hypothesis.

H7: *The degree of coordination and communication costs in a given R&D alliance structure is negatively related to the successful alliance collaboration performance.*

5.3.2 Moderating Effects of Partner Diversity and Technological Base Complementarity

One key research stream on alliance performance is the role of similarities/ differences between alliance partners, particularly in terms of resource complementarity and organizational or strategic fit of partners (Parkhe, 1993; Saxton, 1997; Lin et al., 2009; Lavie, 2012). The effects of partner diversity and resource complementarity are particularly important on the coordinative and communicative alliance structure-performance relationship, because organizational and strategic fit between partners directly affect technological knowledge flow and communication in the alliance. Nevertheless, little is known about whether partner diversity or similarity enhances the alliance collaboration performance. To examine the roles of partner diversity, I identify two primary organizational differences rising from:

(1) National diversity (i.e., Domestic vs. International)

(2) Organizational diversity (i.e., Companies vs. Universities or Research Institutes) of partners.

Partners of different nations tend to have different needs and offer different/unique resources and capabilities increasing the organizational heterogeneity in an alliance (Hitt et al., 2000). And the organizational heterogeneity in an alliance requires more deliberate effort and interaction in sharing, learning and creating technological knowledge. In addition, R&D collaborations with international partners limit close interaction and communication because of geographic distance between partners. Then, increased costs of communication and complexities of knowledge access hamper knowledge transfer (Daft and Lengel, 1986; Shenkar, 2001; Hansen and Lovas, 2004), and decrease communication intensity (Katz and Allen, 1982) making R&D alliances more difficult to create collaborating environments. Given the fact, when firms use an alliance governance structure that entails lower levels of coordination and communication costs (e.g., licensing), collaborating with domestic partners rather than foreign partners can help increase the probability of achieving a successful alliance performance. In other words, it will be easier to communicate with domestic partners and to expect a better alliance collaboration performance when firms adopt the low-integrated alliance governance structure. This is partly because low-integrated alliance governance structure does not provide effective control mechanisms. However, in case when alliance partners choose a governance structure that provides a more organizationally integrated control mechanism (e.g., EJV), national diversity will have lesser effect on alliance performance. In sum, although the costs of coordination and communication in EJV may high which decreases

alliance performance, national diversity would not have a strong impact on this negative relationship due to the stronger and effective control mechanism (e.g., board meeting) embedded in EJV. Given those, I hypothesize that

H8: *The degree of coordination and communication costs, and national diversity of partners in a given R&D alliance have an interaction effect on the successful alliance collaboration performance.*

Organizational diversity refers to the degree to which types of organization in an alliance are different; whether an alliance is formed between firms or between firms and universities or research institutes. Organizational diversity may also moderate the negative relationship between costs of governance structure and performance in the sense that the negative relationship can be worsened when an alliance is formed between firms in the same industry. The reason is that firms, as opposed to universities or research institutes, tend to be a direct competitor against each other which hampers interdependence or interaction of partners in an alliance. Drawing upon the game theoretic perspective (Arend, 2005; Faems et al., 2010), scholars have used the concept of prisoner's dilemma to analyze the likelihood of cooperation or competition in the context of strategic alliances. The need for close communication and fine-grained interaction is a necessary condition for knowledge intensive R&D collaboration activities. However, under the game theoretic perspective, intensive interaction substantially increases the risk of future competition between partnering firms since it allows partners to share complementary resources while at the same time it reveals one's core competencies and capabilities to another partner in

the alliance (Faems et al., 2010). As such, due to the risk of unintended knowledge spillovers under intensive communication and interaction, alliance collaboration may end up turning into future competition. And this negative connotation of intensive interaction can be more significant when the alliance is formed between firms in the same industry (i.e., direct competitors) and may have a negative impact on alliance performance. To sum up, the negative relationship between the coordination and communication costs, and alliance performance can be moderated by organizational diversity. Thus, I hypothesize the followings.

H9: *The degree of coordination and communication costs, and organizational diversity of partners in a given R&D alliance have an interaction effect on the successful alliance collaboration performance.*

Alliance partners' technologies and their technological backgrounds have been recognized as important factors affecting the R&D alliance performance (Lin, 2007; Lin et al., 2009). Partners pool a portion of their technological resources (e.g., technologies and technological capabilities) when they form an alliance. And it is generally accepted that technological complementarity or diversity have a significant impact on knowledge transfer and innovation performance, even though prior studies have shown mixed results; some found positive effects of knowledge base similarity between alliance partners on performance (Lane and Lubatkin, 1998; Ahuja, 2000) while others found non-linear relationships (Ahuja and Katila, 2001; Nooteboom et al., 2007). This may imply that technological complementary has a dual effect on the R&D alliance performance, but the

effect may vary depending upon communication and coordination mechanisms in a given alliance. For instance, the negative relationship between costs of communication and coordination, and alliance performance can be relieved when the technological base similarity between alliance partners is high. In the case of pure single licensing agreement, a firm can in-license and absorb a partner's technologies at a lower communication and coordination cost, due to the similarity of technological bases between partners which may help reduce the need to have intensive interactions and communications to comprehend and assimilate the partner's resources. However, high levels of similarity negatively affect alliance innovation performance particularly when firms look for diverse or unique technological resources (Letterie et al., 2008). Because of the path-dependence of alliance collaboration derived from the high level of similarity, it is hard to change and transform existing technological patterns into the innovative one. In this vein, technological diversity between partnering firms may be useful when they seek to access new and unique external technologies for a better innovation and collaboration performance. This suggests that a certain degree of diversity helps enhance alliance innovation performance. Applying these arguments into this study context, firms using a more hierarchical alliance governance structure such as EJV can actually mitigate the negative relationship between costs of communication and coordination, and alliance performance through the more organizationally integrated control mechanism, particularly when the degree of partners' technological base complementarity is high (i.e., high levels of technological base diversity between alliance partners). Hence, I propose the following hypothesis.

H10: *The degree of coordination and communication costs, and technological base complementarity of partners in a given R&D alliance have an interaction effect on the successful alliance collaboration performance.*

5.4 Methodology

Data and Sample

The research sample consists of strategic alliances announced in between 2000 and 2003 in the pharmaceutical and biotech industry (i.e., U.S. SIC code: 2833 through 2836). I specially focus on those alliances in the pharmaceuticals because the industry, as one of the most knowledge intensive industries where many firms engage in strategic alliances for the technology innovation, is suitable to this study setting emphasizing the role of communication and coordination mechanism in the alliance. In addition, the significant distinction between research and development activities in the pharmaceuticals provides a better study context in measuring an alliance performance, particularly a successful alliance collaboration performance. The successful alliance collaboration performance that goes beyond the innovation performance measurement (e.g., patent grant) allows me to capture a variety of research and development alliance activities. Figure 1.2 shows value creation activities in the pharmaceutical industry; research activity focuses on drug discovery whereas development is associated with the human-based clinical trials. As noted, I employed only those alliance deals in 4-year period (i.e., 2000 ~ 2003). R&D in the pharmaceuticals, as described in Figure 4, is a time-consuming activity taking up to 15 years to develop one drug product. In order to be able to measure the successful alliance collaboration performance, we need to see whether the alliance activity goes through the

next stage in the R&D process. For instance, the outcome of an alliance formed in the research stage (i.e., drug discovery) in 2003 will be able to see, for example, 4 years later in 2007. And the outcome of alliances formed in 2008 might not be able to count in, because it is still an on-going project of a company. Thus, I had to limit those alliance deals announced in 4-year period to increase the possibility to measure the success of alliance collaboration.

To examine the relationship between costs of communication and coordination, and alliance performance, I used 181 R&D alliance deals; initially the number of sample was 237, but I had to eliminate those without having a final report of their alliance activity on 10-K or 10-Q report. Moreover, since the study focuses only on R&D alliance, I incorporated those alliance deals in Research (e.g., discovery and preclinical), and Development (e.g., phase I, II and III clinical trials), and excluded those in commercialization stages (e.g., marketing/manufacturing alliances). And I used a unique data source, Current Agreements Database, which provides a broad scope of global alliance deals ranging from equity joint ventures to detailed project level deals such as technology license, joint research/development, loan, and equity. The database contains alliance deal announcement date, alliance partners (e.g., nationality and address), actual contract documents (actual contract and/or financial information is sometimes not disclosed), alliance deal components (i.e., types of alliance: licensing, development, and so on), and stages of development ranging from discovery to phase III clinical trial.

Measures

Dependent Variable

The dependent variable is the *Successful Alliance Collaboration Performance*. And it measures the successful alliance collaboration whether an alliance collaboration achieves any milestones allowing a firm to move towards the next stage in R&D process, and thus captures stage-by-stage alliance collaboration performance. I coded '1' if alliances have any milestone achievements, and coded '0' for otherwise. And I consider the followings as milestone achievements:

(1) **Research Stage:** Drug compounds filed to an Investigational New Drug application, IND (e.g., the creation of new chemical compound that successfully goes through the Phase I clinical trials). Or any types of alliance collaboration that allow alliance partners to move to the Phase I clinical trial.

(2) **Development Stage:** Success of an immediate clinical trial engaged when the alliance is formed.

The advantages of this dependent variable are twofold. *First*, the measurement is useful particularly when there is a variety of value creation activities involved in the R&D, and a significant difference between the activities of research and development; to develop one drug product, firms in the pharmaceutical industry tend to involve in multiple alliances with diverse partners under the alliance portfolio strategy. This may mean that the alliance collaboration performance can be independent at each stage. *Second*, unlike patent/product based performance measurement of the others (Lin et al., 2009; Chen et al., 2011), the dependent variable in this study provides a more direct measurement of R&D alliance performance as it measures the quality of alliance collaboration outcomes (i.e., the

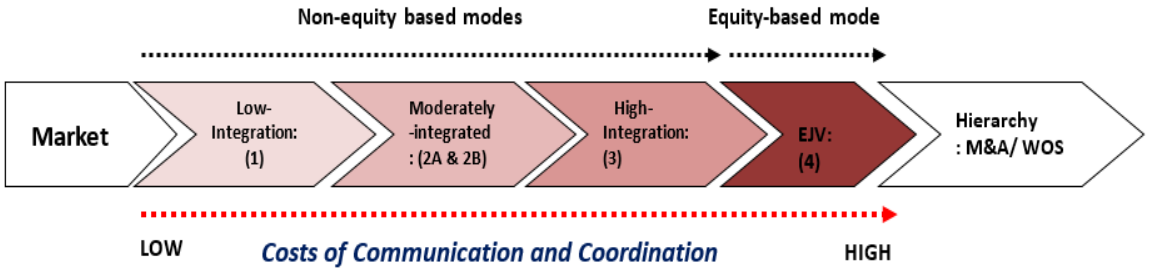
probability of successful alliance collaboration). Financial performance also has its drawbacks, because it can be affected by multiple factors such as market condition, marketing alliance, manufacturing alliance, and so on.

Independent Variables

The degree of communication and coordination costs in a given R&D alliance (R&D alliance governance structure) is a major independent variable. And I took several steps to measure this variable. I first identified types of alliance and then classified them into five (four, if 2A and 2B are combined) different categories by using two dimensions: Degree of Interaction (Communication Cost) and Degree of Complexity (Coordination Cost) of alliance deals[12]. I classified four different alliance governance structures and indicated costs along with the governance structures in order to represent communication and coordination costs of a given R&D alliance. Thus, the degree of communication and coordination costs is ranged from 1 (Low) to 4 (High) along with the alliance governance structures from low-integrated to EJV as described in Figure 5.3.

FIGURE 5.3

Coordination and Communication costs in an Alliance Structure



[12] See also for the results of discriminant analysis

Nevertheless, it is important to separate moderately-integrated alliance structure into two (i.e., 2A and 2B), since the degree of communication and coordination costs of 2A and 2B is different; as mentioned earlier, 2A is the group of more communicative alliances whereas 2B is the group of more coordinative alliances. In order to see the effect of either coordinative or communicative alliances on the successful alliance collaboration performance, I control for those more coordinative alliances. And more details about this control variable will be introduced later in the measurement part for control variables.

Partner Diversity

(1) *National Diversity*: I coded '1' if an alliance is formed by foreign partners, and coded '0' for the alliance with domestic partners.

(2) *Organizational Diversity*: I coded '0' for alliances between firms and otherwise coded as '1' for those alliances between firms and universities/ research institutes including contract research organizations.

Technological Base Complementarity

To measure the *technological base complementarity/diversity* between partnering firms, I used a product-related technology base measurement (i.e., therapeutic classes of commercialized drugs of a firm). I measurement is better than the patent class, because it allows me to capture a more direct and specialized technological base of the firm. For instance, one patented chemical compound can be diluting the boundary of technological specialization of the firm if the compound is indeed used for multiple diseases (Zimmermann et al., 2007). In other words, one patented chemical compound actually has potential to be tested and commercialized for unknown target diseases. And the commercialization of a drug means that a firm has specialty in a specific therapeutic class;

as of today, Amgen, for instance, has 12 commercialized products while the company has more than 1000 patents.

I obtained firms' therapeutic classification of commercialized drugs through IMS health-USC code. I compiled commercialized drugs of each firm approved by US FDA (Food and Drug administration) and European Medicines Agency, because firms sometimes launch their products in the global market. Since European Agency uses WHO (World Health Organization)'s ATC (Anatomical Therapeutic Chemical) Classification code, I used a combination of ATC and USC code, and made drug lists of each firm. And then I converted drugs with ATC code to USC code to make unified drug lists of the firm. This process is critical particularly when the firm has approved drugs in European Countries, but not in the U.S. Finally, in order to calculate therapeutic area difference between partnering firms, I tabulated the 3-digit USC therapeutic classification to which each drug belongs, and then I used the following calculation method (Sampson, 2007; Van de Vrande et al., 2009) to calculate technological base complementarity of partnering firms.

$$\textit{Technological Base Complementarity} = 1 - \frac{T_i T_j'}{\sqrt{(T_i T_i')(T_j T_j')}}$$

Where T_i(j) represents the distribution of firm i (j)'s number of drugs across therapeutic classification. So it has multidimensional vector, for instance, T_i = (1, 4, 5, 6) in therapeutic class A, B, C and D. T_j = (0, 3, 2, 0). Then, the technological base complementarity will have a value from 0 to 1, with a value 1(0) indicating the greatest possible technological base diversity (complementarity) between two partnering firms; in this example, the technological base complementarity between firm i and j is 0.309.

Control Variables

I incorporated several control variables to isolate the effect of communication and coordination mechanism on alliance performance. *First of all*, I control for '*Firm Size and Age*', because bigger and older firms tend to have better capabilities and experiences that influence alliance performance (Rothaermel and Deeds, 2004; Lin et al., 2012). Firm size is measured by the number of employee. And firm age is measured by the age between the year of founding and the year the company allies with partners. However, I consider the size and age gaps between partnering firms since the unit of analysis of this study is an alliance deal. *Second*, I employed '*Cultural Difference*' between partnering firms to control for the effects of culture on the communication (e.g., knowledge transfer) and coordination in an alliance (Simonin, 1999; Garcia-Canal et al., 2008; Lavie et al., 2012). And I measured cultural difference by using Hofstede's Five Cultural Index, and calculated it through the formula proposed by Kogut and Singh (1988). *Third,* I control for '*Prior Alliance Experience'* with the same partners since alliances with the same partners have a positive effect on the better interaction and coordination of alliance (Lin, 2007; Dyer et al., 2007). And I count the number of prior alliances with the same partners to measure the alliance experience. *Fourth, 'Absorptive Capacity'* has been recognized as one of critical factors affecting R&D collaborations such as learning, knowledge transfer and interaction (Lane and Lubatkin, 1998; Tsai, 2009). Absorptive capacity of firm, university and research institute was measured by the accumulated number of patents from the year of inception to the year alliance formed. Many firms in the sample alliances are multinational corporations that have many different subsidiaries in multiple locations. And those subsidiaries do not always assign a patent to their own subsidiary in which the innovation

took place. In order to count all patents filed by subsidiaries, I first see the name of subsidiaries, and then trace the parent firms to which the subsidiaries belong. For this process, I have especially used Who Owns Whom and/or FACTIVA which provides company profiles. In addition, I have also researched the name of the firms to make sure that the patent is correctly assigned to the right firm, because firms sometimes change their name for some reason. And finally the accumulated number of patents is summed. *Fifth,* I incorporated *'R&D Uncertainty'* to control for the effect of difficulty in conducting research and development. According to DiMasi et al., (2010) and PhRMA (2011), approximately 6 out of 5,000 to 10,000 compounds enter the clinical trials, and one out of six drugs that enter the clinical trials can eventually obtain approval for marketing in the U.S. In addition, the success rate of three clinical trials varies; Phase I-64%, Phase II-39% and Phase III-66% (DiMasi et al., 2010). Therefore, the measurement for the R&D Uncertainty is based on the success rate of Research and three phases of clinical trial. *Finally,* I employed '*More Coordinative Alliances'* to separate the effects of more coordinative alliances (2B) from those more communicative alliances (2A). I coded '1' for those belong to the group 2B, and coded '0' for otherwise.

Model Specification

The dependent variable of this study is the Successful Alliance Collaboration Performance, and is a dichotomous variable taking the value of 1 for the successful milestone achievement and 0 for otherwise. With a binary dependent variable, logistic regression was applied to estimate the main effect and the interaction terms on alliance performance (Makino and Delios, 1996; McCann and Folta, 2011). And since the logistic

regression coefficients indicate the log odds of the dependent variable, it has the following equation:

$$\text{Ln}\left[\frac{P\,(Y=1)}{1-P\,(Y=1)}\right] = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + \beta_5 X_1 X_2 + \beta_6 X_1 X_3 + \beta_7 X_1 X_4 + \cdots + \beta_k X_k$$

Where β_0 is the constant, and X_n denotes independent as well as control variables.

5.5 Results

Table 5.3 represents descriptive statistics and a correlation matrix of all variables employed for this empirical test. Since variables are not correlated, multicollinearity is not a serious problem. To make sure this, we checked the VIF (Variance Inflation Factor) score of all variables. And it shows average 1.30 which is low, and thus does not seem to have a multicollinearity problem.

TABLE 5.3

Descriptive Statistics and Correlation Matrix

	VARIABLES	MEAN	S.D.	1	2	3	4	5	6	7
1	COLLABORATION PERFORMANCE	0.691	0.464	1.000						
2	AGE	2.656	4.638	0.111	1.000					
3	SIZE	2.390	4.250	0.093	0.045	1.000				
4	R&D UNCERTAINTY	3.414	0.071	-0.057	0.104	-0.227**	1.00			
5	ABSORPTIVE CAPACITY	2.145	8.731	0.052	0.135	0.304**	-0.117	1.00		
6	CULTURAL DIFFERENCE	0.534	1.017	0.010	-0.029	0.005	-0.114	-0.029	1.00	
7	ALLIANCE EXPERIENCE	0.083	0.276	0.028	-0.062	0.078	0.038	-0.031	-0.057	1.00
8	MORE COORDINATIVE ALLIANCES	0.691	0.461	0.007	0.127	-0.155	0.110	-0.063	0.065	-0.062
9	GOVERNANCE STRUCTURE	2.221	1.020	-0.247**	-0.113**	0.139**	-0.067	-0.048	0.059	-0.057
10	NATIONAL DIVERSITY	0.453	0.499	0.057	-0.121	0.251**	-0.148*	0.062	0.578**	-0.032
11	ORGNIZATIONAL DIVERSITY	0.166	0.373	0.106	0.419**	-0.201**	0.215**	-0.082	-0.180	-0.080
12	TECHNOLOGICAL BASE COMPLEMENTARITY	0.947	0.112	-0.018	0.098	-0.120	0.172*	-0.030	0.041	-0.115

*Correlation is significant at the 0.05 level

**Correlation is significant at the 0.01 level (two-tailed)

	VARIABLES	MEAN	S.D.	8	9	10	11
8	MORE COORDINATIVE ALLIANCES	0.691	0.461	1.00			
9	GOVERNANCE STRUCTURE	2.221	1.020	-0.015	1.00		
10	NATIONAL DIVERSITY	0.453	0.499	-0.074	0.129	1.00	
11	ORGNIZATIONAL DIVERSITY	0.166	0.373	0.294**	-0.277**	-0.197**	1.00
12	TECHNOLOGICAL BASE COMPLEMENTARITY	0.947	0.112	0.022	-0.077	0.039	0.214**

Table 5.4 shows the results of logistic regression on the successful alliance collaboration performance. As shown in Model 1, control variables such as firm age, size, prior alliance experience, cultural difference, absorptive capacity, more coordinative alliance and R&D uncertainty were entered first in the equation. However, no control variables except the firm age have direct effects on alliance performance reducing the significance of the base model. Model 2 represents the main model of this study estimating the effect of degree of communication and coordination costs in a given R&D alliance on alliance performance.

TABLE 5.4

Results of Logistic Regression

Variables	Model 1	Model 2	Model 3	Model 4	Model 5
Age	0.445 (.030)*	0.032 (.029)	0.028 (.028)	0.023 (.031)	0.019 (.030)
Size	0.021 (.026)	0.034 (.027)	0.021 (.028)	0.023 (.028)	0.022 (.029)
Alliance Experience	0.158 (.367)	0.035 (.366)	0.076 (.369)	0.081 (.368)	-0.044 (.386)
R&D Uncertainty	-0.155 (.220)	-0.157 (.223)	-0.323 (.235)**	-0.337 (.237)**	-0.309 (.244)**
Absorptive Capacity	0.002 (.015)	0.000 (.017)	0.005 (.018)	0.006 (.019)	0.007 (.022)
Cultural Difference	0.005 (.097)	0.022 (.099)	-0.041 (.122)	-0.033 (.125)	-0.020 (.125)
More Coordinative Alliances	0.170 (.367)	0.089 (.226)	0.141 (.388)	0.186 (.395)	0.154 (.413)
Coordination and Communication costs of Alliance Governance Structure		-0.352 (.109)***	-0.721 (.173)***	-0.694 (.184)***	-3.964 (1.541)**
National Diversity			-1.172 (.547)**	-1.153 (.550)**	-1.251 (.558)**
*Alliance Structure * National Diversity*			0.688 (.236)***	0.677 (.237)***	0.724 (.243)***
Organizational Diversity				0.272 (.665)	0.569 (.680)
*Alliance Structure *Organizational Diversity*				-0.078 (.361)	-0.189 (.368)
Technological Base Complementarity					-8.416 (3.782)**
*Alliance Structure * Tech. Base Complementarity*					3.360 (1.553)**
-2 Log Likelihood	219.093	208.109	198.675	198.481	192.028
Chi^2	4.960	15.680***	25.340***	25.570***	32.180***
NagelKerke R^2	0.037	0.118	0.184	0.185	0.228
N	181	181	181	181	181

Standard errors are in parentheses
*P < .10 ; **P < .05 ; ***P< .01

Hypothesis 7 proposes that the presence of higher levels of partner interaction and task coordination cost reduces the probability of successful alliance collaboration performance.

The result provides a strong support for this argument (*P<.01*). Model 3, 4 and 5 (full model) are about moderating effects of national diversity, organizational diversity and technological base complementarity of alliance partners on the relationship between costs of communication and coordination, and alliance performance. As can be seen from Model 3, ***Hypothesis 8*** proposing a moderating effect of national diversity of partners is also strongly supported (*P<.01*). To visualize the moderating effect of national diversity (i.e., Domestic vs. Foreign partners), I plotted the interaction of costs of alliance governance structure and national diversity on the probability of successful alliance collaboration performance (Figure 5.4). As shown in Figure 5.4, national diversity significantly moderates the costs-performance relationship in the sense that when firms adopt low-integrated alliance mode, alliance with domestic partners rather than foreign partners can have a higher probability of alliance performance because of reduced communication and coordination costs in the alliance. However, when firms ally with foreign partners, high-integrated modes such as EJV can actually weaken the coordination and communication costs on alliance performance; it shows that the negative slope becomes less steep (Figure 5.4). Thus, the results strongly support the second hypothesis. And this finding is consistent with prior studies (Parkhe, 1993; Teng and Das, 2008) in the sense that due to the more hierarchical alliance governance structure that deters opportunistic behavior yet enhances understanding of ongoing tasks, EJV is particularly effective when firms collaborate with foreign partners. ***Hypothesis 9*** is about the moderating effect of organizational diversity. But as shown from Model 4, I could not find any significant effects of organizational diversity on alliance performance. Therefore, it fails to support the third hypothesis. Finally, ***Hypothesis 10*** argues that firms adopting a low-integrated alliance governance structure

which entails low levels of communication and coordination can achieve a better performance when the technological base complementarity between alliance partners is low. But firms using a more organizationally integrated alliance mode such as EJV can actually ease the negative costs of communication and coordination-performance relationship, particularly when the technological base complementarity is high. Model 5 provides a strong support for this argument ($P<.05$). To gain insights from this interaction effect, I also plotted the interaction effect of costs of alliance governance structure and technological base complementarity on the probability of successful alliance collaboration performance (Figure 5.5). As can be seen from Figure 5.5, the negative slope is higher when the costs of communication and coordination are low and when technological base complementarity is low. However, the negative slope becomes less steep when technological base complementarity is high, and when firms use EJV.

FIGURE 5.4

Interaction of Alliance Structure and National Diversity

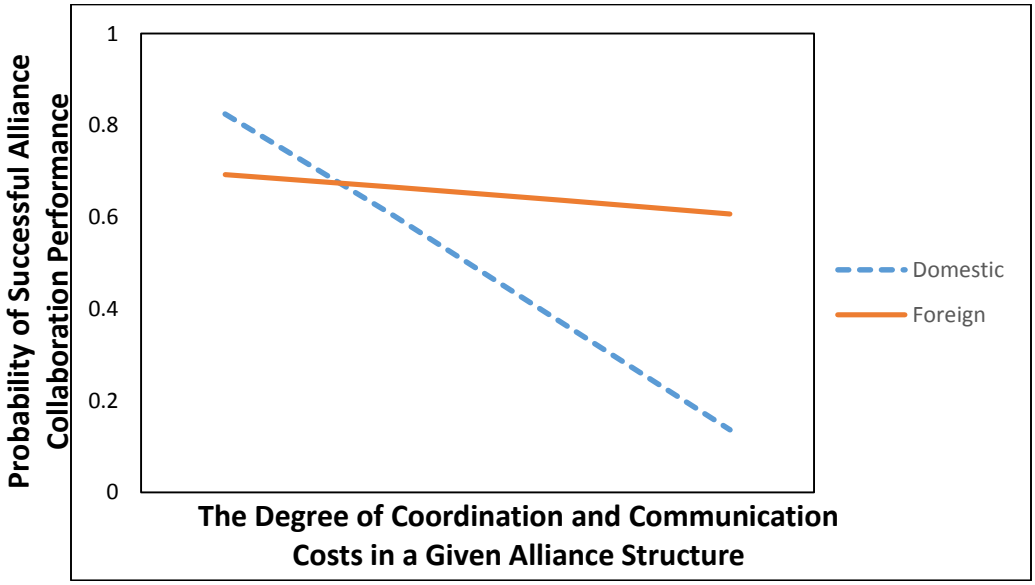
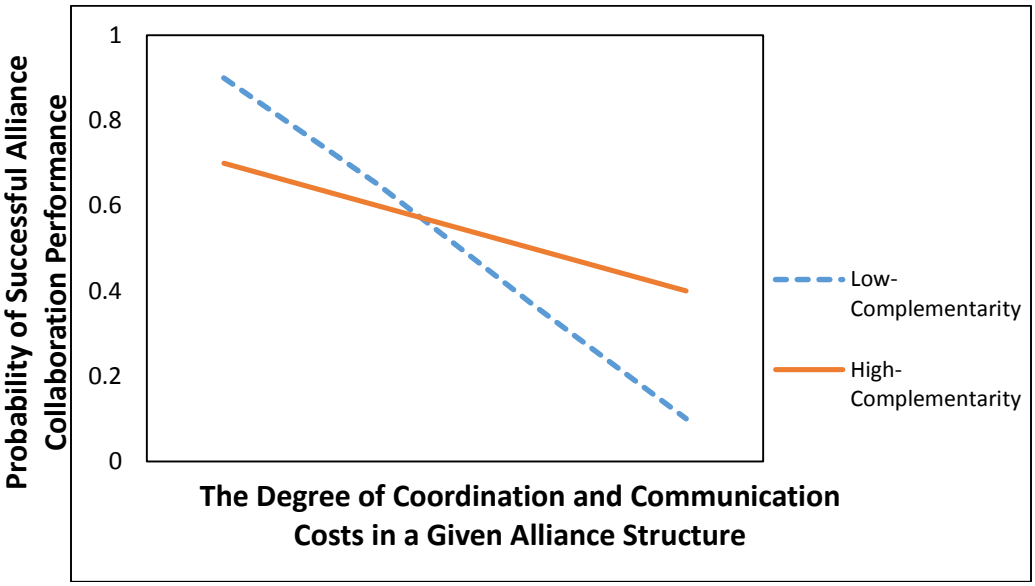


FIGURE 5.5

Interaction of Alliance Structure and Tech. Complementarity



5.6 Additional Findings

Although there is no direct effect of R&D uncertainty on the successful alliance collaboration performance, I suspect the interaction effect of R&D uncertainty with other independent variables because of unexpected significance of R&D uncertainty as shown in Model 3 ~5 in Table 5.4. I conducted a further test for a possible interaction effect, and found the three-way interaction effect among the following variables: Degree of communication and coordination costs in a given alliance structure, National Diversity and R&D uncertainty. And the result is reported in Table 5.5 and described in Figure 5.6.

TABLE 5.5

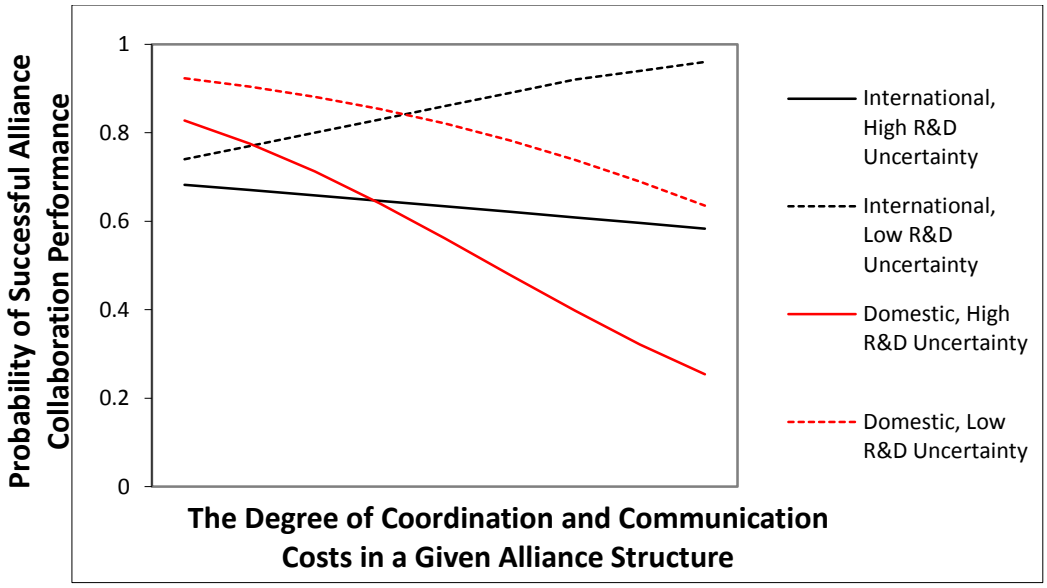
Three-way Interaction Effect

Variables	Model 6
AGE	0.034 (.045)
SIZE	0.029 (.050)
Alliance Experience	0.319 (.638)
R&D Uncertainty	-0.179 (.854)
Absorptive Capacity	0.018 (.034)
Cultural Difference	-0.083 (.217)
More Coordinative Alliances	0.355 (.418)
Alliance Governance Structure	-0.912 (1.055)
National Diversity	-8.858 (4.675)**
Alliance Structure * National Diversity	5.973 (2.714)***
Alliance Structure * R&D Uncertainty	-0.128 (.304)
National Diversity * R&D Uncertainty	1.713 (1.230)*
Alliance Structure * National Diversity * R&D Uncertainty	-1.194 (.702)**
-2 Log Likelihood	185.348
Chi^2	36.959***
Nagelkerke R^2	0.261
N	181

Standard errors are in parentheses
*P < .10 ; **P < .05 ; ***P< .01

FIGURE 5.6

Three-way Interaction Effects



As supported in hypothesis 2, when firms adopt low-integrated alliance modes that incur lower communication and coordination costs, alliances with domestic partners rather than foreign partners have a higher probability of successful alliance performance because of reduced communication and coordination costs in the alliance. In addition, alliance with foreign partners through high-integrated alliance modes can weaken the negative impact of communication and coordination costs on alliance performance. However, this moderating effect varies depending upon the R&D uncertainty. In both cases (alliances with foreign and domestic partners), alliances under low R&D uncertainty, as opposed to high R&D uncertainty, tend to show increased probability of successful alliance performance.

5.7 Discussion and Conclusion

By using a new classification of alliance governance modes and addressing the cost side of governance structure, the study not only reveals intriguing yet critical factors affecting the alliance collaboration performance, but also provides implications for researchers and practitioners into the paradoxical phenomenon taken place in one of the most knowledge intensive industries. Firms in the pharmaceutical and biotech industry prefer a more flexible yet complex alliance structure to equity-based alliances (e.g., EJV) even though their R&D activities are highly knowledge intensive. To explore some possible explanations, in this study, I examine the effects of communication and coordination mechanism in a given R&D alliance on the successful alliance collaboration performance. Based on this main model, I further investigated moderating effects of national diversity, organizational diversity, and technological base complementarity of alliance partners. And the findings demonstrate that coordination and communication costs derived from the partner interaction associated with the ongoing tasks, and the complexity of alliance components in a given alliance governance structure hinder the achievement of successful alliance performance. This finding partly explains why firms in the pharmaceuticals are more likely to use more complex yet flexible alliance modes than equity joint venture. Nevertheless, as shown from the moderating effects of national diversity and technological base complementarity of partners, EJV provides a better and more organizationally integrated control mechanism that enhances the alliance collaboration performance. More specifically, when firms use EJV, national diversity and technological base diversity of partners does not much have negative impacts on alliance performance. Firms under the equity-based control mechanism providing an informal interaction opportunity as well as

a conflict solution in case of miscommunication can actually relieve the costs of governance structure and enhance tacit knowledge transfer and creation, when they collaborate with foreign partners and partners with diverse technological backgrounds (Gulati and Singh, 1998; Teng and Das, 2008). Given those, the findings are consistent with the arguments of KBV about EJV as a vehicle that promotes better knowledge transfer and creation performances in the face of partner diversities (Kogut and Zander, 1992; Chen, 2004; Oxley and Wada, 2009).

The study framework and findings have a few theoretical contributions to the business management literatures. *First*, this study provides a new classification of alliance governance mode that can be utilized further for the more complex and in-depth study of strategic alliance in the context of challenging environment that brings more severe competition and higher uncertainty. For instance, under ROT (Real Options Theory) it supports the argument that firms facing radically changing environments and thus increased uncertainty are more likely to use more flexible and complex alliance governance structures than equity-based alliance which usually entails greater sunken costs, so that they can minimize uncertainties while having more options to alter their initial decision on the choice of alliance governance mode (Folta, 1998; Hagedoorn and Duysters, 2002; Colombo, 2003; Van de Vrande et al., 2009). The new classification can be fully utilized as alternative options of alliance governance structure that might have been neglected in prior studies. *Second*, this study enhances the study of strategic alliance as the findings extend the KBV. Previously under KBV, researchers have emphasized the types of alliance, whether those are non-equity or equity-based alliances, as a method to transfer and create technological knowledge. And it did not provide explanations on what alliance governance

mechanisms really promote or hamper alliance collaboration performance. By focusing on the coordination and communication mechanism of alliances, the findings extend the KBV of strategic alliance and provide a more insightful reasoning on the choice of alliance governance structure for enhancing the performance. *Finally*, the findings also provide implications to related fields of study such as international business, which examine factors affecting the choice of international alliance governance structures. The interaction and coordination in international alliances can be more costly and difficult to govern. I believe that scholars studying alliances in the context of international business should be able to use the findings that underscore the effective alliance coordination and communication mechanisms and the importance of balancing similarity and complementarity of alliance partners.

In addition to theoretical contributions of this study, the study also provides insightful managerial implications. The findings show that the lower the communication and coordination costs in a given R&D alliance, the more likely is it that the alliance achieves a successful alliance performance. And it seems from the results that the low-integrated alliance governance structure in general is better than others. Then it is questioned that what degree of interaction and complexity is ideal for the better alliance performance. As can be seen from the discriminant analysis for the classification of new alliance governance modes, the cut-off degree of interaction and complexity for the low-integrated alliance governance structure are 4 and 33 respectively. This suggests that when firms form an alliance, they can use combined alliance modes that contain multiple alliance deal components where the deal components yield up to 4 interactions (e.g., cross-licensing + joint research collaboration= 4) and low levels of complexity in order to facilitate

communication and coordination, and to achieve a better performance. The alliance governance structure that goes beyond the cut-off degree of interaction and complexity may yield negative impacts on the communication and coordination and thus the performance. Nevertheless, firms can utilize equity-based alliance governance structure, particularly when they collaborate with foreign partners and partners with diverse technological bases. Therefore, firms should be able to adjust and adopt a best suitable alliance governance structure, because the relationship between alliance governance structure and performance is contingent on the degree of alliance partner diversity and technological base complementarity.

Although the framework and findings provide implications to scholars and practitioners, there are a couple of limitations of this study which may in turn offer possible future research opportunities. *First*, the dependent variable measuring the successful alliance performance, which may include knowledge transfer, creation, modification, transformation, application and combination of any of these activities, takes a behavioral view point and may neglect the importance of financial achievement of firms. One of critical motivations for the formation of alliance is to share costs of R&D. And this is salient in the knowledge intensive industries such as pharmaceuticals where it is hard to amortize R&D investments on product developments. If I incorporate financial achievement as one of performance measurements, it may have different results from the findings based on the success of alliance collaboration measurement. I could not employ the financial achievement since it is hard to get financial data; in many cases, financial information is not disclosed even in the real contract. *Second*, limited number of years of window (i.e., 4 years) I looked to test the models has its drawback in defining the successful

alliance performance. In the case of failure of commercialization of drug products (i.e., FDA approval), it is confusing whether the success of prior alliances at any stages in the R&D process was really the successful one. Therefore, further study will need to expand the time window in order to be able to see the alliance portfolio at the firm level, and thus clearly define the successful alliances.

CHAPTER 6

CONCLUSION AND IMPLICATIONS

6.1 Summary of Dissertation

International alliance governance mode choice is one of critical research streams in the field of international business. It is also an important strategy, particularly for those firms involving in R&D activities in a knowledge intensive industry, because choosing an appropriate alliance governance mode directly affects the innovation performance as well as overall growth of firms. However, it is highly uncertain when it comes to choosing international R&D alliance governance modes since alliance partners and national R&D environments vary across countries. In addition, it is unsure which alliance governance structures provide a better incentive and mechanism for sharing technological knowledge while protecting firms' proprietary technology and minimizing opportunism from alliance partners.

The dissertation is specially designed to address those challenging issues rising from the choice of effective international R&D alliance governance modes. In addition, the research setting focusing on alliances in the one of knowledge intensive industry, pharmaceuticals, provides a good research context, because the usage of different types of alliances is dominant and there is a significant distinction between Research and Development activities allowing me to examine the factors affecting the choice of R&D alliance governance modes under different activity (i.e., R vs. D). The first study of the dissertation investigates the determinants of international R&D alliance governance mode choice. It seems that all national factors (e.g., quality of human capital, culture, institution and geographic distance) significantly affect the choice of more-integrated alliance

governance modes. However, it does not necessarily mean that industry and firm-specific factors are meaningless, because those national, industry and firm-specific factors have different impacts on the choice of alliance governance modes depending upon whether firms are in R stage or D stage. In sum, firms are more likely to choose a more-integrated alliance governance structure in order to promote knowledge sourcing activity, protect proprietary technologies and avoid partner opportunism, particularly when they ally with partners in geographically distant locations and institutionally (i.e., weak IPP regime) different countries. Less-integrated alliance modes can also be used when firms collaborate with partners where cultural environment is different and the quality of human capital is not available since those differences rising from culture and quality of human capital may block knowledge flow between partners. However, due to work characteristics of Development (relatively short-term and standardized activity compared to Research), firms in development phase are more likely to use less-integrated alliance modes when they ally with partners in different culture, industrial technology specialization and technological bases.

After firms make a decision on the appropriate alliance governance mode, then the question is whether the alliance mode chosen can help achieve a better alliance collaboration performance. Given this, the second study of dissertation answers the following question "How does the alliance governance structure (i.e., interactive and coordinative structure) influence the success of alliance collaboration?" The second study particularly provides insightful implications and explanations for a paradoxical phenomenon taken place in the knowledge intensive industry; unlike what theory suggests (e.g., Knowledge Based View of alliance), the hierarchical alliance mode such as EJV is

not widely used in the pharmaceutical industry although it is, according to KBV, an ideal mode for knowledge sharing and transferring activity since it provides organizationally integrated interaction mechanisms between partnering firms.

I specifically investigate coordinative and communicative alliance governance structure and its impacts on the successful alliance collaboration performance (i.e., probability of successful alliance collaboration) which goes beyond the simple knowledge transfer and share activities of partnering firms. And I found that the higher the coordination and communication costs in a specific alliance mode, the lower the probability of successful alliance collaboration performance. In addition, partner's national diversity (i.e., foreign vs. domestic) and technological base complementarity has an interaction effect on the coordinative and communicative alliance structure-performance relationship. Specifically, when alliances are formed between foreign partners, the negative alliance structure-performance relationship becomes weakened. It means that the most integrative alliance mode (i.e., EJV) provides a more organizationally embedded collaboration mechanism even though its interaction/communication and work coordination costs between partners are greatest. And, when the technological base between partnering firms is diverse rather than complement, the negative alliance structure-performance relationship is mitigated meaning also that the high-integrative alliance structure, although it is high in coordination and communication costs, promotes knowledge sharing activity through a better incentive alignment and a more integrative collaboration mechanism. All the hypotheses and the results are presented in the Table 6.1.

TABLE 6.1

Summary of Results

HYPOTHESIS		RESULT
H1	*The greater the difference in the quality of human capital of the home nations of the allies, the lower the likelihood of using a more integrated alliance mode.* *Moreover, this negative relationship will be even stronger when the R&D is in the development phase rather than the research phase.*	Partial Support
H2	*As the difference between the nations of the allies increases, in terms of institutional factors such as the rule of law, there will be a greater likelihood of using a more integrated alliance mode.* *And this positive relationship will be even stronger when the R&D is in the development phase rather than the research phase.*	Supported
H3A	*As cultural difference in power distance between partnering firms increases, the likelihood of using a more-integrated alliance mode will decrease.* *Moreover, this negative relationship will be stronger for R&D in the development phase rather than in the research phase.*	Supported
H3B	*As cultural difference in long-term orientation between partnering firms increases, the likelihood of using a more-integrated alliance mode will decrease.* *Moreover, this negative relationship will be stronger for R&D in the development phase rather than in the research phase.*	Partial Support
H4	*As geographic distance between partner firms increases, the likelihood of using a more-integrated alliance mode is increased.* *And this positive relationship will be stronger for R&D in the research phase rather than in the development phase.*	Supported
H5A	*As the gap between allies in Industrial R&D intensity increases, the likelihood of using a more-integrated alliance mode will decrease.* *And this negative relationship will be stronger for joint work in the development phase rather than in the research phase.*	N.S.

H5B	*As the gap between allies in Industrial technology specialization increases, the likelihood of using a more-integrated alliance mode will decrease.* *And this negative relationship will be stronger for joint work in the development phase rather than in the research phase.*	Partial Support
H6	*As the Therapeutic Area Difference between partnering firms increases, the likelihood of using a more-integrated alliance mode will decrease.* *And this negative relationship will be stronger in the development phase than in the research phase.*	Partial Support
H7	*The degree of coordination and communication costs in a given R&D alliance structure is negatively related to the successful alliance collaboration performance.*	Supported
H8	*The degree of coordination and communication costs, and national diversity of partners in a given R&D alliance have an interaction effect on the successful alliance collaboration performance.*	N.S.
H9	*The degree of coordination and communication costs, and organizational diversity of partners in a given R&D alliance have an interaction effect on the successful alliance collaboration performance.*	Supported
H10	*The degree of coordination and communication costs, and technological base complementarity of partners in a given R&D alliance have an interaction effect on the successful alliance collaboration performance.*	Supported

6.2 Theoretical Contributions

This dissertation provides a number of critical theoretical contributions to International Business and Global Strategy literatures. *First*, the dissertation identifies various R&D alliance modes used in one of knowledge intensive industries (i.e., pharmaceuticals); there are at least 12 different types of alliance as described in the appendix. This is a very important and a critical contribution, because, previously under TCE, alliance modes tend to be classified into the dichotomous category (i.e., non-equity vs. equity based alliances) limiting to describe few alliance activities. By identifying mixed alliance modes (e.g.,

licensing plus joint research collaboration agreement), the dissertation enhances the concept of incentive alignment of such alliances. For instance, under TCE, firms can reduce transaction costs through a stronger incentive alignment provided by a hierarchical mode. But this dissertation describes the usage of mixed alliance modes as a means to incentivize alliance partners' resource commitment and to reduce partner opportunism, and thus enhances the traditional TCE. *Second*, the dissertation also provides a new classification of alliance governance modes based on two dimensions (i.e., the degree of complexity and the degree of interaction in a given alliance agreement), and new labels on those four categories (Figure 4.2) from low-integrated non-equity based alliance modes, to moderately-integrated modes, to high-integrated modes, and to equity-based alliance mode (e.g., equity joint venture) as the most integrative mode. As long as this classification is based on those 12 different types of alliance agreement, it allows researchers to revisit the study of alliance governance mode, and to capture dynamisms of alliance activities. Moreover, this classification covers mixed collaboration modes such as a combination of licensing with a joint development agreement that is new to the International Business literature. *Third*, the study design investigating multi-level factors affecting the choice of R&D alliance governance modes enhances the arguments of international alliance formation and provides better explanations of previously mixed results. As mentioned earlier in the introduction part, the study about the determinants of international alliance formation has shown inconsistent results due to the diversity of the research context (e.g., R&D, marketing and manufacturing alliances) and various motivations for alliance formation. This dissertation provides a better approach, and thus better explanations regarding the mixed results by focusing on multi-level determinants (e.g., country, industry

and firm-specific factors), one industry and its motivation, the R&D activity. And the model of first study of this dissertation splitting R from D is particularly useful since it scrutinizes the impacts of multi-level factors in a different stage of alliance activity. *Fourth*, the second part of dissertation that examines the relationship between coordination and communication structure of an alliance, and the successful alliance collaboration performance bolsters the KBV of strategic alliance. The method used in this study, the discriminant analysis measuring the coordinative and communicative structure of alliances, supports a better explanation on the reasons for the paradoxical phenomenon in the usage of alliance mode; unlike what KBV suggested, the most organizationally integrative alliance mode such as EJV is not a preferred mode among firms in the pharmaceutical industry due to high coordination and communication costs. On top of this, the findings support the KBV in the sense that the negative relationship described above is contingent upon the degree of alliance partner's national diversity and technological base complementarity. Thus, the findings of this dissertation cover the limitations of KBV while it strongly support the arguments of KBV. *Finally*, the measurement for the successful alliance collaboration performance is particularly useful to capture a more direct R&D alliance collaboration performance where the performance is not simply an outcome of knowledge creation in the form of patent or knowledge transfer (i.e., the amount of knowledge transferred to the partner firm). The question rising from prior studies was what if those knowledge transferred or created through an alliance collaboration are not useful or unqualified in terms of its application to the product development; in the case of pharmaceutical firms, there have tens of thousands of drug compounds that are unqualified or limited to apply to human basis clinical trials although those drug compounds are the

outcome of research alliance collaboration. Moreover, financial performance, for instance, also has its drawbacks, because it can be affected by multiple factors such as market condition, marketing alliance, manufacturing alliance, and so on. Hence, unlike patent/product based performance measurement of the others, the performance measurement used in this dissertation provides a more direct measurement of R&D alliance performance as it measures the quality of alliance collaboration (i.e., the probability of successful alliance collaboration).

6.3 Managerial Implications

The dissertation also provides insightful implications for practitioners. Firms engaging in international R&D alliance have always been facing challenging decisions on where to locate their R&D, which alliance partners, and which alliance modes they should choose. This dissertation gives practitioners potential strategic options to respond those challenging issues.

Knowledge (technological knowledge) is a key resource of competitive advantage of companies for their growth and sustainability. Firms can develop the new technological knowledge on their own through in-house R&D. However, because of increased industry rivalry, radically changing technology and its environment, and globalization, relying on in-house R&D does not guarantee a sustainable growth of the firms. In addition, firms in a knowledge intensive industry tend to face more difficulties due to the complexity of technology and the vertically disintegrated R&D activity. This has been contributed to the increased costs and risks of doing in-house R&D, and negatively affected profitability and sustainability of firms since the firms fail to amortize their R&D expenditures. As such, it

has become the most critical strategy for firms to reduce the costs and risks of R&D while they develop new technologies.

Firms now actively engage in external knowledge sourcing activities rather than rely entirely on in-house R&D. And they use different types of alliance as a means to access, learn and source new external knowledge, as well as to share costs and risks of R&D. Moreover, because of path-dependency of technological development, and limited availability of external technology within a country, firms are more likely to involve in international R&D activities. But international knowledge sourcing is a challenging activity and thus brings important strategic questions mentioned above. *First*, firms need to approach systematically when it comes to the location and partner choice for their international R&D activities, because location and partner selection is not attributable to a single factor (e.g., partner's technological background) but to multiple factors. For instance, firms in the U.S. increasingly outsource clinical trials (Development) to foreign clinical centers located particularly in Asian countries (except Japan). Firms can choose a less-integrative alliance governance mode such as low and moderately-integrated alliance modes to remain flexible in the face of uncertainty rising from organizational cultural difference (country-specific factor), lack of specialized technology in the industry (industry-specific factor), and firm-specific technological base difference. Firms in Asian countries tend to be culturally different from those in the U.S. In addition, those Asian countries tend not to be industrialized in the biopharmaceuticals, and have a shorter industry history. Firms or other contract development institutions in those countries have their experience and specialty for designing and conducting specific clinical trials. Then, it is better for U.S. companies to use low-integrated alliance modes since the alliance modes

are more reversible at a lower sunken costs in the case of unsuccessful event from the experimentation. Nevertheless, firms need to consider a little more integrated alliance modes such as moderately-integrated modes if those Asian countries provide a weak IPP regime. The reason is that no firms want to outsource clinical experiments to countries where the countries do not strongly provide standardized experiment procedures nor protect clinical trial results (this can be a trade secret of a firm). Hence, a moderately-integrated mode containing more complex provisions in the agreement can provide a better monitoring and controlling mechanism that helps relieve uncertainty from weak IPP regimes.

On the other hand, firms involving in research activities rather than development need to particularly consider the geographic location of partners as well as quality of human capital in the location, due to the characteristics of research activities requiring a closer communication and interaction among scientists. Firms collaborating with geographically distant partners can use moderately-integrated alliance modes such as mixed mode (cross-licensing plus joint research collaboration agreement) in order to promote knowledge transferring and sharing activities between partnering firms. However, if those locations are not attractive for research activities due to lack of qualified human capital and absorptive capacity, it will not be encouraging knowledge sharing and creating activities. In this case, firms can still collaborate with less skilled partners by allying through a low-integrated mode. For example, by simply licensing out firms old/outdated technology, they can monetize their technologies.

In sum, alliance governance modes and their coordination and communication structures have become more complicated as the degree of diversity of technology and

R&D activities increases. This makes firms in a technology intensive industry more difficult to choose an effective alliance governance modes. Firms should be able to systematically take into account multiple factors when they internationalize their knowledge sourcing activities. But also firms need to be nimble and flexible in terms of adopting proper alliance modes in the face of unsuccessful events from R&D alliances. In general, non-equity alliance modes such as those classified into low, moderately and high-integrated alliance modes tend to lead a better performance because of less coordinative and communicative structure of alliances compared to equity-based joint ventures. And those alliance modes are reversible at a lower sunken cost in the face of unsuccessful outcomes. Firms sometimes form a JV for a long-term multiple R&D project. However, when firms deal with very complicated R&D activities under highly uncertain technological environments, EJV as a collaboration mode is not recommendable due to the greater sunken costs (non-reversible) and increased communication and coordination costs rising from multiple R&D activities; firms tend not to form a joint venture for a single project such as Phase I clinical trial.

6.4 Limitations and Future Research

Although the dissertation contributes to the study of strategic alliance and provides significant implications to the researchers and practitioners, there are a couple of limitations that need to be considered for further research. *First of all*, the dissertation looks into samples in 4-year period from 2000 to 2003. It is old data, and thus the results from the empirical analyses might not be generalizable for today's business activities. For instance, it has recently (after 2005) seen that many foreign pharmaceutical firms

increasingly outsource their clinical trials to those development centers in Asian countries (e.g., India). However, there was only one US-INDIA alliance (that was EJV) in the sample. There are at least two reasons for this unique trend. *First,* historically there are three big markets in the world that consist of almost all pharmaceutical R&D activities; European Union, North America (U.S.), and Japan. *Second,* due to lack of strong intellectual property regimes, many multinational firms are reluctant to conduct clinical trials in those Asian countries. The major concern was that the results of their clinical trials can be leaked out and used by other local firms. That is why U.S. and European pharmaceutical firms have been hesitant to conduct clinical trials in India until the government approves the stronger patent act in 2005. Nevertheless, the rule-of-law score representing the strength of IPP law is still low for those Asian countries. Thus, the limited time window of the sample does not have serious impact on the results. More fundamentally, the primary reason why I employ those sample firms during 2000 to 2003 is to measure the successful alliance collaboration performance, the dependent variable for the second study. For example, the success of such alliance formed in 2003 for conducting phase I clinical trial is not known until the alliance completes 3~4 years of experiment. But the time consumption may vary depending upon its protocol. In this case, I had to look for the result of clinical trial available in 2007. This process contributes to the limited time window of this dissertation.

Another limitation of this dissertation lies in the single industry setting. For instance, clinical trial is a very industry-specific development activity. And due to the difficulties in finding volunteer patients for clinical trials, firms geographically diversify their clinical trials to reduce costs and possible delay in conducting trials. However, firms in other

knowledge intensive industries (e.g., IT and Telecommunication) tend to perform R&D in a single or a few locations. Moreover, R&D activities of IT and Telecom industries are not as much fragmented as those of biopharmaceuticals. Given these, the results of this dissertation may not be practical for managers in other than pharmaceuticals. Nevertheless, according to Hagedoorn et al. (2008), those alliance types (i.e., mixed modes: Licensing plus joint collaboration agreement) that also belongs to one of the alliance governance classification systems of this dissertation are widely used among firms in IT and Telecom industries. Therefore, researchers and practitioners may have to discretionally apply the findings of this dissertation to their research setting or their business practice.

The dissertation also provides future research opportunities.

(1) ***Application to the Real Option Theory***: The concept of real options has been highlighted in the management and strategy literatures in the past few decades since it embeds real options reasoning in an organization; a firm's ability to sequence and reverse investments made under conditions of uncertainty as strategic processes (Kogut, 1991; Trigeorgis, 1996; Leiblein and Miller, 2003). In this sense, real options can be viewed as a decision-making technique/strategy that focuses on value creation and resource reconfiguration (McGrath et al., 2004; Miller and Arikan, 2004). In addition, real options theory (ROT) emphasizes the value of investments that allows firms to control uncertainty in a flexible manner through a right choice of organizational governance mode. One of research stream that fits well with the real options logic is Research and Development (R&D), and knowledge sourcing activity (Van de Vrande et al., 2009), because firms in high-tech industries oftentimes have to

make investment decisions on how to access and acquire external technological knowledge through appropriate governance modes (e.g., outsource through a licensing or collaboration through an Equity Joint Venture-EJV) under uncertain environments. Given the fact, alliance governance mode classification provided in this dissertation can be used as an option to reverse initially chosen alliance mode in the case of alliance failure. Sometimes it is too risky and costly to use EJV, because technological environment uncertainty and operational uncertainty such as failure of knowledge share and coordination activity may lead to the adverse selection problem. But rather, firms can use a more flexible yet organizationally embeddedness mode, the high-integrated governance mode for a better knowledge sharing activity.

(2) ***R&D Alliance Portfolio Strategy***: As can be seen from Figure 1.4, a firm has collaborated with diverse partners for multiple times to commercialize only one drug. This means that successful commercialization may be depending upon a firm's right collection of alliances with diverse partners (i.e., alliance portfolio strategy). Prior studies have focused on alliance portfolio as a composition of alliance partners (Hagedoorn and Schakenraad, 1994; George et al., 2001; Lavie, 2007; Jiang et al., 2010). And their findings generally emphasize the importance of strategic optimization and balance of heterogeneous resources and knowledge of partners in order to maximize performance. However, the usage of different types of alliance governance mode throughout the R&D activities need to be investigated as part of alliance portfolio strategy.

(3) ***Design the Alliance Contracts for Mutual Benefits***: Recently, scholars have increasingly interested in understanding the alliance contract and its design for mutual

benefits of alliance partners. For instance, Contractor and Reuer (2014), and Reuer and Ariño (2007) classified alliance agreement governance over a wider spectrum of categories, and proposed specified alliance contracts for a better inter-firm collaboration. However, it is underdeveloped the method to craft complex alliance agreements for achieving mutual benefits. Using my alliance governance mode classification containing those mixed and complex contractual provisions, future research can explore what contractual provisions need to be included for a better knowledge sharing activity while it guarantees future earnings. For instance, by adding a joint research steering committee as part of incentive alignments, both partnering firms can actively engage in knowledge sharing and creating activity without partner opportunism. In addition, both firms can also add financial reward terms (e.g., royalty payment for each milestone achievement) to ensure future earnings from their collaboration. Therefore, both partner firms can gain mutual benefits from the alliance agreement.

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8. APPENDIX

The Components of International Alliance Agreements in the Pharmaceutical Field

I. Alliances that are contractual and do not involve equity joint ventures

(1) Tangible Asset Purchase (AP): One company acquires legal control of one or more physical assets such as manufacturing plants/ equipment, all finished or work-in-progress product inventories, all laboratory supplies, laboratory animals and so on.

(2) Contract Development (CD): One party sponsors clinical trials at the other company; e.g., a pharma company sponsors clinical trials at a small biotech, where the biotech completes all developments (i.e., clinical trials on its own). More specifically, the sponsoring party conducts, monitors and governs clinical trials in accordance with the protocols. And the sponsored party delivers status reports, data and results to the sponsoring party.

(3) Contract Research (CR): In a Research agreement, a sponsoring party engages another party to perform basic research services in the discovery and/or lead stages of an R&D project

(4) Cross-Licensing (CrL): One party obtains a license to the intellectual property of the other party in exchange for granting a license of its own intellectual property

(5) Passive Equity Purchase (E): An agreement in which one company issues shares of its stock to the other company, either in exchange for cash or loan amounts. Many agreements utilize equity investments as part of the upfront or continuing compensation to the other company; Equity purchases are a method of payment for certain research services (e.g., screening and analysis) or funding the research costs of the other party

(6) Joint Development (JD): Both parties participate in and share the costs and risks of clinical Development and/or commercial expenses; both parties may form a JSC (Joint Steering Committee -- an advisory committee) to design and monitor the clinical development plan. Both parties are responsible for all direct and indirect costs and expenses incurred in carrying out Development Activities. And they prepare and review protocols for clinical trials; One party may conduct a clinical trial and keep its progress known to the other party, while the other party provides or transfers technology for clinical trials

(7) Joint Research (JR): Both parties participate in the basic research program. They may exchange data, information and materials necessary for each party to perform its obligations under the research plan. And either party may supply the other party with proprietary materials for use in the research program. Joint research activities include screening assays for identifying and testing the activity of compounds, and selecting lead compounds for clinical development and commercialization

(8) License (L): One party obtains a License under the other party's intellectual property to research, develop, make, use, sell, or market or promote a product or technology. Under a License agreement, the originator of the technology typically retains some rights in the product/technology and receives continuing payments such as royalties on net sales of the product/technology throughout the term of the agreement

(9) Loan (Lo): A Loan is a payment or promise of future payment from one party to another. Repayment may be in the form of cash or equity from the borrowing company. A loan can be used for studies or research funding. And in return, the party proving the funds will receive repayment upon any achievements in clinical stages and/or regulatory stage

(10) Manufacturing (M): In a Manufacturing agreement, one party manufactures a product, usually a compound, for use by the other company in clinical development or commercialization stages.

(11) Supply (S): In a Supply agreement, the company will make or have made a product for use or sale by the client company. The major difference between supply agreement and manufacturing is that a supply agreement usually contains delivery/distribution of products or lead compounds for clinical development trials as well as active pharmaceutical ingredients.

II. Alliances that are equity joint ventures

(12) Equity Joint Venture (EJV): Company A and company B (or more parties) create a new separate legal entity which is jointly staffed and operated by the principals.

7.1 An Illustration of R&D Alliance Activities

Vertex Pharmaceuticals Inc.[13]

FDA Approves INCIVEK™ (telaprevir) for People with Hepatitis C Virus (HCV) on May 23, 2011

1. Early Drug Discovery Stage

Vertex Pharmaceuticals Inc. was conducting a discovery research program to develop compounds to treat Hepatitis C virus diseases. The company signed a research collaboration agreement with Eli Lilly in June 1997. Under this agreement, Vertex and

[13] Vertex Pharmaceuticals Inc. is one of sample companies in the database, and has nothing to do with this dissertation project.

Lilly jointly manage the research, development and commercialization of drug candidate from the collaboration. Vertex has responsibilities for drug design, process development and pre-commercial drug substance manufacturing, and Lilly has responsibilities for formulation, preclinical, clinical development and global marketing.

Along with the research collaboration, one of their agreements was ***royalty financing contract***[14]. Lilly were agreed to pay Vertex up to $51 million, comprised of a $3 million payment paid in June 1997, $33 million of product research funding over six years and $15 million of development and commercialization milestone payments. And Vertex will owe Eli Lilly royalties on any future sales of drug, if launched in markets.

2. Preclinical Stage

In December 2001, Vertex and Lilly, under their research collaboration agreement, identified and selected a compound named VX-950 (LY570310), an oral HCV protease inhibitor, for preclinical development. Eli Lilly engaged in preclinical development from 2001 till it shows significant results for the IND application in order to be able to conduct the Phase I clinical trial. In 2003, Lilly finished preclinical research and presented promising preclinical results for VX-950 in multiple medical and research conferences. By the end of compound development for VX-950, their agreement now ended.

[14] Royalty financing contract is a kind of financing option for companies who need funds for research and development. And the investment company acquires the right to future royalty payments in return for payment of a lump sum payment to the drug development companies for the sales of product.

3. Clinical Trials

3.1 Phase I (a, b)

Vertex designed the Phase I clinical trial and divided into two, Phase I (a) and I(b), to test drug safety and tolerability for healthy volunteers and for HCV-infected patients, respectively. The company conducted and completed Phase I (a) with positive results in late 2004, and also completed Phase I (b) as well in 2005.

In the interim, Vertex entered into a licensing, development and commercialization agreement with Mitsubishi Tanabe Corporation for VX-950 in June 2004. Under the terms of the agreement, Mitsubishi has the right to develop and commercialize VX-950 in Japan while Vertex retains its development and marketing rights to VX-950 in the rest of the world. Mitsubishi conducted Phase I clinical trial for VX-950 to patients in Japan in 2006, and was planning to design a Phase II clinical trial.

3.2 Phase II (a, b)

When Vertex was on the verge of engaging in Phase II clinical trial, the company entered into a licensing, development and commercialization agreement with Janssen, a Johnson and Johnson Company, in June 2006. And Janssen received exclusive rights to commercialize Telaprevir (new label for VX-950) outside of North America and the Far East. Janssen conducted Phase II (a, b) trials in 2006 and 2007, respectively.

3.3 Phase III (a, b, c)

Vertex and Janssen designed three different Phase III clinical trials (i.e., named Advance, Illuminate and Realize). In late 2008, Vertex conducted two Phase III trials, referred to as Advance and Illuminate whereas Janssen conducted one trial named as Realize in 2009. And both companies completed their trials in 2010.

4. FDA Filing for Approval

In November 2010, Vertex filed their new drug, Telaprevir, to the FDA for Approval. And the FDA approved the drug on May 23, 2011.

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