Alliance, discrepancies and firms' innovation performance in pharmaceutical industry

Abstract

Our research proposal categorizes firm performance as exploitative and explorative, and linking them to alliance attributes through a three-dimensional construct which covers both focal and partner firms. We propose three kinds of structural aspects of firm's strategic alliances: relational discrepancy, institutional discrepancy, and technological discrepancy. We then link these alliance-specific factors to firm's performance. We argue that firm's performance in terms of exploitation and exploration is affected by the attributes of these discrepancies. Our study will analyze U.S pharmaceutical firms covering years from 1995 to 2000. The data will be collected from Security Data Company (SDC) strategic alliance database and Compustat. Our propositions hopefully contribute to the debate on whether and how firms benefit from strategic alliances by drawing attention to the nature of alliance structure and its impact on explorative/exploitive innovation.

Key words:

Strategic alliances, exploration, exploitation, firm performance.

I. Introduction

Today the purely internal oriented, centralized R&D has become obsolete. This conventional logic has been substituted by an "open" innovation which embraces external ideas and knowledge in conjunction with internal R&D to realize the value – added objectives (Chesbrough, 2004). Richardson (1972) has early proposed that co-operative agreements could be adapted when firms are reluctant to develop additional capacities but need to access to complementary activities[1].

Theoretically, there are two approaches towards the alternative explanations of the inter-organization alliance, the contractual or transaction cost perspective, and the competence-based perspective. Specifically, transaction cost school (Williamson, 1989), explained alliance from 1) increasing market or political power; 2) economies of scope or synergies; 3) reducing transaction or information costs; and 4) policy and regulation issues; Whereas the competence-based scholars consider the inter-organization technological alliance as the interaction learning process through which firms are able to access to partners' competencies. According to Richardson's (1972) claim from corporate manufacturing approach, these competencies are concerned to be complementary or close complementary to the firms.

Cooperation of R&D and technology-related activities could be concerned as a more complex coordinative form to exchange the uncodified and intangible products-knowledge. There is an increasing interest in the so called learning-based (competence-based) strategic alliances, given that high-technology industries are the arenas in which alliance activity has been most intensive in the recent past (Hagedoorn, 1993). This view is consistent and coincident with the gaining influence of knowledge – based views of the firm (Nelson and Winter, 1982; Henderson and Cockburn, 1994).

Strategic technology alliance (notably strategic alliance or alliance in this paper) has been defined as inter-firm cooperation for which a combined innovative technological activity or an exchange of

[1] Richardson (1972) defined *complementary activities* as those which need to be coordinated, and among those complementary activities, those whose coordination required a detailed, intensive and aggregated cooperation are *close complementary activities*.

technology is at least part of an agreement (Contractor and Lorange, 1988; Hagedoorn,1993). Of the antecedent studies around this topic, researchers have observed the association between the propensity to enter into alliances and a variety of organizational attributes, such as firm size, age, scope, and resources (Shan, et al, 1994; Burgers, Hill and Kim, 1993). Stuart (2000) further called for our attentions on the impacts of interactions between focal firm and partners characteristics on alliances.

It is Koza and Lewin (1998) who first categorized firm's alliances as being motivated by exploration or exploitation objectives and proposed a co-evolutionary theory of strategic alliances. Lavie and Rosenkopf (2005) then linked the formation of these two distinct types of alliances to firm-level attributes, and proposed a multi-dimensional construct to identify explorative alliances and exploitative alliances.

Of the outcomes of strategic alliance, studies are mainly focused on how learning alliances, through acquiring and exploiting knowledge developed by others, allow firms to increase the speed of capability development and minimize uncertainty (Grant and Baden-Fuller, 1995; Lane and Lubatkin, 1998, Hagedoorn and Schakenraad's, 1994). Rothaermel and Deeds (2004)'s study starts to link the exploration and exploitation alliances to firms' outcomes. However, their study was based on the product development project level, but not on the firm level. Apparently, all these studies are only concentrated on one aspect of firm performances. The work analyzing performance outcomes based on various attributes of strategic technology alliances has been missing in the literature.

Our research, at this point, has three objectives. Firstly, following the studies by Koza and Lewin (1998) and Lavie and Rosenkopf (2005), which distinguished the exploration-motivated and exploitation-motivated alliance in multi-dimensional constructs, our study will first improve the construct and identify different attributes of explorative alliance and exploitative alliance in the pharmaceutical industry: relational discrepancy, institutional discrepancy and technical discrepancy. Secondly, this study will further link the characteristics of alliances to firm's explorative and exploitative performances, referring as new products in the market or new patents granted and production cost reduction. Lastly, for each focal firm, this study will examine how the interaction effect of the two types of collaboration strategies

influence firm's overall performance.

2. Literature and Theory

2.1 Exploration alliance and exploitation alliance

The conceptual distinction between exploration and exploitation has been studied as analytical construct in a wide range of researches, especially in innovation adaptation. According to March (1991), *exploration* implies firm behaviors characterized by search, discovery, experimentation, risk taking and innovation, while *exploitation* implies firm behaviors characterized by refinement, implementation, efficiency, production and selection. Some scholars have linked the concepts of exploration and exploitation to strategic alliance.

Among the studies which investigate various factors compelling firms to enter strategic alliance (e.g., Nohria and Garcia-Pont, 1991; Gulati, 1995; Eisenhardt and Schoonhoven, 1996; Walker, Kogut, and Shan, 1997), Koza and Lewin (1998) first suggested that a firm's choice of the type of alliance to enter can be distinguished by its motivation to either explore for new opportunities or exploit an existing opportunity. Lavie and Rsenkopf (2005)'s study later classified exploration alliances and exploitation alliances in three dimensions: functional dimension, structural dimension and attributes dimension from alliance content, partner identity and partner profile perspectives respectively. They found that firm specific (both focal firms and partner firms) characteristics are important determinants of the formation of alliance.

According to Koza and Lewin (1998), exploration alliances are entered into with the motivation to discover something new; they focus on the 'R' in the research and development process, whereas exploitation alliances focus on the 'D' in the research and development process and are entered into with the goal to joint exiting competencies across organizational boundaries in order to generate synergies, which are shared across the partners. In other words, exploration alliances are engaging in upstream activities of the value chain, enabling partners to share tacit knowledge, create and learn new knowledge

and capabilities, and thus generate new technologies and products, whereas exploitation alliance are engaging in downstream activities to help partner firms adopt existing knowledge and technologies (such as management and production control) (Lavie and Rosenkopf, 2005)

In our study, we will follow this exploration-exploitation framework and refine it according to the multi-dimensional discrepancies between alliance partners. We categorize strategic alliances into either explorative or exploitative type, and examine whether they are efficient in terms of the outcomes of the partnerships. We also expect that the interaction between this two constructs is critical to the outcome of firm's overall performance.

2.2 Alliances and firm's performance

Inter-organizational collaboration has long been recognized as critical in supplementing the internal innovative activities of organizations (Dodgson, 1993; Hagedoorn, 2002), and consequently improving firm's performance. The reasons are numerous, such as helping spread operation costs for research and development (Hagedoorn, 2002; Lacity and Hirschheim, 1993), and encouraging the transfer of codified and tacit knowledge (Ahuja, 2000; Doz and Hamel, 1997; Lambe and Spekman, 1997). This is because commercially useful knowledge is not only the outcome of creative innovation by individuals or teams, but also the outcome of interaction, learning and collaboration of the whole innovation systems, strategic alliance creates a greater degree of interaction between the partners' respective paths of learning and innovation.

Related to the exploration – exploitation framework, Rothaermel and Deeds (2004) proposed an integrated product development path model to link exploration/exploitation alliance directly to firm's outputs. However, this exploration alliance– product development – exploitation alliance – product in market sequential model[2] is on the single project level or so called innovation unit analysis. But in reality, most firms engage in both exploitative and explorative activities simultaneously, because they normally

[2] Rothaermel and Deeds proposed that a technology venture's exploration alliances predict its products in development, while a venture's products in development predict its exploitation alliances, and its exploitation alliances in turn lead to products on the market (Rothaermel and Deeds, 2004).

manage several concurrent projects at different stages in a given period of time. At this point, we argue that in a given period of time, firms involve into both exploration and exploitation alliances with distinct objectives and behaviors. Consequently, different partnerships will bring different benefits to firm's performance either on explorative aspect or on exploitative aspect. In other words, specific patterns of partnership tend to bring more benefits to one type of performance over the other.

Previous studies which examined the returns associated with these two types of organizational activities found that explorative firms generate larger performance variation by experiencing substantial success as well as failure, whereas exploitative firms are likely to generate more stable performance (Brown and Eisenhardt, 1998; Lewin et al. 1999). At this point, we argue that explorative strategies are more likely to help firms to improve new competencies such as technology and product generation performance, while exploitative strategies facilitate firms to enhance their production process capabilities. Empirically, Stuart (2000) has used the sales growth and innovation rates in to measure these two types of performances.

Moreover, He and Wong (2004)'s study distinguished explorative strategy (e.g., extend product range, enter new technological fields, etc) and exploitative strategy (e.g., improving existing product quality, reduce production cost, etc)[3] by giving eight types of corporate behaviors. However, we argue that these items are indeed proxying firm's exploration and exploitation performances rather than strategies, because all of them are more output than input type of factors. For this reason, in this study, we select one item from each construct - **new product on the market** and **production cost reduction** to proxy exploration performance and exploitation performance respectively.

Moreover, given that firms need to allocate scares resources efficiently by focusing on their desires, a firm's propensity to enter exploration or exploitation alliances is related to the resource

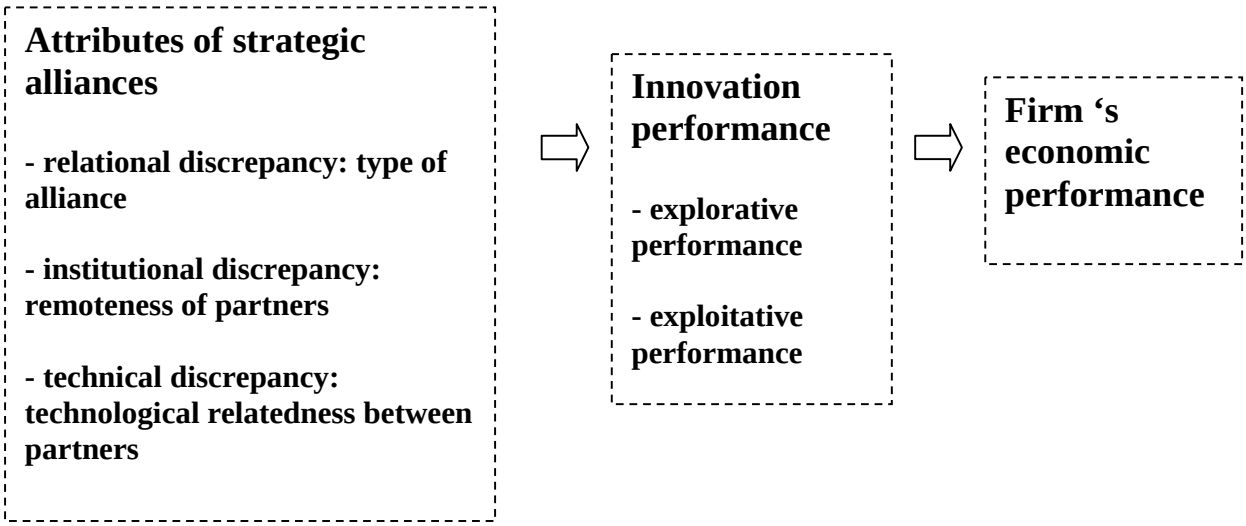
[3] The eight items are introduce new generation of products, extend product range, open up new markets, enter new technology fields, improve existing product quality, improve production flexibility, reduce production cost and improve yield or reduce material consumption, in which the first four items are tested to be explorative innovation strategy and the last four items are tested to be exploitative innovation strategy. The factor analysis results produced acceptable Cronbach alphas[3], which implied that the two groups are distinctly discriminant.

endowments of the firm (Park, Chen, and Gallagher, 2002). And thus the returns of this disequilibrium on alliance strategies tend to be different. At this point, we extend prior studies by moving beyond motivation for alliance entry and the sequential path, by seeking evidence on the effectiveness of an integrated exploration – exploitation alliance system of a given firm. Rather than investigate the antecedents of inter-corporate partnerships, we treat the formation of alliances as exogenous. We do so to focus on the question of whether firms could improve their explorative and exploitative performance through their participation of technological alliances.

2.3 research model and hypotheses

Figure 1 shows the general model of our study. We link the three dimensions of the characteristics of strategic technology alliance to firm's innovation performance, denoted as exploration performance and exploitation performance respectively and consequently to firm's overall economic performance. Figure 2 shows the detailed empirical model of our hypotheses. They will be further stated in the next section.

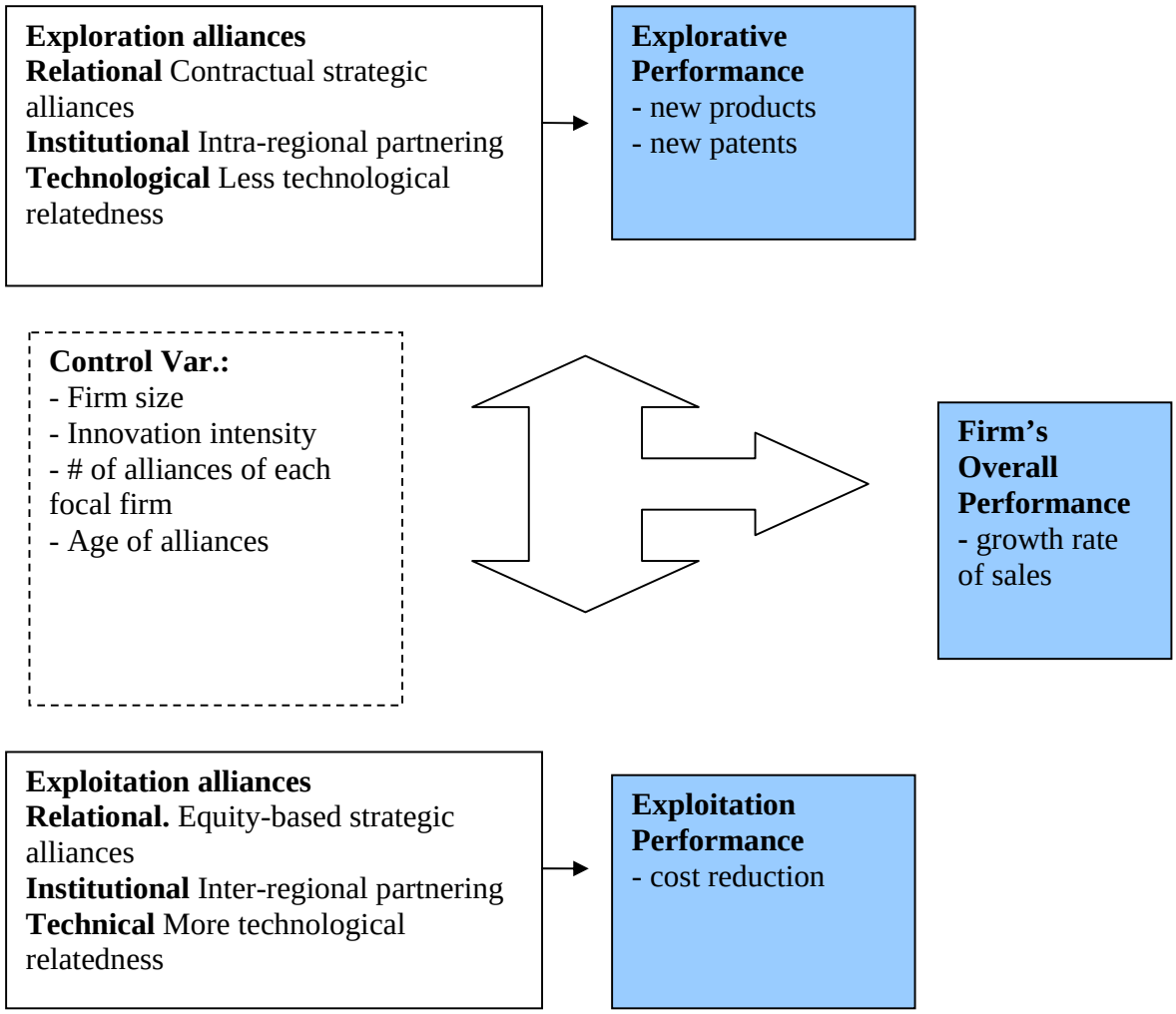
Figure 1, Research model



Notes:

1) Agreement type, partner portfolio and technological relatedness are three dimensions to identify whether the partnering is exploration alliance or exploitation alliance.

Figure 2, Empirical model



Notes:

1) Items in the slash-line box are factors which affect the relationship between attributes of strategic alliances and innovation performance, and thus needed to be controlled.

Relational discrepancy:

Recent research (Hagedoorn and Narula, 1996) suggests that strategic technology partnerships that involve equity sharing and contractual alliances are fundamentally different. Contractual alliances display quasi-market characteristics, equity-based alliances are quasi-hierarchical in nature (Osborn and Baughn, 1990). Along the similar line, Hagedoorn (1993)'s study on the motives for different modes of strategic technology partnering finds that equity sharing type of inter-organizational technology cooperation is aimed at both market- and technology mediated objectives, while a disproportionate share of non-equity arrangements or contractual strategic alliances are primarily innovation-driven.

When studying pharmaceutical industry, scholars find that newly established R&D partnerships consistently prefer contractual partnership to equity-based alliances as major mode of cooperation (Roijakkers and Hagedoorn, 2006). It is because the equity-based joint ventures typically serve the purpose of substantially lowering the costs of transaction between the independent research partners. Hatch et al (1998) have also found that process innovation and learning by doing which reflect the exploitation based on the existing knowledge and capabilities in the semiconductor industry yield are a catalyst for dynamic cost reductions. Therefore, we propose that firms participate in exploitation partnership are expected to obtain cost reduction benefits from it. Whereas, contractual modes of inter-firm R&D partnering, in particular joint R&D agreements have a higher degree of flexibility and enable partners to switch from research in one technological field to another (Barley, et al, 1992; Obleros and MacDonald, 1988). These modes of collaboration are mainly explorative oriented, and thus help improve firms' innovativeness.

Based upon above discussions, we propose that firms tend to form contractual agreements based alliances to explore new scopes of technologies, while to form equity sharing based alliances to exploit their existing knowledge and capabilities to save costs. Our first set of hypotheses are:

H1a: contractual alliances are more likely to improve a firm's exploration performance

H1b: whereas equity-based alliances are more likely to improve a firm's exploitation performance

Institutional discrepancy

The structure-based dimension of exploration-exploitation refers to the path length between the focal firm and partners (Lavie and Rosenkopf, 2005). In our study, we denote *remote partners* as those firms and organizations with different nationalities, either foreign affiliate located in the U.S. or foreign units abroad, while *close partners* as U.S based units. It will be further explained the concerns on this proxy implementation issue in the methodology section.

The relevance of this differentiation of non-domestic alliances is supported by Hagedoorn and Schakenraad (1993) who found that international (remote) alliances between firms from Europe, the U.S or Japan are particularly aimed at market entry, whereas alliances focusing on joint R&D are, in general more intra-national. In other words, inter-national alliances are exploitation oriented and thus have exploitative benefits, while intra-national alliances are more exploration-oriented and have explorative benefits.

There are numerous studies supporting this proposition. Knowledge-based literature proposes that the tacit knowledge (Nelson and Winter, 1982) can not be easily transferred and can only be obtained through "learning by doing and learning by using" course in which the network externalities are created by a growth in the network of users. Hence, since the explorative activities involved tacit knowledge is embodied in institutions and individuals, and transmitted principally through personal contacts. the economic benefits are for the most part geographically and linguistically localized, For instance, Jaffe, Trajetenberg, and Henderson (1993), Jaffe, Audretsch, Feldman and others have demonstrated that the links between science and technology (universities and firms) are geographically localized. Therefore, several scholars (Cantwell and Piscitello, 2000; Nelson, 1993) found that as national innovation system of each country tends to sustain along its historical technological competence, firms from various countries

tend to have distinct technological capabilities. Cross-border alliances thus facilitate firms to access to these superior competencies and technologies which they are not able to easily obtain.

Similarly, studies in the international business field also suggest that firms tend to seek for an increasing share of new technologies abroad which are more likely to be associated with new and general technologies, by tapping into various technological specializations in different locations. But this remote knowledge seeking and competency generation is mainly through knowledge transfer and coordination between firm's foreign affiliates and indigenous firms/organizations. Thus we argue that alliances formed with remote partners are expected to achieve exploitation improvements, while those formed with proximate partners will obtain more exploration benefits.

H2a: partnering with remoter (foreign) organizations is more likely to improve firm's exploitation performance.

H2b: partnering with closer (domestic) organizations is more likely to improve firm's exploration performance.

Technical discrepancy:

Lavie and Rosenkopf (2005) have adopted the inter-temporal variances in terms of organizational attributes (such as administration routines, organizational structures, etc) in the attribute dimension to distinguish exploration alliances and exploitation alliances. In our study instead, we substitute it with technological relatedness which is believed to better represent the scope-seeking (exploration) and depth-seeking (exploitation) of a firm's alliances, especially in the high-tech industry.

Increasing variance (McGrath, 2001) and undertaking long jumps (Levinthal, 1997) enable the firm to explore new knowledge outside its domain (Rosenkopf and Nerkar, 2001), and therefore facilitate the firms to generate new knowledge and products; in contrast, remaining similar technological patterns

allows firms to access and absorb existing knowledge and capabilities from partners and therefore enhance their own performance in the similar context.

Studies also found that highly differentiated innovating approaches appear to provide early signals of effectiveness in terms of seeking new scope of products and markets, but tend to encounter difficulties in scaling (Westerman et al, 2002). Moreover, when the technology is complex and unrelated with recipients' knowledge domains, and if the recipients do not have enough absorptive capacities, the technology transfer will be difficult and costly (Berrill, 1964; Granstrand et al, 1997). In this case, the learning process will be involved high uncertainty, bringing both risk and opportunities to firms in partnership.

Similarly, Richardson (1972) found that the more closely related the technological competences of pair of firms the greater will be the extent of technological complementarity between their activities, and thus the greater are the potential gains from coordinating their respective efforts in improving their common capabilities, such as enhancing production efficiency, reducing production cost, etc.

H3a: Higher technological relatedness between focal firm and its partners is more likely linked to the improvement of exploitation performance.

H3b: Lower technological relatedness between focal firm and its partners is more likely linked to the enhancement of exploration performance.

Firm performance

Tushman and O'Reilly (1996) have early proposed the "ambidexterity" premise that firm need to achieve a "balance" between the exploration and exploitation to achieve superior performance. Then He and Wong (2004) investigated the interaction effect between them and proposed that exploration and exploitation strategies tend to jointly influence firm performance in the technological innovation context.

More specifically, they found that the balanced pattern of explorative and exploitative innovation strategies is positively related to sales growth rate, and vice versa.

Some other studies (Katila and Ahuja, 2002), departing from March's (1991) competing explanations on exploration and exploitation, argue that exploration was the capability to search scope, whereas exploitation was the capability to search depth and they are not orthogonal. Both streams of view admit that exploration and exploitation capabilities are both essential for long-run adaptation. In other words, they coexist within organizations and are both positively influence firm's long – term performance.

Therefore, we suggest that exploration and exploitation strategies should be balanced in their partnership patterns. However, this equilibrium is obtained across different dimensions instead of remaining "equilibrium" in each dimension, thus firms are able to innovate and experiment with emerging technologies while benefit from the efficiency of managing and governing alliances with similar partners (Lavie and Rosenkopf, 2005). In other words, we follow the view that the persistent success lies in 'ambidexterity', which refer to the synchronous pursuit of both exploration and exploitation via loosely coupled and differentiated subunits or individuals, each of which specializes in either aspect (Benner and Tushman, 2003). Summarily, firms who obtain the "balance" of allying activities tend to achieve better performances than others.

H4: The interaction of exploration and exploitation performances tends to improve firm's overall performance.

IV. Data

The empirical locale for this paper is pharmaceutical industry. Pharmaceutical industry is appropriate to study organizational learning issue because: firstly, it is well-known that pharmaceutical industry is research–intensive industry, which implies high complexities and environmental uncertainties (Damanpour, 1996; Tidd, 1995, 1997); also, there is a general trend in this industry that the impact of new

sciences and interrelated technologies (life science and genetics) are changing the paradigm of innovation, thus the technological relatedness is distinct in this context; moreover, although firms traditionally are able to reduce these risks of R&D by sustaining diverse portfolios of research within organizations (Henderson and Cockburn, 1996), considering the problems of growing development time, greater costs and shorter effective patent lives across firms, today's pharmaceutical R&D is no longer a stand-alone activity by single firm, but can rather be defined by a complex web of inter-firm agreements and alliances (Webster and Swain, 1991). In other words, pharmaceutical firm collaboration covers a broad range of partners. Therefore, management of collaborations is a core strategy in pharmaceutical R&D (Tapon and Tong, 1999).

The interactions of pharmaceutical firms with partners cover various domains, including licensing, outsourcing, collaborations, M&As, JVs, spin-offs or divestitures. To ease the analysis, only non-M&A types of alliance are included in our study. Furthermore, because we are intending to examine the innovative improvement on the firm level, the focal firms will be all U.S pharmaceutical firms from 1995 to 2000. For each of them, all alliances will be counted on the unit level. For instance, if Merck participates partnering with both Roche and a small biotech firm, we will count them as two alliances. The risk of biased on the regression result is expected to be attenuated by the number of partners in the control variables.

The initial sample of focal firms included all publicly traded U.S based pharmaceutical firms and the firm-level data, such as firm size, sales, production costs are collected from COMPUSTAT. Following Anand and Khanna (2000)'s study, we first rely on the Securities Data Corporation (SDC) database in compiling records of alliances formed by each focal firm in 1995-2000 period, and then correct these records by searching alliance announcements and status reports in press releases using Factiva database and corporation websites.

V. Constructs and Methodology

Dependent Variable:

A number of measurement constructs on corporate performance have been established to examine the relation between alliance and effectiveness. Most studies in the field are using the growth rate of sales or productivities or the product and technology turnovers (Van Looy and Debackere, 2005) to proxy it. Some others, which address the relationship between interorganizational collaboration and the innovations, are using patenting and citation activities (Ahuja, 2000; Baum, et al, 2000; Shan, Walker and Kogut, 1994). However, all of these constructs only covered one aspect of outcomes of strategic partnering.

Our study instead, will measure two distinct dimensions of performance improvement. As we mentioned in the previous section, exploration performance – new products in the market and exploitation performance – the reduction of production costs have been proved to be distinct and independent. Therefore, **exploration performance** will be proxied by increasing number of new products and the increasing number of patents of the focal firms in the given period, and **exploitation performance** will be measured as the average production cost reduction yearly in the period. Considering the nature of returns on alliance and R&D, our dependent variables are lagged by one year to independent variables.

Meanwhile, the **overall performance** is proxied by sales growth rate, measured as self-reported compound average sales growth rate in the last five years (from 1995-2000 with 1995 as the base year). This study will be only focused on average sales growth rate in this study, because it is suggested that sustained sales growth has been found to be a reliable proxy indicator of superior firm performance, such as long-term profitability and survival (Timmons 1999, Henderson, 1999).

Independent Variables:

Type of agreement: this dimension will be measured by agreement type dummies. Particularly, we distinguished between the contractual partnering alliances which are 1, and those are equity sharing based, the value of which will be 0.

Moreover, considering that the independent variable - alliance type might be endogenous to the dependent variable - exploration-exploitation performance, a supplementary analysis will be adopted in which we distinguish between knowledge-generating agreement based alliances and knowledge-adopting agreement based alliances in the robust test. We will explain it in the next section.

Partner remoteness: the partner remoteness will be measured as dummy variable. Specifically, since all focal firms are U.S based pharmaceutical corporations, if their partners are foreign firm or institutions with the location in another country, the value is 1, and if the partners are U.S firms/organizations and located in the U.S, the value will be 0. Moreover, considering that firms may collaborate with foreign firms and institutions/schools located in the U.S, we still count these alliances as inter-national partnership, because this categorization on institutional discrepancy is concerned with both geographical and cultural distance.

Technological relatedness: the extent of technological relatedness is measured by assessing overlap between the technology codes assigned to focal firms and their partners. This study will examine the primary technological field of each pair of partners in the alliances, and both three-digit industry code and the subclass code will be compared respectively. The classification and the codes will be taken according to the USPTO classification system.

Exploration-exploitation interaction effect: we propose that the joint-effect of both types of alliances tends to influence the overall performance of a firm. It is noteworthy that the interaction effects are neither based on each focal-partner unit level, nor on the single dimension of alliances, but based on the multi-level construct across three alliance dimensions for each (type of agreement, partner remoteness and technological relatedness) focal firm.

Moreover, considering that the independent variables will be centered on their means before creating the interaction term (e.g., Venkatraman 1989), the interaction term will be tested on dependent variable on the focal firm level.

Control Variables:

Firm-level heterogeneity

Firm size: the relation between size and innovation has been much debated. Large firms might take advantages of economies of scale and scope in R&D (Veugelers, 1997), and provide complementary assets to guarantee the success of innovations (Teece, 1986). On the other hand, small firms might outperform large firms with their flexibilities and creativities. For the above reason, the variable size, measured by the logarithm of the number of employees, is included in the study as a control variable.

R&D intensity: controlling the size, firms with higher R&D inputs tend to have more potential to innovate (Hennart, 1991; Singh and Kogut, 1989). Therefore, I use R&D intensity (the average Expense of R&D over sales in the given period) as one of the control variables. This variable has widely been used by strategic management scholars as a proxy for the technological intensity of an industry. Here it is help to control the firm – level R&D heterogeneity.

Alliance heterogeneities:

Age of alliances: considering that older alliances are more likely to yield new product on the market and to reduce costs in production than younger alliances, we control for the average age of a firm's exploration and exploitation alliances in months in the given period.

Number of alliances: in addition, we also control the number of exploration and exploitation alliances for each focal firm, since more alliances presumably tend to increase firm's performance, either in exploration or exploitation or both.

Table 1 provides a summary of the variables.

The proposed relations in the hypotheses will be tested using logistic regression. Since dependent variables have a categorical nature, while the independent variables include both categorical and continuous variables. Therefore, logistic regression model is more appropriate to be adopted in this test.

Table 1. Variables and their descriptions

Variables:	**Descriptions:**
Dependent Variables:	
Exploration capability	number of new products number of new patents
Exploitation capability	reduction of production costs
Firm's overall performance	Growth rate of sales (annually)
Independent Variables:	
Type of partners	1 for contractual alliances.; 0 for equity-based alliances
Partner remoteness	1 for inter-national alliances; 0 for intra-national alliances
Technological relatedness	Primary technology field of firms
Control Variables:	
Firm size	log employee
Innovation intensity	The costs of R&D over sales
The age of alliance	
Number of partners	Number of partners for each focal firm

VI. Robust Test:

Firstly, innovation rate will be involved to substitute the number of new products in the model, this test is considering that pharmaceutical is one of the industries in which patents can be well proxied the innovations. Although patenting or citation activities have been questioned with their generality and accurateness (Deeds and Hill, 1996; Levin et al, 1987), they are believed to be good measurements to examine innovation activities in certain industries, especially in pharmaceutical industry[4]. Moreover, early the work of Comanor and Scher (1969) suggests that the link between patenting and sales in the pharmaceutical industry is more direct than in other industries, since patenting accords direct legal protection of the end product.

Moreover, the distinction between alliances based on the knowledge-generating agreements and knowledge-adoption agreements will be involved to substitute the alliance type variable in the regression,

[4] Levin, Klevorick, Nelson and Winter (1987) showed that it is only in the pharmaceutical industry that patents offer a particularly effective means of protecting intellectual property against others.

since we expect that firms in the knowledge-generating alliances are seeking for scopes of knowledge and more exploration oriented, while the others are motivated by deepening their existing capabilities and broadening the markets. Again, dummy variable will be adopted.

VII. Limitations

Our empirical test is limited to pharmaceutical industry and U.S based firms, and thus may not be fully generalized. Our results are expected to be applied in high-technology context in this sense. Moreover, strong regulatory context in this industry is neglected and thus needs further efforts.

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