Erasmus University, Rotterdam
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December 2009

Master Thesis
Economics & Business

‘Alliances in the US pharmaceutical industry: The effect of repeated partnerships on innovation’

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Abstract

This paper analyses the effect of repeated partnerships on innovation in the pharmaceutical industry. A literature review on the relationship between alliances and partner choice on the one hand and innovation on the other is presented to come to five hypotheses. The data used for the empirical study are obtained from several sources. Data for a 1990-2004 alliance portfolio analysis are obtained from Thomson One Banker and SDC platinum. The number of patent applications during 2005-2008, to measure innovative performance, are obtained from the USPTO. This empirical study, with the firm as the unit of analysis, of 159 USA based pharmaceutical firms shows that an alliance portfolio with repetition(s) has a significant positive effect on innovation. The firms that opted for a repeated alliance once or multiple times during 1990-2004 outperform firms that never opted for a repeated alliance during that period.

Keywords: Alliances, repetition, innovation, knowledge

To my mother, Arlene Jansen,

and to my father, René Jansen

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1. Introduction.

While before 1975 alliances were no common R&D instrument for pharmaceutical firms (Mowery, Oxley and Silverman, 1996), the last decades joint R&D activity has been rapidly growing (Hagedoorn, 2002). Due to the strong patent protection in the pharmaceutical industry, pioneers often become market leaders after a successful product or process launch: the winner takes all principle. In addition the growth of the value of the industry is enormous and thus each year numerous products face patent expiry. Alliances therefore offer great opportunities to generic companies (Prasnikar en Skerlj, 2006). For example for large companies the costs of product or process innovations can substantially be decreased by doing joint R&D with smaller companies.

The literature on alliances in general and with respect to innovation is extensive. However research based on the firm as the unit of analysis is scarce and the studies that do take the firm as unit of analysis often do not examine the influence of partner choice. It is odd that one comes across the word familiarity in the sense of familiar working fields, markets and technology very often, while the relationship between familiarity in the sense of repeated partnerships (e.g., Gulati, 1995; Ciccotello, Hornyak and Piwowar, 2004; Goerzen, 2007) and innovative performance is a rather undiscovered field of study.

It is tempting to state that firms always choose the right alliance partners. After a thorough selection process, including market situation considerations, comparing knowledge bases on the one hand and goals on the other, firms will most of the time end up with the right alliance partners. Sometimes this will be a new partner, sometimes a familiar partner from the past. Though, this thesis is not dedicated to the influence of partner decisions on the overall performance of firms, but only to the influence on innovative performance. In contrast, the alliance partner selection process is not only based on innovation considerations.

In this thesis I will analyze the relationship between alliances and innovative performance in the pharmaceutical industry. Three Poisson regression models are used to determine the relation between the alliance portfolio and the innovative performance of 159 USA based pharmaceutical firms. The initial dataset contains all USA based public firms that formed two or more strategic technology alliances in the period 1990-2004. The 159 firms in the final dataset were involved in 1222 alliances in total.

The main independent variable is binary: yes or no. Are or are there not any repetitions in the portfolio of a firm during the 14 year period of 1990-2004? This variable is created using the SDC platinum database (e.g., Kim and Song, 2007). The dependent variable innovative performance is captured by the count of patent applications during 2005-2008. The data are provided by the United States Patent and Trademark Office[1] (e.g, Gomes-Casseres, Hagedoorn and Jaffe, 2006).

The first part of this thesis consists of a literature review that covers the characteristics of strategic technology alliances, the choice for a new or repeated partnership, and their influences on innovativeness. This review is based on transaction cost economics, the resources of the firm, and network economics. The second part consists of the empirical analysis, and in the final part the conclusions and further implications are given.

[1] www.uspto.gov

2. Literature framework

2.1 Alliances: an overview

Das and Teng (2000) list four major categories of alliances: equity joint ventures, bilateral contract-based alliances, unilateral contract-based alliances and minority equity alliances. The motivation behind alliances consists of, based on the resource-based view of the firm (Barney, 1991; Wernerfelt, 1995), the value generating possibilities of firm resources that are pooled together. Resource characteristics as imitability, substitutability, and imperfect mobility can offer accentuated value-creation, and thus smoothen the process of alliance formation.

Moreover, modes of inter-firm cooperation, taking into account the degree of hierarchical elements and the extent to which they replicate the control and coordination features associated with organizations, can be divided into equity joint ventures and (all other types of) alliances. In other words, the two main differences between joint ventures (JV's) and alliances relate to equity sharing and hierarchical controls. Firstly, JV partners create a new entity in which they share equity, while alliance partners do not share equity. Secondly, a JV entity resembles the hierarchical control features of organization, where there are only few hierarchical controls built into alliances (Harrigan, 1987). JV's and alliances are thus located on the opposite ends of the spectrum.

Within the group of alliances, due to goals, level of agreement (horizontal or vertical) and type of contract, there are also distinctions to be made (Kotabe and Swan,1995**)**. However, in the pharmaceutical industry the most common sort of alliance, which is usual in high-tech industries, is the strategic technology alliance or just strategic alliance. Strategic alliances are modes of inter-firm cooperation for which a combined innovative activity or an exchange of technology is at least part of an agreement (Hagedoorn and Duysters, 2002). A strategic alliance is therefore not the same as an alliance. When one speaks about a strategic alliance, the collaboration needs to be of significant (and not easily replaceable) magnitude, that it is of great importance for the firm, and/or has to be undoubtedly linked to the strategic intent of the firm (Seppälä, 2004). However, in the academic literature the term alliance is often used instead of strategic alliance. Concluding strategic alliances can be divided into four main groups: joint R&D projects, licensing agreements, cross-licensing agreements, equity investments and marketing alliances (Prasnikar and Skerlj, 2006).

Companies internalize knowledge and capabilities that are at least partially exogenous to them. A firm's R&D process always originates from both inside and outside. A firm cannot do R&D completely alone and it also cannot just buy a technology and exploit it; the firm has to have an own R&D base to implement the technology in the business processes. Not to forget, computers, software and other technical equipment also get the name of procured R&D (Odagiri, 2003).

Strategic technology alliances are found at the intersection of internal and external technology development. More specifically, Gulati (1998) defines strategic alliances as 'voluntary arrangements between firms involving exchange, sharing, or codevelopment of products, technologies, or services.'

In the following strategic technology alliances are simply referred to as alliances.

Rationale

The literature on the rationale behind the formation of alliances is extensive. Nielsen (2005) states that the main goal is the transfer, acquisition or absorption of complementary knowledge. Common other arguments for entering alliances are risk sharing, cost sharing and the pooling of resources like complementary technologies (Kim and Song, 2007). By exploiting these benefits, firms are able to achieve technological development faster than would be possible internally.
These diverse motives, just like all motives for other sorts of collaboration, can be put under two headings: synergy or complementarity and growth opportunities or market power (Arranz and Fdez. de Arroyabe, 2008). In the first case partners want to combine their complementary assets, in the second case firms want to improve their competitive positions while their resources are not sufficient to do so. From another angle Tsang (1998) states that there are five main motives for alliances: creation of rents, expansion of resource usage, diversification of resource usage, imitation of resources and disposal of resources. Bajona et al. (2001) sum up the above by mentioning the complexity of technological development, the reduction and sharing of uncertainty and costs, motivations relating to market access, the search for opportunities or novelties, firm size and R&D capacity.

Growth

Most empirical studies show that alliances positively influence growth and innovation (Nooteboom et al., 2005). Organizational growth is one of the major goals of firms and, specifically in high-tech sectors, R&D is a common lever of achieving this organizational growth. As a result, ties with partners are vital for a firm's growth and survival (Parise and Casher, 2003). There are two growth strategies: internal (subsidiaries, divisions) and external (alliances, M&A's, other collaborative agreements). In other words, alliances and mergers & acquisitions are external sources of innovative competencies. They are organizational instruments firms use to increase their market power, enter new markets, or strengthen their capabilities.

Innovation

The innovation process is the major determinant of the competitive success of pharmaceutical firms. Therefore their market share size and growth levels are heavily influenced by the results of this innovation process. Also entry barriers are often mentioned factors of influence. The common entry barriers in an industry are R&D intensity together with advertising intensity and competitive concentration. Since there are more possibilities for new entrants to capture market shares in industries with low entry barriers, firms in an industry with high entry barriers are expected to grow at a higher pace than firms in an industry with low entry barriers (Weinzimmer, 2000).

The positive relationship between innovation and firm growth is underlined when reviewing the often cited theories of the firm: the resource based theory of the firm and the theory of dynamic firm capabilities (Nelson, 1991). The resource based view, first addressed by Penrose, states that the firm consists of sticky and difficult-to-imitate resources (Mowery, Oxley and Silverman, 1996). According to Penrose (1959), firm growth is the endogenous outcome of perennial intra-firm knowledge creation. The environment only determines the direction of this growth, but internal factors, specifically in the appearance of unused resources, determine the growth possibilities. Unused resources, which stem from sales, managerial or research productive excess capacity, are a major driver of diversification and expansion of current products. Furthermore, Penrose argues that in the dynamic changing environment the pharmaceutical industry faces, the chances of survival and consequently growth possibilities are related to the development of a technological base or specialization niche.

The dynamic capabilities view emphasizes the importance of innovative and unique firm capabilities that are attached to the resources. These capabilities are vital for a firm to outperform his competitors. This view looks primarily at the connection between the firm's dynamic environment and the dynamics of its resources and capabilities (Conçalves and Da Conceição Conçalves, 2008), with a stronger focus on development than on exploitation (Mowery, Oxley and Silverman, 1996).

The statements from the academic literature are backed-up by several empirical studies. Zachariadis (2004) shows a positive significant effect of R&D intensity on productivity and output growth in 10 OECD countries. Another study finds that the innovation level increases the growth rate of output in the manufacturing sectors of drugs and medicine, machinery and transport, chemicals and electronics (Ulku, 2007). Furthermore, previous R&D Scoreboards (conducted by the British government[2]) are also supporting. In these scoreboards the positive relationship between R&D growth and sales growth for R&D intensive sectors is underlined.

Lastly, the entry and growth of new firms can be of importance for innovation and growth. According to Audretsch (1995) the likelihood of survival and post-entry growth rates differ systematically per industry. First of all, he argues, resembling the argument of entry barriers, that the survival chances of new entrants decline with the importantness of innovation in an industry. On the contrary, entrants, that do survive in innovative industries grow at a higher pace than comparable firms do in less innovative industries. The accompanying empirical analysis confirms this reasoning and states that when the environment is highly innovative, this will lead to a disparate effect on the post-entry performance of new entrants. The new firms that go with the flow and thus are highly innovative, face higher rates of growth.

[2] http://www.innovation.gov.uk/rd_scoreboard

Performance

The rationale behind the formation of alliances in the pharmaceutical industry is to boost R&D productivity. An empirical study, based on sales growth and innovation figures of a large sample of semiconductor producers, by Stuart (2000) shows that firms with large and innovative alliance partners outperform, in the form of accelerated growth rates, otherwise comparable firms that lack such partners.

Since numerous studies report high failure rates (Parkhe, 1993; Park and Ungson, 2001), the performance of JV's (alliances) themselves is ambiguous. These figures can be explained by the joint venture-paradox: the JV's that are most likely to be constructed are also the ones most likely to fail (Stern, 2005). The probability of being selected for a JV grows with a potential partner's size, age, prior success, and the number of JV's already created in a firm's network, but decreases the chance that the partnership will succeed. This selection process, in which firms select readily available markers of capability and legitimacy, results in the choice for inertial partners with an insufficient adaptation ability. This ability is an essential attribute of new partnerships in dynamic high-tech industries. These findings can suggest that JV's simply are no qualified vehicles for R&D to contribute to a firm's innovative performance. On the other hand, failure is often studied by analyzing termination rates and these rates are not always a good measure of performance. Successful JV's can be terminated because the partners planned to do that on a certain moment: the desired goals are achieved or the set of tasks assigned to the alliance is constrained to a time period (Park and Russo, 1996).

It is also possible that the partners sell the alliance to a third party (e.g. local partner) or one of the firms buys out her partner(s), which results in the creation of a wholly owned subsidiary. In both situations the alliance is still operative, however under a new name (Gomes-Casseres, 1987). In addition, alliances that stay active for a long period are not per se successful (e.g. influence of high exit costs) and performance is not an either/or condition (Gulati, 1998).

The question however remains, how alliances can contribute to the innovativeness of the firm. To begin, there are some studies that look at the number of alliances. For example Deeds and Hill (1996) find a positive relationship between the number of alliances a firm enters and the rate of new product development. This relationship has an inverted U-shape. Moreover, the relationship was negative if the rate of new product development was replaced by the number of patent applications.

2.2 Partner choice

One comes across the word familiarity in the sense of familiar working fields, markets and technology very often in the academic literature. Strangely, familiarity in the sense of repeated partnerships (see, e.g., Gulati, 1995; Ciccotello et al., 2004; Goerzen, 2007), especially with respect to innovative performance, is a rather unexplored phenomenon. Additionally Ciccotello et al. (2004) show that by far the most alliance contracts are signed by new partners. The question now arises whether these partner choices are made on the basis of innovation or other grounds. This research therefore examines whether a firm, in order to increase its innovative performance, should realize an alliance portfolio with or without repeated partnerships.

Success factors

Crucial factors in the performance of pharmaceutical firms are the exchange of knowledge, developing internal expertise and managing contacts with external suppliers of knowledge and talent (Lin and Darling, 1999). More specifically, factors regularly addressed to be of importance for alliance success are management flexibility and support, clear goals and expectations, inter-firm trust, habitual transfer of information, partner compatibility and the ability to act upon as expected (Gulati, 1998; Whipple and Frankel, 2000). In the following part a discussion on how partner choice affects alliance success is presented.

2.2.1 Transaction cost economics

Alliances can solve the governance problem of incomplete contracts. The transaction costs of technology sharing will be lower for allying firms than for unrelated firms, but probably higher than for fully integrated firms (Gomes-Casseres et al., 2006).

Though, transaction cost economics (TCE) has some weaknesses. A common critique of using TCE when discussing alliances, is that the minimum cost perspective does not pay attention to the shared interests of the cooperating firms, but only can be used when interested in the minimum costs of one firm (Gulati, 1998; Zajac and Olsen, 1993). However, in this paper the unit of analysis is not the alliance, but the firm itself. Furthermore, TCE is still a frequently used framework in the academic literature: reduction in transaction costs is one of the main motivations to form an alliance. Lastly, when narrowed down to the core, an alliance is simply an economic transaction between two economic agents.

Three dimensions

TCE analyses each transaction in the economic field using three different dimensions: asset specificity, frequency and complexity or uncertainty (Groenewegen, 2006).

The asset specificity dimension in an alliance transaction can be resembled by the general investments made by the alliance partners, which can only be capitalized on when the alliance is a success and while the alliance is in operation. After the alliance has been terminated, these investments cannot contribute to the firm's performance. An example of such an investment is the renting of expensive equipment during the life-time of the alliance. Another sort of asset specificity are the partner specific investments: i.e. investments necessary to make joint working efforts possible and efficient. Examples are the construction of shared laboratories and the introduction of educational programmes for both firms employees to get acquainted with each other's technological expertises. An important difference with the first type of investment however, is that these investments still represent added value after the termination of the alliance. When a firm decides to go for a repeated tie in the future, some part of the funds invested earlier can still be beneficial for the success of the alliance. These specific investments are thus always lower for repeated ties than for new ties. It is for this reason rather logical to state that in the case of high 'general asset/alliance specificity' a firm can better choose for low 'partner asset/alliance specificity' and thus for a familiar partner instead off a new partner.

The uncertainty dimension, the most common and cited dimension in articles, is to be found in every aspect of transaction costs relating to the behaviour of partners before, during and after the signing of the alliance contract. For example the chance of finding out ex-post that a partner cannot offer the needed complementary resources is smaller when choosing a familiar partner (Deeds and Hill, 1996).

The frequency dimension points at the (expected) frequency of transactions between two firms. In the light of this dimension also experience effects, learning effects and reputational factors have to be considered.

All three dimensions are present in the different transaction costs (negotiating, contracting, monitoring, coordination, punishing, transfer) involved in the alliance formation process.
When a firm enters an alliance the origins of the transaction costs involved are plural and diverse, however the main part of transaction costs arises as the result of the fear for unwanted (opportunistic) behaviour of the counterparty in an economic transaction. First of all, there are the negotiating and contracting costs, which are assumed to be higher in the case of a new partner, since both firms are more insecure and anxious about the partner's behaviour. Due to the level of trust and the familiarity with each other's organizational processes, these costs are lower in the case of a familiar partner. Secondly, there are the monitoring concerns. Monitoring performance will be relatively low for a repeated partnership due to trust and familiarity with the prior routines set in place (Goerzen, 2007). Thirdly, there are the managing concerns. These costs of management, together with the costs of

pooling, tend to decrease with the share of common knowledge in both firms, since knowledge overlap effectuates the development of routines and controls and increases the absorptive capacity. Furthermore, repeated collaborations, due to interorganizational learning and partner-specific experience, enable a more efficient management conduct. Knowledge bases and human capital of cooperating firms tend to get more similar due to repeated alliances. So therefore management concerns will be higher if a firm chooses a new partner. Besides, management costs are the most important when firms are active in multiple alliances at the same time. The valuable and scarce time of the management team then has to be divided between several alliances. For this reason the choice for a familiar partner limits possible management errors.

Moral hazards and other concerns

The costs of forming and controlling alliances are both direct and indirect. First of all, there is the problem of moral hazards. A firm never fully knows how a partner will behave after the alliance contract is signed. This moral hazard cost is also an opportunity cost: there are other ways of spending money on innovation which imply less uncertainty. Another problem regarding the behaviour of a partner is the problem of free-riding. During the existence of the alliance a partner can, while extracting a lot of valuable knowledge from the other firm, contribute very little to the performance of the alliance, but at the end can still benefit in the same ways. In addition, these costs increase when the future revenues of the joint R&D activities become more uncertain.

All the costs and appropriation concerns above, resulting from contracting hazards and behavioural uncertainty (Gulati and Singh, 1998), will be lower in the case of a repeated partnership due to inter-firm trust. Inter-firm trust is the result of the learning effects, with respect to partner behaviour, that evolve during an ongoing interaction (Kim and Song, 2007). Due to this trust less costly contracting procedures and less costly managerial time are needed. Trust provides the incentive for building routines for knowledge transfer (Sherwood and Covin, 2008). The saved resources can be used to contribute to the innovative performance of the alliance.

Before and while the alliance is in operation there are also several coordination concerns, another type of moral hazard, and hierarchical controls. Both types of concerns arise when the alliance partners decide how they have to plan and structure their joint project and organizational processes. Hence, these concerns originate from the organizational complexity of an alliance (Gulati and Singh, 1998). To temper these concerns, costly hierarchical controls can be built into alliances. Once again, the anticipated coordination concerns will be smaller for repeated partnerships due to trust and learning effects, concerning the organization structures developed during a prior collaboration. Put differently, the partners better understand each other's type of management and business culture, and a set of routines for their inter-firm processes may be developed (Zollo, Reuer and Singh, 2002). Also the partnering firms may have, prior to their first collaboration, invested in certain relation specific assets that reduce coordination concerns (Hoang and Rothaermel, 2005).

Both appropriation and coordination concerns are timely and therefore expensive; both use funds that otherwise are beneficial to the performance of the alliance.

The management capability of the firm is an important factor for alliance performance (Conçalves and Da Conceição Conçalves, 2008). As the burdens on management increase with the number of alliances in which a firm is involved (Deeds and Hill, 1996), the mentioned cons of a new partnership are more severe when a firm has to manage a portfolio of alliances (i.e. the normal situation). On the contrary, it is argued that the more alliances contracts signed, the more experience managers have and therefore the better they are in selecting good partners.

Summing up, in the case of a repeated partnership there is more inter-firm trust, the chance of opportunistic behaviour of one of the partners is low, and the incentive to make strong investments for the alliance will be high. For these reasons less costly hierarchical controls are needed and less valuable managerial time is consumed. This benefits the chance of success of the alliance and therefore the innovativeness of both partners.

Hypothesis 1: On the basis of TCE a firm should opt for a repeated partnership.

2.2.2 Transfer and creation of knowledge

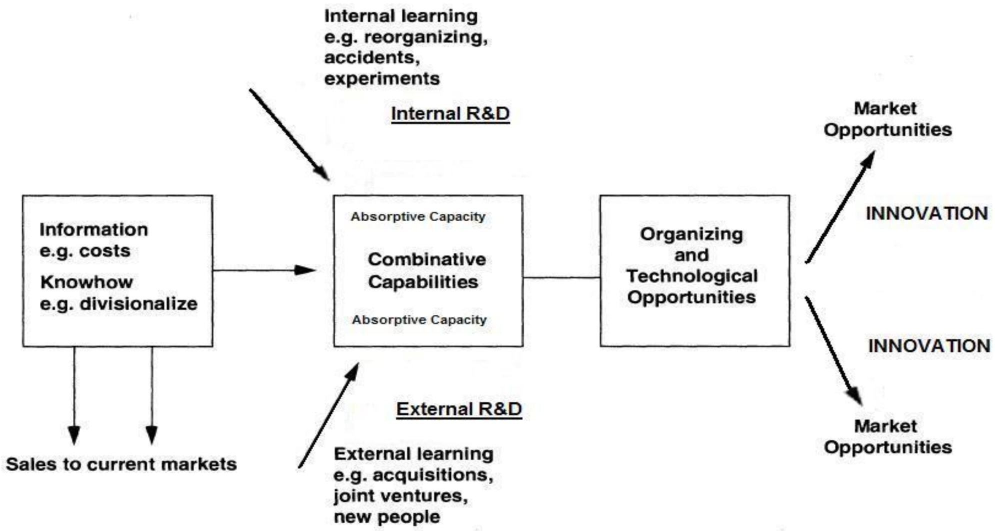
In the analysis of the relationship between repeated alliances and innovation, the arguments pro and con can either be assigned to knowledge transfer processes or to knowledge creation processes. In addition, it is important to underline that knowledge transfer is a necessary condition for knowledge creation (Inkpen and Danur, 1998).

Before discussing these arguments a closer look at the terms knowledge, technology and science is essential. Feldman (2003) describes science as the pursuit of new knowledge: 'It occurs primarily within the domain of the research university and is characterized by a priority-based reward system that emphasizes scientific publication'. She elaborates that the ideas from science are commercialized by technology. The main feature of technology is thus the pursuit of economic returns, therefore it takes place within rent seeking firms. Thirdly, Kogut and Zander (1992) point out that the knowledge (base) of the firm consists of information in the sense of knowing what something means (codified knowledge) and know-how (tacit knowledge). Know-how can be transferred by learning by doing, using and interacting. The contribution of an alliance to innovation depends mainly on if and how the knowledge that contributes to the 'combinative capabilities' (see figure 1), e.g. knowledge in the form of consumer data banks is excluded, is increased. The differences in know-how and information determine the differences in performance.

Innovation process

A firm's innovation process is threefold: Human capital and R&D spending as input, patent citations as throughput, and patent applications or the number of process and product innovations as output.
This process can be further discussed with the help of figure 1 (Kogut and Zander, 1992). The first stage of the innovation process is the current knowledge base, i.e. human capital and the results of past R&D investments. This knowledge base together with new knowledge from both internal R&D and external R&D, lead to, dependent on the absorptive capacity of the firm, an increase of combinative capabilities. The latter are the capabilities to combine new and current knowledge in order to achieve innovative synergy. Consecutively, they can lead to organizing and technological opportunities and eventually, constraint to market opportunities, product or process innovations.

Figure 1[3]: Knowledge and innovation.



Knowledge base complementarity

Most firms want to keep knowledge as local as possible. Nonetheless when cooperating, firms have to break down their 'protection walls'. This means a paradox: to stimulate the knowledge transfer processes and growth of the firm, knowledge should be codified, while this codification means opening the door for unwanted imitation (Kogut and Zander, 1992).

[3] Source: Kogut and Zander, 1992, p. 385

An often discussed factor in the debate on alliance performance is the complementarity or similarity of partner's knowledge bases. For example Cohen and Levinthal (1990) stress that, in order to recognize and utilize new knowledge, a certain amount of prior knowledge in the same research field should be present. Hence, some complementarity of knowledge bases is needed for successful knowledge transfer. Hoang and Rothaermel (2005) argue that partner-specific alliance experience results in higher relative absorptive capacity and more learning opportunities. Also as result of this experience, familiar partners have more similar knowledge/technology bases, organizational structures and dominant logics. In this way similarity benefits both transfer and creation processes.

New partners can of course also share an amount of basic knowledge or technology in a certain field of research. However, it is likely that the technology overlap between familiar partners will be higher than between new partners. Therefore the costs of inter-firm knowledge transfer for familiar partners, e.g. pooling and management, will be lower (Kim and Song, 2007). Partner specific experience can also facilitate knowledge transfer by the strengthening of relative absorptive capacity and the development of inter-firm knowledge sharing routines. The latter are regular patterns of exchanges between partners that allow the creation and the transfer of knowledge (Sherwood and Covin, 2008).

Yet, the benefits of partner-specific alliance experience are limited. A third, fourth or fifth additional tie with a familiar partner (this is a common phenomenon) will negatively contribute to the alliance performance, because the firms will rely on their initial routines and consequently the level of experience will not be increased. This means no boost for knowledge creation possibilities (Hoang and Rothaermel, 2005). Also Tracey and Clark (2003) underline these diminishing benefits. The cons of repeated partnerships, regarding low contribution to new knowledge, increase after the second or third collaboration. Namely, inter-firm learning after some time leads to similar points of view.

Also on the downside, when the technology overlap is too high and the partners are too similar, learning possibilities and thus knowledge creation possibilities are low. At some point the partners cannot offer added value to each other; the combinative capabilities of a firm do not increase. Also regarding creation competencies, Nielsen (2005) states that complementarity is no necessary condition and even can work in the opposite direction, but instead compatibility is needed. Lastly, it can be argued that the chance of successful creation of knowledge increases with the diversity of the firm's alliance partners (Hardy, Phillips and Lawrence, 2003).

Absorptive capacity and trust

The term absorptive capacity, i.e. the capacity of the firm to identify, incorporate and apply new external knowledge (Cohen and Levinthal, 1989), is extended by Lane and Lubatkin (1998). They stress that relative absorptive capacity, which determines the strength of interorganizational learning, depends on three factors. That is, the type of knowledge offered by the partner, the similarity between the partners' organizational structures and compensation practices, and the familiarity with the organizational problems of the partner. The third factor is evident for a repeated partnership: the transfer and creation of knowledge will be less costly due to a higher relative absorptive capacity.

Looking at the transfer of knowledge, and especially tacit or implicit knowledge, there are several factors that can lead to success. First of all, the inter-firm trust of repeated partnerships eases the access to a partner's technology base and enables the construction of, as mentioned in the previous, knowledge sharing routines (Sherwood and Covin, 2008). Also in the light of trust, Szulanski (1996) states that knowledge transferred from a source (if it is initiated in the first place) that is not seen as trustworthy, probably will face resistance. Firms are always anxious to apply knowledge from outside (i.e. 'the not invented here syndrome'). This anxiety will be more severe for new partners. Additionally, he states that the ease of communication and the intimacy between partners, which both are more intense in a repeated partnership, contribute to a successful transfer.

Simonin (1999) argues ambiguity, inertness or stickiness of knowledge, weakens the ability of alliances to transfer knowledge. Ambiguity is influenced by tacitness, experience, specificity, cultural distance, organizational distance, partner protectiveness and complexity. For the choice between a new or familiar partner three of these factors are of importance: experience, partner protectiveness and complexity, which all can be used as arguments pro a repeated partnership. First of all, to assimilate knowledge, firms need to have some experience with the knowledge domain. Or in other words, experience increases the earlier mentioned relative absorptive capacity. The level of experience tends to be higher in a repeated partnership. Secondly, complexity (i.e. the number of different routines and technologies) has a positive impact on ambiguity, since widely spread knowledge is difficult to integrate and to apply across an organization's employees. Complexity tends to be lower for familiar partners, since they are likely to have developed inter-firm routines. Lastly, partner protectiveness refers to the transparency and accessibility of a partner's knowledge base. This protectiveness can take the shape of all kinds of specified instruments, specialized personnel or routines, and increases the stickiness of information. Mainly due to partner trust, there is less protectiveness in a repeated partnership (Nielsen, 2005).

Hypothesis 2a: Regarding knowledge transfer arguments on the whole and absorptive capacity arguments in particular, a firm should opt for a repeated partnership.

Hypothesis 2b: Regarding knowledge creation arguments on the whole and redundancy arguments in particular, a firm should opt for a new partnership.

2.2.3 Network economics

A firm is embedded in a network of linkages, which determines its set of possible actions (Hardy, Phillips and Lawrence, 2003). A social network can be described as a set of nodes (e.g. firms, human beings) which are connected by social relationships (e.g. emotional support by a friend, flows of money) of a specified type (Gulati, 1998). The innovation capacity of this network is influenced by the number of direct and indirect ties and the redundancy among these ties (Gilsing et al., 2008). The linkages or ties in repeated partnerships are strong and in new partnerships they are weak. The first offer the benefit of the higher probability of knowledge sharing (transfer), whereas the latter offer the benefit of increasing the knowledge base and making it more diverse (Rindfleisch and Moorman, 2001).

Network dimensions

When enlarging or scaling down its network, a firm always has to observe the right balance between the possibilities to create innovations on the one hand and its ability to absorb and manage these innovations efficiently on the other hand (Gilsing et al., 2008). This balance is continuously influenced by the four dimensions a firm's network is characterized by. First of all the technological overlap or cognitive distance between the firms plays a role. Secondly there is the position of the firm in the network or its centrality, thirdly there is the density of the network, and lastly there is redundancy. The question now is, how these characteristics should influence the choice for a new or repeated partnership.

To begin, there is the trade-off between centrality and proximity between partners. A new partnership, e.g. by bridging a structural hole, will contribute to centrality and a repeated partnership will contribute to proximity. Centrality, the position of the firm in the network, is the outcome of earlier partner choices of the firm itself, but also of the choices of its prior partners (Robinson and Stuart, 2007a). The more central the firm is located, the more open it will be for new information flows. Put differently, more central firms are more aware of the developments in a network, and therefore can be the first with access to crucial information. As a result, these firms can choose the best alliance partners, and thus have more bargaining power than less central firms. Hence, centrality will have a positive effect on the knowledge creation ability of the firm. According to Soh (2003), centrality has a positive impact on new product performance. The more central the firm, the shorter the ways of acquiring knowledge. Less central firms are inclined to obtain knowledge less efficiently, via (more) indirect ties, and centrality determines to what extent firms can learn from each other (Tsai, 2001). The inefficient knowledge gathering is unbeneficial, because it slows firms down in noticing opportunities (Soh, 2003). The positive impact of centrality depends on the firm's absorptive capacity. The level of absorptive capacity should be matched to the wideness of its knowledge sources.
Lastly, also the reputational effects of centrality should be considered. By being in a network partnering firms can, via communication links, spread privileged information about each other throughout the network. This can lead to reputation effects with respect to future business partners

(Robinson and Stuart, 2007b). However, this information is not available to all firms in the network in the same ways, it depends on network position.

Proximity, which increases when the number of (direct and indirect) links between firms rises, eases the knowledge transfer between partners. To be precise, less network ties are needed to obtain information about one another (Robinson and Stuart, 2007b). Furthermore, proximity also increases when there are fewer intermediaries in a partnership. In addition, it can be an important indicator of success when an alliance starts, because it reflects the information both parties have about the reputation and abilities of one another.

Density and structural holes

Both new and repeated ties can contribute to the density of a network. This density boosts mutual trust and identification with the network, which smoothens knowledge transfer processes (Reagans and Zuckerman, 2001). Due to repetition of existing ties the sharing of knowledge, as a result of e.g. trust and commitment, will be facilitated. New ties will lead, by 'bridging disconnected parts of a network', to non-redundant and timely information (Vanhaverbeke et al., 2009). So again a trade-off arises: in most cases redundant ties facilitate the processing of new knowledge, while non-redundant ties lead to the creation of new knowledge.

Tie density offers the opportunity of sanctioning against opportunism and also makes interactions observable for other firms. This stimulates relation specific investments and brings down monitoring costs. In addition, mutual understanding is increased and counter striking competitive behaviour is limited (Zaheer and Bell, 2005).

Firms that bridge structural holes will outperform firms who do not, due to better connections with information flows (Zaheer and Bell, 2005). On the contrary, the downside of bridging those structural holes is that it limits the possibilities of tacit knowledge transfer (Ozman, 2007).

Repeated partnerships also benefit the recognition of efficient channels of valuable information. The partners are, due to trust and mutual understanding, more willing to 'reveal themselves', which contributes to the utilization of opportunities and to the chance of detecting new possibilities. Throughout the network a shared understanding of communication and coordination develops, and empirics show that reciprocity and trust stimulate knowledge transfers (Soh, 2003).

Opting for a new (non-redundant) tie increases the 'problem' of dealing with all kinds of and higher amounts of new information, in addition this problem also has to be managed more quickly. Secondly, by going only for new ties, the scope of the firm's knowledge will constantly be swung towards different goals (Vanhaverbeke et al., 2009). Both factors result in a lower absorptive capacity for possible novelties created or transferred and inferior skills for the processing of this new information. Overall, the formation of new ties will lead to an increase in access points to new information, whilst the absorptive and processing abilities will decrease.

Embeddedness

Firms seek embeddedness mainly for the reason that they want to reduce uncertainty while seeking new information. Other reasons are the combination of different resources and skills, and the exploitation of power between organizations (Goerzen, 2007).
When firms are in an alliance with another firm they are also in a social network. Being part of a social network offers two overlapping benefits: differential informational advantages and control benefits. The informational benefits can be separated in relational embeddedness or cohesion perspectives (often gets the most attention) and structural embeddedness or positional perspectives (Vanhaverbeke et al., 2009). In the first case, the punch line is that partners that are directly linked to each other have the advantage of sharing common knowledge and information with each other. In the second, the focus is on the information that results from the position of the partners in the network. Not only the different ties in a network create information flows, through the structure of the network itself also information finds his way.

When choosing an alliance partner a firm has to consider several relationships between network determinants. Considering relational embeddedness, its relationship with information redundancy is of importance. If, as a result of a repeated partnership, the proximity and reciprocity among firms increase, this also leads to an increase in knowledge redundancy (Rindfleisch and Moorman, 2001). Relational embeddedness has a positive impact on both information acquisition and information utilization processes as a result of developing closeness, while redundancy only has a positive impact on information utilization. That is, redundancy increases the shared understanding of routines and beliefs, but limits the number of access points to new information. A remark with respect to the first is that a repeated partnership does not make the network more powerful, but only broadens it (Goerzen, 2007). Even if is this remark is ignored, the question remains if the negative effects of the redundancy that accompanies a repeated partnership will outweigh the benefits of increased embeddedness.

Exploitation and exploration

Exploitative learning can be described as the strengthening of existing technology, whereas explorative learning is concerned with experimentation and the search for new technological perspectives (Vanhaverbeke et al., 2009). Namely, exploitation is the use of perspectives already known and exploration is the search for perspectives that might become known (Levinthal and March, 1993).

The literature on the influence of firm characteristics on the decision for either exploration or exploitation is mixed. However, when a firm goes for a prior alliance partner once more this is marked as exploitation and in the case of a new partner one speaks about exploration (Lavie and Rosenkopf, 2006). In general, firms that opt for a familiar partner are opting for a familiar domain of research and thus for exploitative learning. In the pharmaceutical industry most alliances are knowledge based and the focus should thus be on exploration: a firm should cooperate with a new partner. Exploration is also more suitable considering the dynamics of the pharmaceutical industry, since it arms a firm against external changes and helps it obtaining knowledge from outside its domain. In a more dynamic environment, firms therefore will benefit more from exploration than exploitation. Firms should search distant and weak ties; hence new partners (Ozman, 2007). Alternatively, exploration means more cognitive distance or resource heterogeneity between partners , which negatively influences absorptive capacity (Nooteboom et. al, 2005).

Path dependency

According to Hite and Hesterly (2001), the role of path dependency in network evolution might be substantial. Hence, the question arises if there is an influence of prior ties on future partner choices caused by path dependency, trust or familiarity. If so, the decision to collaborate again is perhaps based on the wrong grounds and will not contribute to innovation. More proximate partners, as a result of a direct or indirect (via mutual counterparties) cooperation, are likely to work together in the future. This process is strengthened by the fact that they can observe each other's behaviour more easily (implies a reputation effect) and are aware of each other's abilities (Robinson and Stuart, 2007b).

Network economics offers the following contributions to hypotheses 2a and 2b:

Hypothesis 3a: Regarding proximity, relational embeddedness and exploitation (i.e. absorptive capacity arguments), a firm should opt for a repeated partnership.

Hypothesis 3b : Regarding centrality, redundancy and exploration (i.e. access to new knowledge arguments), a firm should opt for a new partnership.

3. Data and methods

3.1 Data and Sample

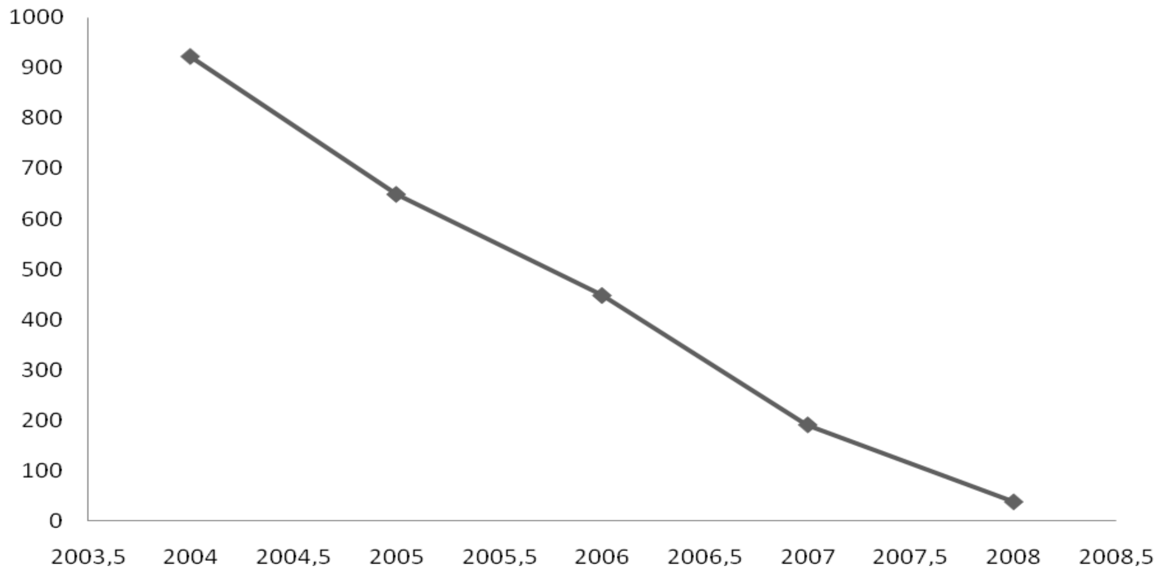
For the construction of the dataset three sources are used: Thomson One Banker, SDC platinum and the United States Patent and Trademark Office (USPTO). Using Thomson One Banker, all active and publicly listed (non-ards) US pharmaceutical firms are gathered. This selection is made on the basis of the industry code of the health sector (i.e. 4000), the SIC code of the drugs subsector (i.e. 283) and the USA country code. The result is a dataset of 352 active firms. Subsequently, 3 firms with no listing in the SDC platinum database are removed. Thirdly, the alliances announced by the 349 firms between 01-01-1990 and 12-31-2004 are listed: 193 firms are involved in one or more alliances and 156 firms are not involved in any alliance during this period. Together with the latter 156 firms, 29 firms with only one alliance announcement, which cannot have a repeated partnership in their alliance portfolio, are excluded. The final dataset contains 164 firms.

3.2 Dependent variable

3.2.1 Innovative performance

All five hypotheses are aimed at the effect of partner choice on the innovative performance. To measure this performance the number of patent applications for each year during 2005-2008 are calculated. The data are obtained from the USPTO. Figure 2 shows an almost linear decline in total patent applications during the four years.

Figure 2. The total number of patents.



The frequency distribution of the dependent (see appendix A) indicates that the total number of patents is right skewed and that, because of the steep curve, the kurtosis is much higher than for a normal distribution. These expectations are confirmed by the descriptive statistics in Table 1: the skewness and kurtosis measure are both positive.

Table 1. Descriptive statistics *Total number of patents*

N	164
Minimum	0
Maximum	275
Mean	7,96
Std. Error	2,071
Std. Deviation	26,520
Variance	703,312
Skewness	7,411
Std. Error	0,190
Kurtosis	66,639
Std. Error	0,377

3.3 Independent variable

3.3.1 Partner choice: new or repeated

The main independent variable of this study concerns the alliance partner choice of the firms during 1990-2004. The data are obtained from the SDC platinum database by checking for identical 6 digit CUSIP partner codes in this 14 year time period. Since only 36 firms opted for a repeated partnership and 128 firms did not (see Table 2), a binary variable is created and the variance of the number of repeated partnerships across the former firms is ignored. The firms with one or more repeated partnerships in their 1990-2004 alliance portfolio are assigned a 1 and firms with no repeated partnerships are assigned a 0.

Table 2. 'Number of repetitions' frequencies

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	0	128	78,0	78,0	78,0
	1	26	15,9	15,9	93,9
	2	4	2,4	2,4	96,3
	4	1	0,6	0,6	97,0
	5	2	1,2	1,2	98,2
	6	2	1,2	1,2	99,4
	7	1	0,6	0,6	100,0
	Total	164	100,0	100,0	

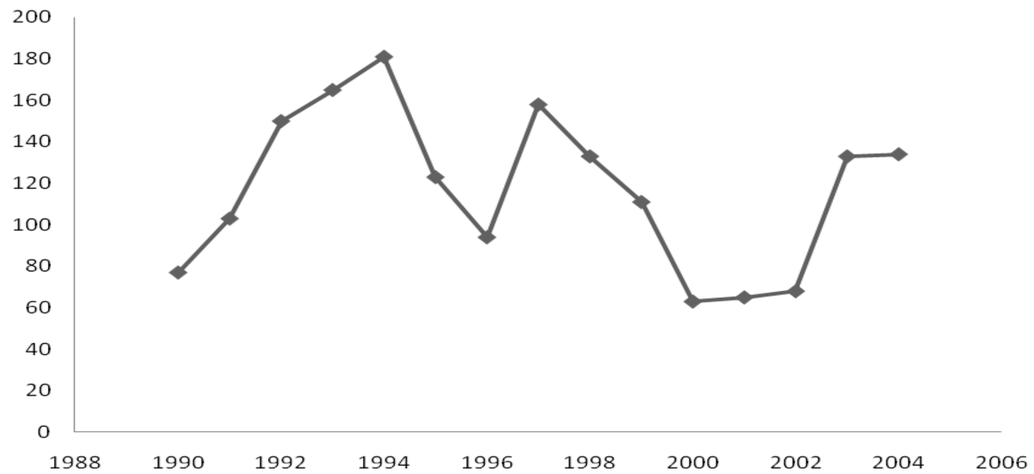
To be complete, appendix B presents a scatter plot of the number of repetitions and the number of patent applications. The latter is put in relation to the number of alliances. The scatter plot shows that there is no strong relationship between the number of repetitions and the number of alliances.

3.4 Control variables

3.4.1 The number of alliances

The SDC platinum database is also used for the calculation of the total number of alliances each firm announced during 1990-2004. This variable *Total alliances* is taken into account for two reasons. First of all, the number of alliances tends to have a positive impact on the innovative performance of firms (Deeds and Hill, 1996). Secondly, the chance of a firm having one or more repeated partnerships in its alliance portfolio increases with its total number of alliance. For these reasons it is expected that this variable may impose a moderation effect. Figure 3 shows the dynamics of the alliance announcements per year for all 164 firms together.

Figure 3. The total number of alliances.



3.4.2 R&D

In combination with human capital, R&D is a major driver of innovation (e.g., Gilsing et al., 2008). Forming an alliance means R&D investment will increase, however also other factors can contribute to R&D investment. In addition, previous R&D investment can be seen as a proxy for absorptive capacity which positively effects innovation (Cohen and Levinthal, 1990). The analysis should therefore control for the effects of absorptive capacity and factors (not related to alliances) that, through a positive impact on R&D investment, influence innovative performance. This control variable is defined as the natural logarithm of the average R&D expenses (in US dollars) over the period 1990-2004 (e.g., Lane and Lubatkin, 1998). The natural logarithm is used to control for the diminishing returns of investment and to normalize the distribution.

3.4.3 Size

Logically, large firms spend proportionally, not disproportionally, more on R&D (Cohen and Klepper, 1996) and therefore are likely to have more patent applications than smaller firms. Furthermore, according to Acs and Audretsch (1987) several factors, of which size distribution in the industry, market shares and economies of scale determine the innovative performance of the firm. All these factors are in turn influenced by firm size. In addition it is often argued that large firms have broader and more diverse resource bases and consequently can benefit more efficiently from alliances than small firms (e.g., Kotabe and Swan, 1995; Mowery, Oxley and Silverman, 1996). In addition, growth, as mentioned in the previous, and thus size positively influences innovation and vice versa. Lastly, there are also empirical studies that show that firm growth is negatively related to firm size (e.g., Evans, 1987; Hall, 1987).

A common measure of firm size is the number of employees (e.g., Sherwood and Covin, 2008). For this reason the average number of employees over the 1990-2004 period is calculated. A time period, instead of a single year, is used to resemble the strength and market share of the firm when managing its alliances during 1990-2004. The size variable is operationalized by taking the base-2 logarithms of the average numbers of employees. Taking the logarithms normalizes the distribution and due to the base-2 logarithms (instead of natural logarithms) the influence of doublings of the independent can be analyzed more easily.

The data source for both *R&D* and *Size* is the Thomson One Banker database.

3.4.4 Interaction

To determine a possible moderation effect regarding *Total alliances* and *Repetition*, the interaction variable *InteractionAR* is created. Namely, there might be a substantial difference in the number of alliances between firms with ‘repetition(s)’ and firms without ‘repetition(s)’, and also the chance of a firm having any repeated partnerships increases with this alliance portfolio size. In both situations the effect of *Repetition* on innovation will be influenced by the number of alliances.

3.5 Descriptive analyses

3.5.1 Outliers

Before starting the regression analyses, 5 firms are marked as outliers and are removed from the dataset. Especially regarding the variables 'total number of patents' and 'total number of alliances', this marking is based on the Cook's distance measure, several scatter plots and box plots. By eliminating the outliers the disturbing high variance and kurtosis measures of *Total Patents* are reduced substantially (see appendix C). To give an indication of the distribution of *Total Alliances* and its relationship with *Total Patents*, a scatter plot (of the final 159 firms) is presented in appendix D. On the basis of the plot no significant relationship is to be expected.

3.5.2 Distribution

In line with the adjustments to the raw data mentioned in the previous, the Kolmogorov-Smirnov-tests (Table 3) show that both *R&D* and *Size* are normally distributed. Since for *Total Alliances* no adjusting calculations are made there is no normal distribution. The non-normal distribution of *Total Patents* is taken into account in the method section (3.6).

Table 3. Kolmogorov-Smirnov-tests

		Total number of patents 2005-2008	Total number of alliances 1990-2004	RandD 1990-2004	Size 1990-2004
N		159	159	148	159
Normal Parameters[a,,b]	Mean	4,94	7,69	9,324694	6,836165
	Std. Deviation	11,577	8,736	1,6335312	2,1313438
Most Extreme Differences	Absolute	,335	,258	,094	,106
	Positive	,281	,243	,065	,106
	Negative	-,335	-,258	-,094	-,073
Kolmogorov-Smirnov Z		4,220	3,248	1,145	1,338
Asymp. Sig. (2-tailed)		**,000**	**,000**	**,145**	**,056**
a. Test distribution is Normal.					
b. Calculated from data.					

3.5.3 Multicollinearity

Strong correlation between the independent variables can be troublesome for the regression analyses as a result of its influence on individual P-values and confidence intervals. Table 4 shows all Pearson correlations.

Table 4. Pearson Correlations

	1	2	3	4	5
Total patents (1)	1	,293 (0,000)	,346 (0,000)	,392 (0,000)	,407 (0,000)
Repetition (2)	,293 (0,000)	1	,464 (0,000)	,268 (0,001)	,216 (0,006)
Total alliances (3)	,346 (0,000)	,464 (0,000)	1	,522 (0,000)	,560 (0,000)
R&D (4)	,392 (0,000)	,268 (0,001)	,522 (0,000)	1	,720 (0,000)
Size (5)	,407 (0,000)	,216 (0,006)	,560 (0,000)	,720 (0,000)	1

(2-tailed significance)

Remarkably, all the correlations are significant at the 0,01 level. However the correlation coefficients are only quite high between *Total Alliances*, *R&D* and *Size*. Firstly, this supports the literature on the positive relationship between size and R&D, secondly this indicates that most alliances in this study are indeed R&D based. The correlation between *Repetition* and *Total Alliances* can be marked as disturbing; this may implicate a moderation effect.

3.6 Methods

All five hypotheses are tested by analyzing the effect of repetition(s) in the alliance portfolio on the total number of patents in the time period 2005-2008. For this analysis three regression models are constructed (Table 5). The regressions are executed by using the Poisson (loglinear) method in SPSS 17.0.

Since the dependent variable is not normally distributed (high kurtosis and right-skewed) and is measured during the time period 2005-2008, the Poisson model is used for the reason that it is a model on the rate of events in a particular fixed time period (e.g., Gilsing et al., 2008).

However, since the dependent is Poisson overdispersed (variance is greater than the mean), the Negative binomial model might lead to more realistic results. For this reason model 1 is run with both the Poisson and Negative binomial method (see appendix E). The model fit statistics (deviance, pearson chi-square and log likelihood) are in favour of the Negative binomial method. Though, *Repetition* is highly significant under the Poisson and not at all under the Negative binomial model. For the latter reason and because the null hypothesis of the Negative binomial model assumes a high variance of experiment results, all regression models are run with the Poisson method[4].

Table 5. Regression models

	Dependent	Independent	Controls
Model 1	Total patents 2005-2008	Repetition(s): yes or no	R&D 1990-2004
			Size 1990-2004
Model 2	Total patents 2005-2008	Repetition(s): yes or no	R&D 1990-2004
			Size 1990-2004
			Total alliances 1990-2004
Model 3	Total patents 2005-2008	Repetition(s): yes or no	R&D 1990-2004
			Size 1990-2004
			Total alliances 1990-2004
			Interaction A*R

[4] This decision was made after consulting dr. R.D. Morey, department of Psychometrics and Statistical Techniques, Rijksuniversiteit Groningen

3.7 Results

Table 6 presents regression results of the three models. The B parameters indicate the extent to which each predictor influences the rate of the dependent.

Table 6. Parameter estimates: Models 1-3

Parameter	**Model 1**			**Model 2**			**Model 3**		
	B (std.error)	Wald*	Sig.	B	Wald	Sig.	B	Wald	Sig.
Repetition	**0,824** (0,2528)	10,620	0,001	**0,984** (0,2784)	12,501	0,000	1,133 (0,3818)	8,802	0,003
R&D (log)	**0,406** (0,1541)	6,927	0,008	**0,438** (0,1558)	7,900	0,005	**0,428** (0,1564)	7,469	0,006
Size (log)	0,047 (0,0860)	0,298	0,585	0,077 (0,0877)	0,772	0,380	0,068 (0,0891)	0,583	0,445
Total alliances				-0,015 (0,0121)	1,458	0,227	0,000 (0,0282)	0,000	0,995
Interaction A*R							-0,015 (0,0259)	0,330	0,566

***Wald Chi-Square**

Bold: significant at 0,01 level

Model 1

The results show that *Repetition* is highly significant (0,01 level) in model 1. Thus, when only controlling for *R&D* and *Size*, there is a significant positive relationship between firms with repetition(s) and innovation. The B coefficient of 0,824 implies that having one or more repeated partnerships in the alliance portfolio, multiplies the number of patents with **e^0,824 (≈ 2,28),** compared to having no repeated partnerships in the portfolio.

Also *R&D* is significant at the 0,01 level in model 1. Since this variable is captured by the natural log, the positive B coefficient of 0,406 implies that for every increase of R&D spending by **e (≈ 2,718)** times, the number of patents is increased by **e^0,406 (≈ 1,50)** times. Put differently, the B coefficient indicates a positive and significant elasticity of R&D spending for the number of patents. This finding supports the literature that R&D is an important determinant of innovation.

Model 2

In model 2 the regression results also show a significant positive effect on innovation for both *Repetition* and *R&D*. Furthermore, adding *Total alliances*, increases the significance and the value of the B coefficient for both *Repetition* and *R&D*, while the B coefficient for *Total alliances* is negative (not significant). This might indicate that, as a result of the decreasing marginal returns to alliance portfolio size, the effect of repeated partnerships and R&D spending on innovation is strengthened.

Intermezzo:

The strength of the positive effect of *Repetition* in model 2 does not decrease when the dependent is changed. When taking sequentially Patents in 2005, Patents in 2006 and Patents in 2007 as dependent, *Repetition* remains significant at the 0,01 level (see appendix F). Only the regression analysis with Patents in 2008 as dependent does not produce a significant result. In addition, the Poisson model fit statistics improve, when measuring the dependent in 1 year instead of the 4 year time period.

Model 3

Since the B coefficient of the interaction variable is not significant at all and it only slightly changes the estimates for *R&D* and *Size*, it is not likely that *Total alliances* is a moderator for the relationship between *Repetition* and innovation.

4. Discussion and Conclusions

Due to the evident role of alliances in the pharmaceutical industry, the academic literature and the empirical studies on alliances and innovation are extensive. However, a lot of niches still need to be explored . This study contributes to this quest by focusing on partner choice. The literature framework narrows partner choice down to a binary one, new or familiar, and analyzes the consequences of this choice from three different angles: TCE, resource view, and network economics. From these three views, only TCE is straightforward in favour of repeated partnerships, the other two views are not conclusive.

TCE in its most pure form simply states that R&D completely should take place within firms. However when there is a need for external technology, a firm should, mainly on the basis of management and control costs, form an alliance with a familiar partner (H1). Secondly, based on the transfer/creation of knowledge and knowledge base characteristics, two different hypotheses are formulated: absorptive capacity points towards repeated partnerships (H2a) and redundancy towards new partnerships (H2b). Thirdly, also the network economics view is not completely conclusive. The trade-offs between density and structural holes, embeddedness and redundancy, and exploration and exploitation do not offer a straightforward answer (H3a and H3b).

On the contrary, the results of the regression analyses are clear and strong. In both Poisson models, with the number of patents in 2005-2008 as dependent, the independent variable Repetition is significant at the 0,01 level and has a positive coefficient value. These results imply that the firms with repeated partnerships during 1990-2004 outperform (in terms of innovative output) firms with no repeated partnerships during that period. Approximately the same results are presented when taking patents in 2005, 2006 or 2007 as dependent. Only when taking patents in 2008 as dependent no significant result is found. Regarding these significant results H1, H2a and H3a are supported: TCE, embeddedness and absorptive capacity arguments seem to be of more importance for innovative performance than redundancy and knowledge creation arguments. This can be supported by the latest focus in the pharmaceutical industry on more intense collaborations during longer time periods. For example the partners ‘Roche’ and ‘Genentech’ are very successful by opting for severe reciprocal investments during a longer time period.

Concluding; transfer, absorption and utilization processes should not be underestimated. It can be argued that these factors are indeed necessary conditions for the creation of knowledge and thus innovation. Perhaps the positive effects that result from new ties can only be capitalized on when the positive effects of dense ties already improved the firm’s capabilities.

Limitations and future research

The limitations of the empirical analysis offer several directions for future research. Firstly, the number of patent applications is an often criticized measure of innovativeness. Multiple firms collaborate in an alliance, however sometimes only one firm is assigned the resulting patents. In addition, firms do not always apply for patents when possible, because at the moment a patent expires the knowledge becomes publicly available. Not to forget, an invention is not equal to an innovation; many innovations are never patented (Acs and Audretsch, 1987). A more adequate measure might be the rate of new product development (Deeds and Hill, 1996). Secondly, the empirical study does not consider the fact that alliances can be formed by various types of partners: competitors, subcontractors, subsidiaries etc. (Tracy and Clark, 2003). In addition, future studies should include an age variable, since alliance/network choices change when firms move from emergence to early growth (Hite and Hesterly, 2001).

Lastly, the most important implication for future studies probably is to construct a large sample of research intensive firms that consists of a large share of firms with repetitions in their alliance portfolio's and also shows a high variance within the number of repetitions. Then a more powerful and clear view on the role of repetition in alliance portfolio's can be presented.

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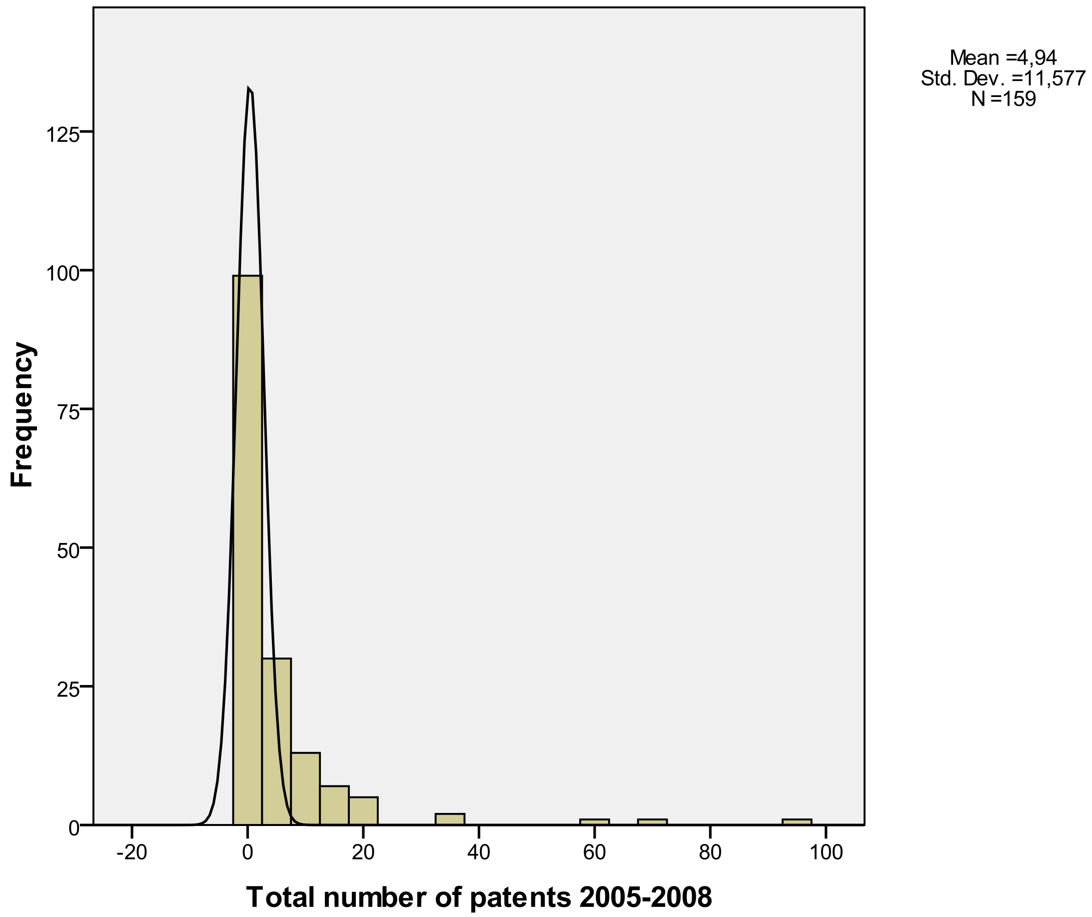
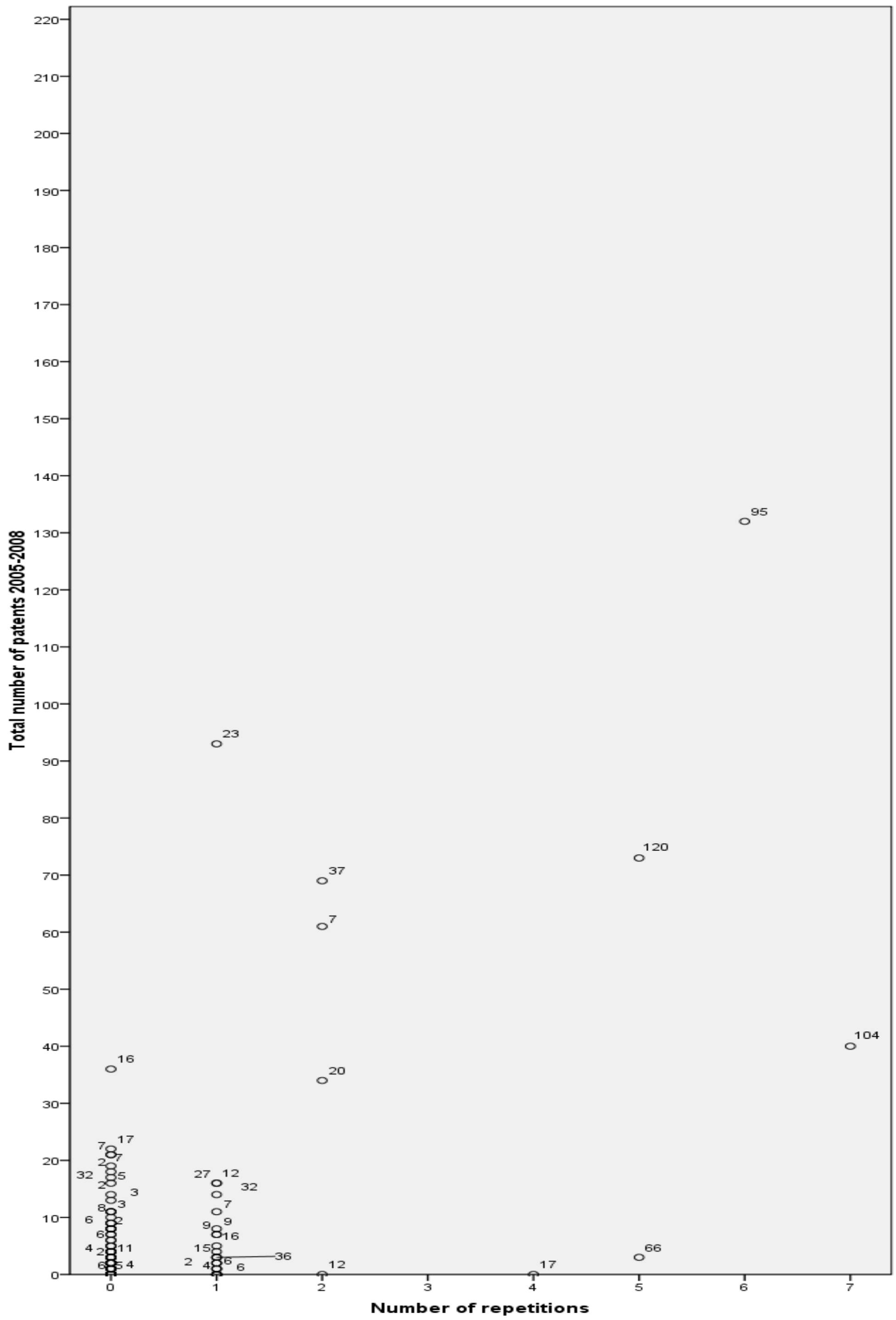
Appendix

Appendix A – Frequency distribution of *Total Patents*



Appendix B – Scatter plot of the number of repetitions and the number of patents. The numbers in the plot correspond to the total number of alliances.

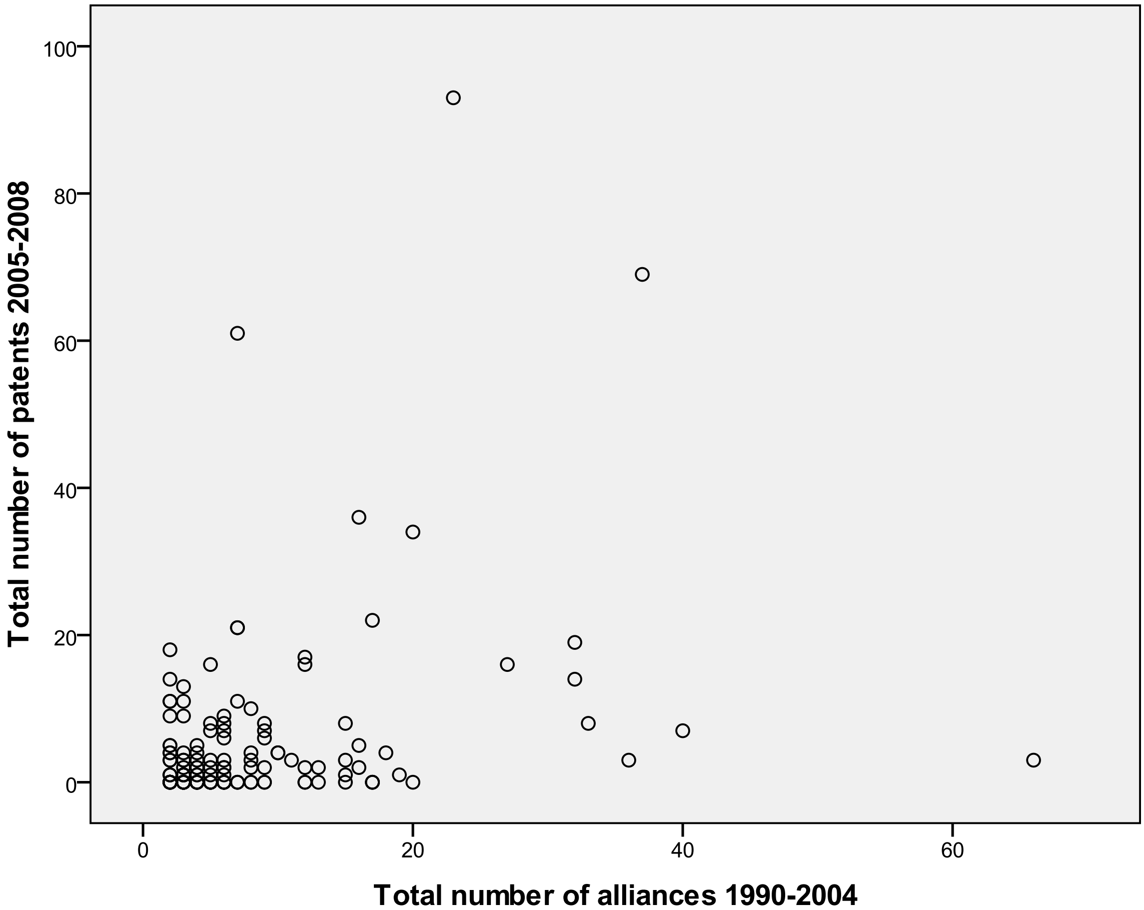


Appendix C – Descriptives *Total Patents*

Descriptive Statistics

	N	Minimum	Maximum	Mean		Std. Deviation	Variance	Skewness		Kurtosis	
	Statistic	Statistic	Statistic	Statistic	Std. Error	Statistic	Statistic	Statistic	Std. Error	Statistic	Std. Error
Total number of patents 2005-2008	159	0	93	4,94	,918	11,577	134,028	4,931	,192	29,478	,383
Valid N (listwise)	159										

Appendix D – Scatterplot *Total Alliances* and *Total Patents*



Appendix E – Regression results Model 1: Poisson and Negative binomial method

Poisson method

Goodness of Fit[d]

	Value	df	Value/df
Deviance	1218,710	144	8,463
Scaled Deviance	112,143	144	
Pearson Chi-Square	1564,921	144	10,868
Scaled Pearson Chi-Square	144,000	144	
Log Likelihood[a,,b]	-747,375		
Adjusted Log Likelihood[c]	-68,772		
Akaike's Information Criterion (AIC)	1502,750		
Finite Sample Corrected AIC (AICC)	1503,030		
Bayesian Information Criterion (BIC)	1514,739		
Consistent AIC (CAIC)	1518,739		

Parameter Estimates

			95% Wald Confidence Interval		Hypothesis Test		
Parameter	B	Std. Error	Lower	Upper	Wald Chi-Square	df	Sig.
(Intercept)	-2,280	1,0870	-4,410	-,149	4,397	1	,036
[Repetition=0]	-,824	,2528	-1,320	-,328	10,620	1	,001
[Repetition=1]	0[a]	.	.	.	.	.	.
RandD	,406	,1541	,104	,708	6,927	1	,008
Size	,047	,0860	-,122	,216	,298	1	,585
(Scale)	10,868[b]						

Dependent Variable: Total number of patents 2005-2008

Model: (Intercept), Repetition, RandD, Size

a. Set to zero because this parameter is redundant.

b. Computed based on the Pearson chi-square.

Negative binomial method

Goodness of Fit[d]

	Value	df	Value/df
Deviance	231,985	144	1,611
Scaled Deviance	120,792	144	
Pearson Chi-Square	276,558	144	1,921
Scaled Pearson Chi-Square	144,000	144	
Log Likelihood[a,,b]	-331,746		
Adjusted Log Likelihood[c]	-172,736		
Akaike's Information Criterion (AIC)	671,493		
Finite Sample Corrected AIC (AICC)	671,773		
Bayesian Information Criterion (BIC)	683,482		
Consistent AIC (CAIC)	687,482		

Parameter Estimates

			95% Wald Confidence Interval		Hypothesis Test		
Parameter	B	Std. Error	Lower	Upper	Wald Chi-Square	df	Sig.
(Intercept)	-5,526	1,3769	-8,224	-2,827	16,107	1	,000
[Repetition=0]	-,204	,3456	-,882	,473	,350	1	,554
[Repetition=1]	0[a]	.	.	.	.	.	.
RandD	,610	,1626	,292	,929	14,087	1	,000
Size	,144	,1028	-,057	,346	1,967	1	,161
(Scale)	1,921[b]						
(Negative binomial)	1						

Dependent Variable: Total number of patents 2005-2008

Model: (Intercept), Repetition, RandD, Size

a. Set to zero because this parameter is redundant.

b. Computed based on the Pearson chi-square.

Appendix F – Poisson regression results Model 2

Dependent: Patent applications in 2005

Goodness of Fit[d]

	Value	df	Value/df
Deviance	601,179	143	4,204
Scaled Deviance	118,719	143	
Pearson Chi-Square	724,137	143	5,064
Scaled Pearson Chi-Square	143,000	143	
Log Likelihood[a,,b]	-399,323		
Adjusted Log Likelihood[c]	-78,857		
Akaike's Information Criterion (AIC)	808,645		
Finite Sample Corrected AIC (AICC)	809,068		
Bayesian Information Criterion (BIC)	823,631		
Consistent AIC (CAIC)	828,631		

Parameter Estimates

			95% Wald Confidence Interval		Hypothesis Test		
Parameter	B	Std. Error	Lower	Upper	Wald Chi-Square	df	Sig.
(Intercept)	-3,660	1,1259	-5,866	-1,453	10,565	1	,001
[Repetition=0]	**-,775**	,2843	-1,332	-,218	7,429	1	**,006**
[Repetition=1]	0[a]	.	.	.	.	.	.
RandD	**,469**	,1586	,158	,779	8,724	1	**,003**
Size	,046	,0895	-,129	,222	,265	1	,606
Alliances	-,005	,0114	-,027	,018	,159	1	,690
(Scale)	5,064[b]						

Dependent: Patent applications in 2006

Goodness of Fit[d]

	Value	df	Value/df
Deviance	550,617	143	3,850
Scaled Deviance	98,389	143	
Pearson Chi-Square	800,278	143	5,596
Scaled Pearson Chi-Square	143,000	143	
Log Likelihood[a,,b]	-357,039		
Adjusted Log Likelihood[c]	-63,799		
Akaike's Information Criterion (AIC)	724,078		
Finite Sample Corrected AIC (AICC)	724,501		
Bayesian Information Criterion (BIC)	739,064		
Consistent AIC (CAIC)	744,064		

Parameter Estimates

			95% Wald Confidence Interval		Hypothesis Test		
Parameter	B	Std. Error	Lower	Upper	Wald Chi-Square	df	Sig.
(Intercept)	-4,595	1,4309	-7,399	-1,790	10,311	1	,001
[Repetition=0]	**-1,068**	,3297	-1,714	-,421	10,483	1	**,001**
[Repetition=1]	0[a]	.	.	.	.	.	.
RandD	**,614**	,1999	,222	1,006	9,434	1	**,002**
Size	,000	,1104	-,217	,216	,000	1	,995
Alliances	-,029	,0168	-,062	,004	2,929	1	,087
(Scale)	5,596[b]						

Dependent: Patent applications in 2007

Goodness of Fit[d]

	Value	df	Value/df
Deviance	281,323	143	1,967
Scaled Deviance	103,481	143	
Pearson Chi-Square	388,761	143	2,719
Scaled Pearson Chi-Square	143,000	143	
Log Likelihood[a,,b]	-189,066		
Adjusted Log Likelihood[c]	-69,545		
Akaike's Information Criterion (AIC)	388,132		
Finite Sample Corrected AIC (AICC)	388,554		
Bayesian Information Criterion (BIC)	403,118		
Consistent AIC (CAIC)	408,118		

Parameter Estimates

			95% Wald Confidence Interval		Hypothesis Test		
Parameter	B	Std. Error	Lower	Upper	Wald Chi-Square	df	Sig.
(Intercept)	-2,758	1,2862	-5,279	-,237	4,598	1	,032
[Repetition=0]	**-1,530**	,3533	-2,223	-,838	18,768	1	**,000**
[Repetition=1]	0[a]	.	.	.	.	.	.
RandD	,160	,1822	-,197	,517	,775	1	,379
Size	,263	,1040	,059	,466	6,382	1	,012
Alliances	-,023	,0151	-,053	,007	2,295	1	,130
(Scale)	2,719[b]						

Dependent: Patent applications in 2008

Goodness of Fit[d]

	Value	df	Value/df
Deviance	93,897	143	,657
Scaled Deviance	33,735	143	
Pearson Chi-Square	398,021	143	2,783
Scaled Pearson Chi-Square	143,000	143	
Log Likelihood[a,,b]	-57,466		
Adjusted Log Likelihood[c]	-20,646		
Akaike's Information Criterion (AIC)	124,932		
Finite Sample Corrected AIC (AICC)	125,354		
Bayesian Information Criterion (BIC)	139,918		
Consistent AIC (CAIC)	144,918		

Parameter Estimates

			95% Wald Confidence Interval		Hypothesis Test		
Parameter	B	Std. Error	Lower	Upper	Wald Chi-Square	df	Sig.
(Intercept)	-2,072	2,6327	-7,232	3,088	,619	1	,431
[Repetition=0]	-,465	1,0370	-2,497	1,568	,201	1	,654
[Repetition=1]	0[a]	.	.	.	.	.	.
RandD	-,291	,3687	-1,014	,431	,624	1	,429
Size	,382	,2437	-,096	,859	2,453	1	,117
Alliances	,010	,0380	-,064	,085	,074	1	,786
(Scale)	2,783[b]						