# Alliance Addiction: Do Alliances Create Real Benefits?

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**Although their advantages are well known, technology alliances may not always positively affect innovative performance. Previous studies have found several explanations for this problem. Technology alliances often require excessive resources and capabilities to create and maintain relationships with partners. In addition, they divert managerial attention and functions from internal research and development (R&D) activities. In this study, we hypothesize that firms often execute inefficient technology alliance strategies, thus affecting their innovative capabilities negatively and consequently reducing their subsequent innovation performance. Specifically, we test whether firms with greater prior experience in technology alliance are more likely to execute inefficient technology alliance strategies. Second, we attempt to investigate the negative effects of technology alliances on firms' internal R&D capabilities. To test our hypotheses, we employ data from 1,036 technology alliances in the US nanobiotechnology sector. Implications from the analyses are offered for executives and technology alliance strategies. Specifically, we propose that firms should adopt technology alliance but with due consideration of its negative aspects and the firms' limited resources.**

## Introduction

Technology alliances are voluntary arrangements between firms to exchange and share knowledge as well as resources with the intent of developing their processes, products or services (Gulati, 1998). Technology alliances have many advantages for firms in that they transfer partners' knowledge and diversify risk under the condition of uncertainty. As evidenced by their ubiquitous use in many different industries, technology alliances have become an important strategic tool for firms (Hagedoorn, 1993).

However, is it always right that firms choose technology alliance to improve their competency? We can answer this question using the case of Motorola, a leading company in the mobile handset industry. According to a report by Perkins, Rech and Panicker (2008), Motorola's performance peaked thanks to their volume model named Razr 1 in 2006, but in the course of the standard war for smartphones, the company did not release a subsequent competitive product due to excessive technology alliance and M&A strategy, which were costly and did not contribute to making profits. Consequently, in 2008, Motorola decided to split the handset business from its other businesses and, recently, handed over its second position in the market to Samsung Electronics. In the same context, some recent studies argue that technology alliances are less successful than expected. For instance, Kale and Singh (2009) point out that technology alliance is highly likely to fail, and Wittmann, Hunt and Arnett (2009) emphasize that 70 per cent of technology alliances are not successful. There is no strategy that is totally integrative, so technology alliances may also have negative aspects.

Theories on technology alliances have developed significantly among strategy and organizational researchers. The majority of prior research focuses on how technology alliances affect financial and innovation performance (Belderbos, Carree & Lokshin, 2006; Faems, Van Looy & Debackere, 2005) and characteristics (Deeds & Rothaermel, 2003; Park & Kang, 2009), which can result in successful alliance formation. However, the negative aspects of alliances for firms have not been examined adequately. While researchers including Hitt et#x2009;al. (1991) have made



10.1111/caim.12016

some progress on investigating the negative aspects of mergers and acquisitions (M&A) between firms, there is almost no prior research in the case of technology alliances. There have been a few studies that examine the negative relationship between technology alliance and innovation performance under specific conditions such as within a short alliance period and on the purpose of cost reduction (Duysters & Hagedoorn, 2000; Vanhaverbeke, Duysters & Beerkens, 2001), but these are not sufficient to understand the negative aspects of technology alliance. Accordingly, this study is expected to improve understanding on the negative aspects of technology alliances and to contribute a reasonable decision-making tool for practitioners when they choose an alliance strategy.

We introduce the concept of 'organizational routine' to analyse the negative aspects of technology alliances. Organizational routine is mentioned frequently in organizational learning and evolutionary economics. Nelson and Winter (1982) define it is a 'gene' which guides organizational behaviour. Routine is constituted by the accumulative experience of firms, and one of its characteristics is path dependency because it is strengthened by continuous experience. We estimate that the organizational routine built by inter-firm alliances brings negative effects for firms. Therefore, we try to analyse how the alliance experience that builds organizational routine affects firms.

The specific steps of our research are as follows. First, we confirm the fact that alliance experience affects firms in their choice of strategies. More specifically, we suggest the possibility that firms' choice of strategies does not result from reasonable decision making but from organizational inertia. Second, we argue that alliance experience decreases the internal research and development (R&D) capability of firms so that we can understand why technology alliances have negative aspects for firms. For an empirical test, we collect 1,036 technology alliance cases in the US nanobiotechnology industry, and combine the financial and patent information of each company to constitute our data set. This data set is then analysed using negative binomial regression and multiple regression.

The article is divided into sections. First, we review prior research on alliance experience to establish the logical background of relationships between alliance experience and alliance formation, and alliance experience and internal R&D capability, in order to set the hypotheses. Second, we describe the sample, variables and regression analysis in the methodology section. We then present our results, followed by a discussion and conclusion in the final section.

## Theoretical Background and Hypotheses

### *Organizational Routine and Technology Alliance*

Organizational routine has become a cornerstone in theories on organizational learning and evolutionary economics (Becker, 2004; Cohen, 1991; Levitt & March, 1988; Nelson & Winter, 1982; Walsh & Ungson, 1991). However, despite its increasing popularity, there are inconsistencies in explaining the concept involved. This is because organizational routine is difficult to define exactly, given its abstract and dynamic characteristics. But generally, it can be summarized as three different things: a gene which guides organizational behaviour (Nelson & Winter, 1982), a grammar which typifies patterns of behaviour (Pentland & Rueter, 1994), and a programme that controls behaviour (March & Simon, 1958). According to earlier research on organizational behaviour, organizational routine is built up by past experience, and it affects future organizational behaviour. In particular, organizational behaviour is not determined by decision, but rather by automatic responses as an effect of organizational routine (Pentland & Rueter, 1994).

Many researchers have increasingly tended to apply the concept of routine to analyse inter-firm co-operation (Barney, 1991; Dyer & Singh, 1998; Hagedoorn & Duysters, 2002; Hoang & Rothaermel, 2005; Ireland, Hitt & Vaidyanath, 2002; Kale, Dyer & Singh, 2002; Rothaermel & Deeds, 2006; Wang, 2011). For example, Hagedoorn and Duysters (2002) argue that routine plays a role in firms' decision to choose between M&A and technology alliance strategy, and it also determines firms' tendency to prefer a specific strategy. Hoang and Rothaermel (2005) consider routine as part of the alliance management capability, that is, the capability to manage relationships with partner firms. Zollo, Reuer and Singh (2002) redefine routine as interorganizational routine which specializes in inter-firm co-operation.

From the point of view of intra-organizational routine, when a specific experience such as inter-firm alliance is repeated accumulatively, an intra-organizational routine that increases the capability to absorb and exploit knowledge in future alliances is formed and results in positive effects on firm performance (Barney, 1991; Levitt & March, 1988). From the point of view of inter-organizational routine, accumulative alliance experience improves alliance management capability which enables firms to manage and operate alliances and to acquire outcome. It also

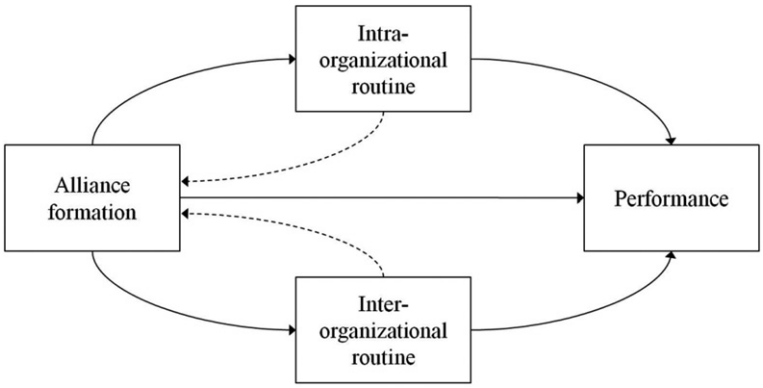


*Figure 1. Organizational Routine's Operating Mechanism*
*Source*: Adapted from Zollo and Winter (2002) and Heimeriks and Duysters (2007)

improves alliance portfolio capability, which enables firms to manage diversified partners effectively (Hoang & Rothaermel, 2005; Kale, Dyer & Singh, 2002; Rothaermel & Deeds, 2006). We acknowledge two aspects from the previous studies mentioned earlier. First, prior alliance experience can be used to measure intra- and inter- organizational routine (Kale, Dyer & Singh, 2002). Second, the effect of intra- and inter- organizational routine is indirect but positive for firm performance. Figure 1 depicts the mechanism of the effect of organizational routine.

This study attempts to approach organizational routine from a different point of view from prior research. Organizational routine is basically a concept that excludes value judgement. It plays a positive role in improving firm performance by allowing quick decision making and operational efficiency according to its use. At the same time, however, it can play some negative roles such as rigid decision making and resistance to variety. By focusing on the latter, the present work suggests that organizational routine can have a negative effect on firms' decision-making processes and internal R&D capability. Specifically, we suggest that routine interferes with reasonable decision making when organizations choose a strategy, leading them to make passive decisions because of previous experience. In addition, firms' preference developed by path dependency can have a negative effect on internal R&D capability. Furthermore, we correct the defects of prior research, which measure routine only by the total sum of prior alliance experience, by refining variables for alliance experience into three different ones, namely, accumulative alliance experience, recent alliance experience and diversified alliance experience, in order to analyse the negative aspects of routine more specifically and in a multi-dimensional manner.

### *Alliance Experience and Alliance Formation*

The technology alliance literature has provided empirical evidence for the positive effects of alliance formation on firm performance. Using cardiovascular drug discovery industry data, biotechnology industry data, aircraft engine control systems industry data and cross-sectional data, Henderson (1994), Orsenigo, Pammolli and Riccaboni (2001), Brusoni, Prencipe and Pavitt (2001) and Mowery, Oxley and Silverman (1996) have respectively found that established firms with multi-technology and intense R&D activities are very skilful in absorbing new knowledge generated outside firm boundaries. Many researchers have also investigated the advantages of technology alliances, which are well known to practitioners. Technology alliance helps firms strengthen their competitiveness by enhancing market power (Kogut, 1991), accessing external resources and capabilities (Rothaermel & Boeker, 2008), and entering new markets (Garcia-Canal et al., 2002; Park & Kang, 2010). Consequently, alliance strategy is highlighted as a frequently used firm strategy by managers during the last two centuries (Hagedoorn, 1993).

However, recent prior research suggests that technology alliance is more probable to fail than expected (Kale & Singh, 2009; Wittmann, Hunt & Arnett, 2009). Kale and Singh (2009) point out that technology alliance is highly likely to fail, and Wittmann, Hunt and Arnett (2009) also emphasize that 70 per cent of technology alliances are not successful. In many cases, the formation of such relationships has resulted in shareholder value destruction for those firms that engage in them (Kale, Dyer & Singh, 2002). Despite the prevalence of technology alliances, their low success rate affirms their misuse by decision makers or managers.

In this section, we focus on the organizational decision-making process. Motorola carried on an excessive alliance strategy based on unreasoned judgement. In the mid-2000s, for instance, it allied with various partners such as Compal and CMCS in Taiwan and Pantech in South Korea to launch new products and to reinforce competitiveness in the handset sector. However, problems in product standardization and compatibility emerged between partners. Motorola promoted platform integration to resolve these problems and fostered sequential alliances to develop a platform-related technology. However, this strategy did not work out. Despite its successive failures, Motorola acquired patents of a British handset manufacturer, Sendo, in 2005, and shares of a platform developer, TTP Com, to procure the technology necessary for platform integration outside the firm boundary. Why did Motorola stick to the alliance strategy despite its successive failures? Why do firms like Motorola, which have talented manpower, adopt an excessive alliance strategy and fail? We conjecture that these firms made unreasonable decisions because of the effect of organizational routine built up and improved by past alliance experience.

Generally, firms have path dependency in absorbing external knowledge (Arthur, 1989). For example, once a firm has chosen alliance for absorbing external knowledge, they accumulate capabilities of searching and selecting partners, and executing and maintaining alliances. Afterwards, they build a preference for alliance strategy (Hagedoorn & Duysters, 2002; Powell, Koput & Smith-Doerr, 1996). Osborn and Hagedoorn (1997) state that from the perspective of institutionalization theory, companies search for a 'rule of conduct' with regard to different forms of organizations that are not only embedded in particular industrial settings but are also copied over time as they become institutionalized within companies. Harrigan and Newman (1990) indicate that the propensity of firms to seek alliances is an important characteristic of differences with respect to the behaviour of firms in this context.

Various terminologies in previous research (i.e., preference, path dependency and rule of conduct) explain the characteristics of organizational routine. We reorganize the conclusions of prior research through an organizational routine lens. If firms have continuously carried out alliance strategy, organizational routine for forming and facilitating alliance strategy is built up, and its characteristic of path dependency strengthens and induces itself to grow. In other words, decisions after building up organizational routine are not made by reasoned judgement, but by unreasonable and biased judgement. These negative aspects of organizational routine induce firms to establish excessive alliance strategy, which can harm firms' fundamentals.

In this study, we set past alliance experience as proxy for organizational routine and suggest hypotheses for how organizational routine affects alliance formation. Additionally, we classify alliance experience into accumulative alliance experience, recent alliance experience and diversified alliance experience to analyse the effect of organizational routine on alliance formation specifically.

*Hypothesis 1-1. The more accumulative alliance experience firms have, the more likely they will choose alliance strategy subsequently.*

*Hypothesis 1-2. The more recent alliance experience firms have, the more likely they will choose alliance strategy subsequently.*

*Hypothesis 1-3. The more diversified alliance experience firms have, the more likely they will choose alliance strategy subsequently.*

### *Alliance Experience and Internal R&D Capability*

Utilizing external resources through alliance strategy is important under the condition of rapid change of a firm's environment (Bettis & Hitt, 1995; Dittrich & Duysters, 2007; Lichtenthaler, 2008; Nicholls-Nixon & Woo, 2003). However, the core body that makes innovation is a focal firm. The improvement of internal R&D capability is also closely related to the survival of firms who compete through technological innovation (Christensen & Overdorf, 2000; Foster, Kaplan & Peoples, 2001). Many researchers have emphasized the importance of internal R&D capability and have analysed its relationship with innovation performance (Griffith, Redding & Van Reenen, 2004; Hagedoorn & Duysters, 2002; Lokshin, Belderbos & Carree, 2008; Love & Roper, 2002). Internal R&D capability is a core asset for firms that aim to achieve innovation (Griliches, 1979; Rothaermel & Hess, 2007; Scherer, 1982). They make innovation happen through investments in internal R&D and the 'learning-by-doing' process (Prahalad & Hamel, 1990; Winter, 1987). There are also some studies which emphasize the interaction between internal R&D capability and utilizing external knowledge resources. Teece, Pisano and Shuen (1997) argue that internal innovation capability is essential to make innovation through knowledge transfer from external firms. In other words, utilizing external knowledge resources is complementary to internal R&D capability.

In the same context, Lokshin, Belderbos and Carree (2008) and Lee, Lee and Pennings (2001) also find that combining internal R&D capability and technology alliance contributes significantly to productivity growth, with the positive effect of technology alliance 'only evident' in the case of sufficient internal R&D capabilities. Cohen and Levinthal (1990) suggest the concept of absorptive capacity, the capability to utilize external knowledge, and emphasize the importance of internal R&D effort to absorb and internalize external knowledge resources. As mentioned in many previous studies such as those of Griliches (1979) and Scherer (1982), internal R&D capability is critical to the innovation and growth of firms. Furthermore, it is a very important asset that determines the efficiency of co-operation with external firms.

Some recent research, however, suggest that alliance strategy, including technology alliance, has a negative effect on internal R&D capability (Higgins & Rodriguez, 2006; Laursen & Salter, 2006; Watkins & Paff, 2009). The reasons for negative relationships forming between technology alliance and internal R&D capability are as follows. First, alliance formation and internal R&D capability have a trade-off relationship. In the context of the resource-based view, executing alliance strategy allocates firms' limited human and physical resource to alliance activities, which means a decrease in resources to invest in internal R&D activities. This reduces internal R&D activities and consequently weakens firms' innovation capability in the long run (Dodgson, 1993; Hitt et al., 1991; Miles & Snow, 1992; Quinn, 1992). Second, alliance formation processes usually absorb considerable managerial attention. During this process, the attention of top managers and managing functions may be diverted from internal R&D activities, such as developing new products and innovation (Hitt, Hoskisson & Ireland, 1990). Third, due to a lack of absorptive capacity, firms cannot fully transfer knowledge into their boundaries. Specifically, when firms reduce efforts for knowledge creation through internal R&D activities, the extent to which knowledge transfers into the firms decreases due to the decrease in absorptive capacity and can result in the formation of a vicious cycle (Cohen & Levinthal, 1989).

The problems mentioned earlier, namely, the negative effects of alliance strategy on internal R&D capability, would stand out in bold relief in the case of firms that have ever chosen a number of alliance strategies in the past. The more alliance experience firms have, the more likely it is that they put less resources into the internal R&D area in the past. Most of all, the more alliance experience firms have, the more likely firms will strengthen their organizational routine and specialize for the execution of alliance. We also suggest that this relationship leads to the carrying out of excessive alliance strategy and the decreasing interest in the internal R&D area. In this paper, we set and test the hypothesis which proves the correlation between strong organizational routine for alliance strategy, in other words, abundant alliance experience and negative aspects of internal R&D capability. We classify variables for alliance experience into accumulative alliance experience, recent alliance experience, and diversified alliance experience, as with Hypothesis 1.

*Hypothesis 2-1. The more accumulative alliance experience firms have, the larger the negative effects on firms' internal R&D capability.*

*Hypothesis 2-2. The more recent alliance experience firms have, the larger the negative effects on firms' internal R&D capability.*

*Hypothesis 2-3. The more diversified alliance experience firms have, the larger the negative effects on firms' internal R&D capability.*

## Methodology

### *Data and Sample*

To test the hypotheses, we collect data from nanobiotechnology firms. Nanobiotechnology is a cross-disciplinary area combining nanotechnology, which analyses atoms and molecules in nanoscale, and biotechnology, which examines diseases and biological phenomena, to produce related products (No & Park, 2010; OECD, 2005). This field is relatively young, as research on it began only in the last decade. Nevertheless, biotechnology and pharmaceutical incumbent firms have increased their R&D investment in nanobiotechnology for growth in the next generation; in fact, the US and Japan support R&D in nanobiotechnology at the national level (Koopmans & Aggeli, 2010; Thomas & Acuna-Narvaez, 2006). Also, nanobiotechnology is one of the fastest emerging segments in the nanotechnology field (Roco, 2003; Roco & Bainbridge, 2003).

Collection of data was carried out as follows. First, we obtained the technology alliance sample of nanobiotechnology firms in the US provided by the Bioscan database from 1990 to 2008. Next, we added financial information such as sales, number of employees, and size of R&D investment provided by the Datastream database. Finally, we added patent information provided by the US Patent and Trademark Office. A total of 1,036 technology

alliance samples from 136 firms were collected. Our samples comprise four technological groups: dendrimer, nanoparticle, drug delivery and therapeutics.

The reasons for choosing the nanobiotechnology sector are as follows. First, nanobiotechnology is a cross-disciplinary field which combines nanotechnology and biotechnology. Therefore, it requires knowledge from different fields such as physics, biology, chemistry and the engineering sciences (No & Park, 2010; OECD, 2005). Considering these characteristics of a cross-disciplinary technology, there is active co-operation among firms for the development of technology and to achieve innovation (Roco, 2003; Rothaermel & Thursby, 2007; Thomas & Acuna-Narvaez, 2006). Accordingly, it is appropriate to test empirically for organizational routine built up by alliance experience thanks to a vast array of technology alliance data. Second, the emergence of nanobiotechnology is a radical technological change for biotechnology incumbents (Rothaermel & Thursby, 2007). In fact, the incumbents in biotechnology sectors carry out active M&A and technology alliance to acquire nanotechnology, and the pace at which they are doing so is also growing. However, previous literature has still focused largely on the technology alliance case within solely biotechnology despite the industrial and technological significance of nanobiotechnology (Carayannopoulos & Auster, 2010; De Carolis, 2003; George, Zahra & Wood, 2002; Powell, Koput & Smith-Doerr, 1996; Zhang & Baden-Fuller & Mangematin, 2007). Accordingly, we use data from the nanobiotechnology industry so we can ensure the possibility of technology alliance research within the industry and so we can improve understanding of the industry. Finally, precise data are available within a single industry and this raises the reliability for test results because controlling the industry is not necessary (Brouthers & Hennart, 2007).

### *Dependent Variables*

We introduce two dependent variables, *alliance formation* and *internal R&D capability*. *Alliance formation* is the number of total technology alliances made by focal firms from 2007 to 2008. Searching for a potential alliance partner and processing the contract take time. Therefore, we can reduce bias from this problem when we count alliances committed over a two-year period.

*Internal R&D capability* is derived by dividing the total number of patents by invested R&D expenditure. This calculation is from innovation productivity research, and there is a one-year time lag between R&D expenditure and new patents (Han & Lee, 2007). In this study, we are interested in the change in internal R&D capability. We measure internal R&D capability over 2 years, similar to *Alliance formation*, to reduce the bias derived from an insufficient time window. The equation used for calculation is as follows.

$$\Delta\text{Internal R\&D capability}_i = \frac{\text{New patents}_{i,2007-2008}}{\text{R\&D expenditure}_{i,2006-2007}} - \frac{\text{New patents}_{i,2005-2006}}{\text{R\&D expenditure}_{i,2004-2005}}$$

A more than 5 per cent decrease is coded as –1 and considered for the decrease of internal R&D capability. We coded it as 0 when internal R&D capability does not change more than 5 per cent, and coded it as 1 when internal R&D capability increases more than 5 per cent.

In addition, some previous studies adopt R&D expense or R&D spending as variables for measuring internal R&D capability (Cohen & Levinthal, 1989; Irwin & Klenow, 1996; Sakakibara, 1997). Generally, previous literature, which uses R&D expense as a dependent variable, assumes that a high level of R&D expense is better than a low one. However, this assumption does not reflect the fact that a more effective innovation process or economies of scale lower the R&D expense of firms (De Man & Duysters, 2005). Moreover, it does not explain the case of Motorola, which sustained R&D investment but experienced a decrease in capabilities for new product releases. Consequently, this study uses a measure for internal R&D capability which adopts the concept of productivity and efficiency instead of a measure for R&D expense.

### *Independent Variables*

Independent variables used for the test are related to prior alliance experience. Prior alliance experience has generally been used as a proxy to measure organizational routine in much prior research (Hagedoorn & Duysters, 2002; Hoang & Rothaermel, 2005; Kale, Dyer & Singh, 2002; Zollo, Reuer & Singh, 2002). However, these works have limitations because they measured organizational routine simply by the total sum of prior alliance experience. Therefore, we address the limitations of prior research by refining the independent variables for alliance experience into three different ones, namely, *accumulative alliance experience*, *recent alliance experience*, and *diversified alliance experience*.

The first measurement, of *accumulative alliance experience*, is the total sum of alliance experience from 1990 to 2006. This method is

verified in much earlier research on alliance experience (Deeds & Hill, 1996; Hoang & Rothaermel, 2005; Kale, Dyer & Singh, 2002; Rothaermel, 2001; Rothaermel & Deeds, 2004; Sampson, 2005; Shan, Walker & Kogut, 1994; Zollo, Reuer & Singh, 2002). Second, *recent alliance experience* is measured by the total sum of alliance experience contracted from 2005 to 2006. There is a term named 'recency effect' in cognitive psychology. Recency effect is understood to be the outcome wherein recent past experience highly affects person's learning and doing. It is rarely applied to firm organizations, but Carley (1997) and Carley and Svoboda (1996) test simulated firms on how recent experience makes a difference in organizations. Third, *diversified alliance experience* measures the amount of alliance experience with different firms from 1990 to 2006. To make this variable effective, the Herfindahl Index, usually used for measuring the level of rivalry within an industry, the level of firm's diversification (Berry, 1975), and the level of R&D dispersion (Singh, 2008), is applied to measure the diversified alliance experience (Misztal, 1996). The equation used for calculation is as follows.

$$\text{Degree of diversified alliance experience}_i = 1 - \sum_{j=1}^{J} \left( \frac{n_{ij}}{N} \right)^2$$

As the value approaches 1, the focal firm allies with diversified firms. In the calculation, i represents the focal firm, and $n_{ij}$ represents the amount of past alliance experience of the focal firm with one of its partners, j.

### *Control Variables*

In this study, five control variables are used. First, *firm size* measures the sales of firms. Considering the cycle of economy, this variable uses the average value of sales from 2004 to 2006. *Firm age* measures the number of years from the year when the first revenue is realized until 2006. Park and Kang (2010) empirically tested the existence of interaction effects between the difference of entry timing and alliance formation. This is also included in the control variables. *Prior M&A experience* counts the number of M&A contracts published by firms since their establishment up to 2006. *Technology capability* is controlled. It measures the total number of patents up to 2006. Finally, the variable *IPO* stands for whether firms did an initial public offering (IPO) (coded as 1) or not (coded as 0). IPO means listing on the stock market so that a private company can open its ownership to the public and publicize its financial information. In the case of firms which went through IPO, their ownership is decentralized, and they are obliged to publicize their information. Therefore, their decision-making processes, such as choosing a strategy, is likely to be different from those firms that did not do IPO. Therefore, we control this variable to increase the reliability of the test results and to verify the pure effect of alliance experience.

A summary of the variable information and measurements is given in Table 1.

### *Empirical Model Specification*

In this paper, new alliance formation and internal R&D capability are dependent variables. We use different methods according to the distribution of dependent variables. A negative binomial regression model is used to analyse new alliance formation, and a multiple regression model is used to analyse internal R&D capability. Table 2 shows that new alliance formation is a variable for discrete events having a positive integer value. The mean value is 1.79 and standard deviation is 2.86. In particular, variance is almost two times larger than the mean value and shows an over-dispersion distribution. In this case, negative binomial regression raises the reliability for results.

## Results

Table 3 presents the results from applying the negative binomial regression. In Model 2, the effect of all variables relating to prior alliance experience was significant. First, accumulative alliance experience is positively correlated to future alliance formation, and this relationship is highly significant ($p < 0.01$). This result suggests that previous accumulative alliance experience builds organizational routine, which induces firms to continuously form alliances. After an organizational routine is established, a dynamic process emerges between alliance formation and organizational routine (Nelson & Winter, 1982; Zollo, Reuer & Singh, 2002). Consequently, alliance formation induces organizational routine which, in turn, induces another alliance formation. Furthermore, organizational routine is also intensified.

The second independent variable, recent alliance experience, also has a positive relationship with future alliance, and this relationship is highly significant ($p < 0.01$). Thus, the more firms have recent alliance experience, the more they tend to form future alliances; this finding supports hypothesis 1-2. In addition, this result suggests that the effect of organizational routine, which induces firms to choose an alliance strategy, can be

*Table 1. Variable Information and Measurement*

| Variable Information | | Measurement |
|---|---|---|
| Dependent variables | New alliance formation | Number of new alliance formations in year 2007–2008 |
| | ΔInternal R&D capability | $\frac{\text{New patents}_{i,2007-2008}}{\text{R\&D expenditure}_{i,2006-2007}} - \frac{\text{New patents}_{i,2005-2006}}{\text{R\&D expenditure}_{i,2004-2005}}$ |
| | | –1 if the value is under –5%, 0 if the value is between –5% and 5%, 1 if the value is over 5% |
| Independent variables | Accumulative alliance experience | Total number of accumulative alliance experience until 2006 |
| | Recent alliance experience | Amount of alliance experience in year 2005–2006 |
| | Diversified alliance experience | $1-\sum_{j=1}^{J}\left(\frac{n_{ij}}{N}\right)^2$ |
| Control variables | Firm size | LN(Average sales size in 2004 –2006) |
| | Firm age | Post-entry active period until 2006, *Firm age*=2006-year at entry |
| | Prior M&A experience | Number of M&A contracts before year 2006 |
| | Technology capability | Number of accumulative patents before year 2006 |
| | IPO | 1 in case of IPO, otherwise 0 |

*Table 2. Descriptive Statistics and Correlations among the Variables*

| Variables | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | Mean | SD |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Firm size | 1.00 | | | | | | | | | | 6.75 | 5.34 |
| Firm age | 0.29 | 1.00 | | | | | | | | | 12.91 | 4.88 |
| M&A experience | -0.18 | 0.32 | 1.00 | | | | | | | | 0.35 | 0.54 |
| Technology capability | 0.48 | 0.47 | -0.13 | 1.00 | | | | | | | 156.71 | 400.74 |
| IPO | 0.53 | 0.49 | 0.18 | 0.34 | 1.00 | | | | | | 0.53 | 0.50 |
| Accumulative alliance experience | 0.44 | 0.31 | -0.04 | 0.19 | 0.39 | 1.00 | | | | | 5.35 | 8.31 |
| Recent alliance experience | 0.29 | -0.03 | -0.02 | 0.18 | 0.24 | 0.18 | 1.00 | | | | 0.44 | 1.01 |
| Diversified alliance experience | 0.04 | -0.21 | -0.02 | -0.17 | -0.18 | -0.26 | -0.20 | 1.00 | | | 0.18 | 0.38 |
| Alliance formation | 0.37 | -0.12 | -0.07 | -0.01 | 0.33 | 0.52 | 0.58 | 0.03 | 1.00 | | 1.79 | 2.86 |
| ΔInternal R&D capability | -0.22 | -0.21 | -0.19 | -0.35 | -0.31 | -0.28 | -0.15 | -0.13 | -0.41 | 1.00 | -0.29 | 0.71 |

*Table 3. Negative Binomial Regression Results for the Alliance Formation*

| Dependent variable: Alliance formation | Model 1 | | Model 2 | |
|---|---|---|---|---|
| | Coefficient | S.E | Coefficient | S.E |
| *Control variables* | | | | |
| Firm size | 0.192*** | 0.042 | 0.096*** | 0.037 |
| Firm age | -0.154*** | 0.035 | -0.096*** | 0.031 |
| M&A experience | -0.428 | 0.281 | -0.409* | 0.237 |
| Technology capability | -0.001** | 0.001 | -0.001** | 0.001 |
| IPO | 1.114*** | 0.389 | 0.658** | 0.325 |
| *Independent variables* | | | | |
| Accumulative alliance experience | | | 0.057*** | 0.014 |
| Recent alliance experience | | | 0.333*** | 0.086 |
| Diversify alliance experience | | | 0.739* | 0.304 |
| *N* | 136 | | 136 | |
| Log likelihood | -207.229 | | -193.253 | |
| Pseudo $R^2$ | 0.129 | | 0.188 | |
| LR Chi$^2$ | 61.39 | | 89.34 | |
| Regression *p*-value | 0.000 | | 0.000 | |

*Notes*: *$p < 0.10$; **$p < 0.05$; ***$p < 0.01$.

intensified by recent alliance experience. In other words, the recency effect exists in a firm's decision whether to choose an alliance strategy or not. Hypothesis 1-3 (suggesting diversified alliance experience), which has a positive effect on future alliance formation, is supported. Generally, corporate culture and work process vary from one firm to another. Therefore, various problems occur until the termination of the alliance, for example, in the duration of the alliance contract between firms and in the course of sharing human and physical resources to effect performance. Diversified alliance experience means that organizational routine, which entails contracting and maintaining an alliance relationship smoothly and minimizing the occurrence of potential problems, is built up sufficiently. This leads firms to underestimate the risk of problems occurring in situations in which decision makers have no prior alliance experience and lack information on a partner firm, consequently stimulating firms to choose an alliance strategy.

Table 4 presents the results from applying the multiple regression model and those from the test of how prior alliance experience affects the change of internal R&D capability. The results show that all variables, except recent alliance experience, weaken internal R&D capability. Results for hypothesis 2-1 indicate that accumulative alliance experience decreases internal R&D capability, and the relationship is highly significant ($p < 0.01$). Viewed from a resource-based perspective, forming an alliance, which transfers external resources within the boundaries of firms, leads to the reduction of human and physical resources for investing in internal R&D. Cohen and Levinthal's (1989, 1990) absorptive capacity finds the problem of reduced investment in internal R&D. Reduced investment in internal R&D lowers absorptive capacity. This has a negative effect on firms' innovation performance to process and recreate knowledge. Accordingly, much accumulative alliance experience has a negative effect on internal R&D capability because it induces less investment in internal R&D. Furthermore, hypothesis 2-3, which states that diversified alliance experience has a negative effect on internal R&D capability ($p < 0.01$), is also supported. Diversified alliance experience means that firms have established alliance relationships with multiple partners in the past. When firms establish networks with multiple partners, maintaining those relationships is very costly. In addition, establishing alliances with multiple companies nurtures management commitment to focus on alliance activities (Hitt et al., 1991) and to comparatively reduce interest in internal R&D. This problem causes a reduction in internal R&D capability. Table 5 shows the test results for the hypotheses mentioned earlier.

*Table 4. Multiple Regression Results for the Internal R&D Capability*

| **Dependent variable: ΔInternal R&D capability** | **Model 3** | | **Model 4** | |
|---|---|---|---|---|
| | **Coefficient** | **S.E** | **Coefficient** | **S.E** |
| *Control variables* | | | | |
| Firm size | -0.004 | 0.014 | 0.026* | 0.014 |
| Firm age | 0.022 | 0.015 | 0.022 | 0.015 |
| M&A experience | -0.343*** | 0.119 | -0.331*** | 0.112 |
| Technology capability | -0.001*** | 0.000 | -0.001*** | 0.000 |
| IPO | -0.267* | 0.147 | -0.280** | 0.140 |
| *Independent variables* | | | | |
| Accumulative alliance experience | | | -0.028*** | 0.007 |
| Recent alliance experience | | | -0.058 | 0.056 |
| Diversify alliance experience | | | -0.617*** | 0.151 |
| *N* | 136 | | 136 | |
| *R*-squared | 0.2445 | | 0.3832 | |
| Adjusted $R^2$ | 0.2143 | | 0.3318 | |
| Regression *p*-value | 0.000 | | 0.000 | |

*Notes*: *$p < 0.10$; **$p < 0.05$; ***$p < 0.01$.

*Table 5. Summary of the Hypotheses and Results*

| **Hypotheses** | | | **Test results** |
|---|---|---|---|
| New alliance formation | H1-1 | The more firms have accumulative alliance experience, the more they choose alliance strategy subsequently | Supported |
| | H1-2 | The more firms have recent alliance experience, the more they choose alliance strategy subsequently | Supported |
| | H1-3 | The more firms have diversified alliance experience, the more they choose alliance strategy subsequently | Supported |
| Internal R&D capability | H2-1 | The more firms have accumulative alliance experience, the larger the negative effects on firms' internal R&D capability | Supported |
| | H2-2 | The more firms have recent alliance experience, the larger the negative effects on firms' internal R&D capability | Not supported |
| | H2-3 | The more firms have diversified alliance experience, the larger the negative effects on firms' internal R&D capability | Supported |

## Conclusions and Implications

On one hand, technology alliance is an excellent tool with many advantages in that it complements internal resources, diversifies risk and makes firms enter new markets. On the other hand, it has a negative side in that it induces indiscriminate alliance strategies and reduces internal R&D capability. However, this implication does not suggest that firms should reduce their technology alliance. Instead, we propose that firms should adopt a reasonable alliance strategy taking consideration of its and pros and cons.

There are two key findings of this study. First, previous alliance experience induces firms' new alliance formation. It also ascertains that prior alliance experience has a posi-

tive effect on the decision to choose a new alliance strategy, and it further accumulates to become an 'experience-selection mechanism'. In this mechanism, past alliance experience induces firms to select a subsequent alliance strategy, which accumulates into alliance experience again. In other words, the experience-selection mechanism is a circulating process which strengthens organizational routine. When firms create an experience-selection mechanism, they fall into a state of 'alliance addiction' due to the strengthened organizational routine. They tend to acquire knowledge outside their boundaries under alliance addiction status, and they also tend to make irrational decisions when selecting an alliance strategy by inertia. 'Too much of a good thing' cannot be an exception for the alliance strategy as well. Therefore, managers have to judge carefully whether an alliance is chosen reasonably or not. In addition, the negative relationship between alliance experience and internal R&D capability has been established. When firms choose an alliance strategy frequently, they can lose their long-term competency because of a worsened internal R&D capability. Aside from having a weakened internal R&D capability that damages absorptive capacity, the choice of an alliance strategy frequently makes difficult the transfer by firms of other organizations' knowledge within their boundaries. Firms still need to pay attention to and invest in internal R&D capability even when they ally with their partners for strategic needs.

Finally, we suggest two further directions for future research. First, nanobiotechnology requires further research relating to technology alliance in consideration of the cross-disciplinary characteristics of the technology. Although there is active development of nanobiotechnology in the biotechnology sector, only a few studies have focused on technology alliance in this field. Second, most previous works have investigated the positive aspect of technology alliance. De Man and Duysters (2005) have reviewed 40 papers relating to technology alliance and found that 73 per cent of these examine the positive aspects of technology alliance. In comparison, only 10 per cent of them examine the negative aspects of technology alliance. Therefore, further research on the negative aspects of technology alliance is required to improve its success rate and effective use.

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