International Technology Alliances, Technology-based M&As, and the Innovative Performance of EU and non-EU Firms*

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ABSTRACT

In this paper we examine to what extent strategic technology alliances and technology-based mergers and acquisition (M&As) improve the innovative performance of firms. We analyze the innovative performance (patent applications) of 104 EU firms that are leading in EU manufacturing and services industries between 2001 and 2007, and compare this to the performance of a sample (61) of non-EU firms with a strong presence in the EU. Results of fixed effects panel data analysis suggest that both technology alliances and technology based M&As can improve innovative performance. The empirical results, however, show marked differences between the effects of the two sourcing modes for EU and non-EU firms, and important differences with respect to the location of the partner or target firm. Overall, technology alliances improve innovative performance with the strongest effects observed for alliances with EU firms. Technology based M&As with EU targets have a positive impact, but in contrast, M&As with non-EU targets *reduce* innovative performance. Similarly, alliances with firms based in emerging economies reduce, rather than increase, innovative performance.

1. INTRODUCTION

Globalization and the increasing intensity of product market competition are increasingly driving firms to develop competitive strength through the development and utilization of technological assets. As internal sources of technology development are often insufficient to cope with complex and uncertain technological developments, external knowledge acquisition has become a cornerstone of many firms' R&D strategies. The need for broader development of technology assets and broader search for sources of new technology has been accompanied by an increasing internationalization of R&D and external knowledge acquisition (e.g. Archibugi and Michie, 1995; OECD, 2007, Patel and Pavitt, 1992). Foreign R&D to create new technologies is part of the response, as firms need to get access to centers of excellence in scientific and technological development as well as to pools of talented scientists and engineers at lower costs. One way to build up an international R&D presence and to tap into technological knowledge abroad is through high tech cross-border acquisitions and collaborative modes of international R&D.

In this paper, we examine to what extent strategic technology alliances and technology-based mergers and acquisition help improve the innovative performance of firms. We consider M&As and alliances as part of a broad portfolio of technology sourcing mechanisms and focus on effect of the geographic scope of M&A and alliance activity, in particular their international character. While there is an abundant literature on the performance effects of alliances (e.g. de Man and Duysters, 2005; Lavie, 2007; Gulati, 1999) and M&As (e.g. Ahuja and Katila, 2001; Grimpe, 2007; Bertrand and Zuniga, 2005), very little attention has been given to their joint effects on performance. We examine to what extent these two modes of (international) technology sourcing are complements or substitutes, and which strategy has the largest comparative impact on performance.

Empirically, we analyze the innovative performance (patent applications) of 104 EU firms leading in European manufacturing and services industries between 2001 and 2007, and compare this to the performance of a sample of (61) non-EU firms that are leading firms in Europe. We examine the impact of strategic technology alliances and technology-based M&As in fixed effects panel data models, controlling for various other firm specific characteristics affecting performance.

The remainder of this paper is organized as follows. In Section 2, we detail the theoretical background and prior studies on innovative performance and the role of technology alliances and technology based M&As. In section 3, we describe the database, and in section 4, we present the key data on alliances and M&As. In section 4, we define the variables and empirical model and section five presents the empirical results. We conclude in Section 6.

2. BACKGROUND: TECHNOLOGY ALLIANCES, TECHNOLOGY-BASED M&As, AND INNOVATION

External sourcing of technology has been the subject of a large and growing body of research. While the mechanisms of technological sourcing are varied, those that are most frequently examined and used are strategic alliances and M&As. We can discern three broad categories of studies. One set of studies examine the factors that shape the choice between M&As and alliances, as they entail varying degrees of financial commitment, control and flexibility. Two other strands of literature focus on the effectiveness of one of the two external technology-sourcing mechanisms -alliances or M&As- in enhancing innovative performance. A fourth subset of studies that is relevant here gives specific attention to the difficulties in managing a diverse portfolio of alliances. Prior studies have not examined the joint performance effects of technology sourcing strategies combining M&As and technology alliances - the subject of the current paper. Based on the extant research we formulate a number of research questions that we attempt to answer in the empirical analysis. We pay particular attention to the geographic (international or national) dimension of alliances and M&As -the focal characteristic of technology sourcing strategies in this paper.

The choice between M&As and Alliances

In the literature on external technological sourcing, one major strand has focused on the factors shaping the choice between alliances and M&As (Hagedoorn and Duysters, 2002a; Vanhaverbeke et al., 2002; Villalonga and Macgahan, 2005; Carayannopoulos and Auster, 2010). The main conclusions emanating from this literature is that the flexibility and limited financial commitment of alliances are particularly preferred under circumstances of technological and market uncertainty. Hagedoorn and Duysters (2002a) find that firms prefer M&As for their core businesses, while they demonstrate a higher preference for alliances in their other businesses where they lack key competitive advantages. The size of the target firms has also been found to be of importance. Given that large target firms are rather difficult to 'digest' and integrate and diseconomies of scale and scope may arise when a company acquires more knowledge than what is desirable, alliances may be more effective (Hennart, 1991; Hennart and Reddy, 1997). On the other hand, alliances are found to be less effective in the sourcing of complex knowledge because access to complex knowledge requires access to a variety of knowledge elements (Carayannopoulos and Auster, 2010). Alliances limit the interaction to specific segments of the organization, and hence do not ensure a broad access that will ensure the transmission of complex knowledge.

Only a handful of studies have paid attention to the role that differences in the geographic dimension (nationalities of partners or targets) play in shaping the choice between alliances and M&As, with mixed findings. Vanhaverbeke, et al (2002) in their study of the application-specific integrated circuits industry find that international technology activity is more likely to be a strategic alliance rather than an M&A. In a similar vein, Kogut and Singh (1988) observe that when the home country of firms entering the United States is culturally distant from the United States, joint ventures are preferred to M&A. The common explanation is that international and cultural differences make M&As a more cumbersome technology sourcing mode (Kogut, 1988; Mowery et al, 1996), as M&A requires the complete integration of the two firms’ knowledge bases. For firms with different corporate cultures this is likely to be more difficult given that a substantial amount of learning routines lose their purpose after M&A (Barney 1999). Cultural differences also reduce the ability of managers to absorb each other's knowledge (Madhok 1996), thereby increasing the cost of learning. In addition, large differences in corporate (R&D) practices might increase the chances of key researchers leaving the acquired firm or reducing their efforts (Ernst and Vitt, 2000). In such circumstances, alliances offer greater flexibility to the firm in that it can ‘cherry pick’ the most desired knowledge available from a partner (de Man and Duysters, 2005). In some contrast, Gulati (1995) finds that international alliances are more likely to be of the equity-form than of the more flexible non-equity based form, compared with national alliances. The argument is that governance modes that yield greater control can be preferred when firms have not built enough trust with their partners and trust is likely to exist less among firms in different countries.

M&As and Innovative Performance

On the contribution of M&As to innovative performance, many prior studies have found the effect of M&As to be either neutral or negative (for a review, see de Man and Duysters, 2005).[1] The literature has suggested that owing to divergent management practices integrating newly acquired business units with the existing ones can lead to efficiency losses, and that many M&As decisions may be driven by the pursuit of managerial objectives and the availability of excess cash flow rather than by the pursuit of efficiency (Caves, 1989; Ravenscraft and Scherer, 1989).

Recent research however provides a more nuanced view: while M&As that are not technological in nature have a negative impact on innovative performance, technology motivated M&As are found to have positive performance consequences (Ahuja and Katila, 2001; Cloodt, et al. 2006). In other words, only acquisitions that provide technological inputs should be expected to improve the innovative performance of the combined firm. The international dimension of M&A activity is more often than not found to be a positive moderator, perhaps because the variety in knowledge ensures the greatest complementarity in technology development and ideas. Ahuja and Katila (2001) find that cultural differences do not lead to any post-acquisition conflicts, and may even have a positive effect on innovative performance; the latter findings is confirmed by the replication study of Cloodt, et al (2006). Hagedoorn and Duysters (2002b) similarly find that firms with a focus on international M&As improve their technological performance relatively more.

A limited number of studies have looked into the reorganization of R&D activities in the acquiring and target firm after M&As. Hall (1999) finds that acquiring firms experienced a significantly greater increase in R&D intensity and growth in total factor productivity post merger compared to firms that did not engage in M&As. Firms with a high probability of acquiring were much larger than other firms and had lower R&D intensities and higher Tobin's Q. These results might suggest that acquisition would have a positive performance effect only when it generates economies of scale in R&D, and the acquirer does not have to divert its R&D budget to service any debt associated with the acquisition (c.f. Baysinger and Hoskisson, 1989). Bertrand (2009) in a study of acquisitions of French firms by foreign firms finds that R&D in the foreign target firm tends to increase.post-acquisition if the target

[1] Early research into the performance effect of M&As focused mainly on financial performance (for a review see, Caves, 1989; Hagedoorn and Schakenraad, 1994).

continues to operate separately and is not fully integrated. This suggests that technology-based M&As may be an instrument to redefine the organization of a firm's R&D and may lead to greater specialization in specific technology fields. This may be suggestive of increasing regional knowledge specialization through M&As.

Alliances and Innovative Performance

Compared to the innovative contribution of M&As, the performance consequences of technology alliances has been the subject of much more extensive research and the evidence has been much less ambiguous. The greater majority of studies has found that technology alliances have a positive influence on innovative performance (e.g. DeMan and Duysters, 2003; Nooteboom, 1992; Anand and Khanna, 2000; Baum et al., 2000; Owen-Smith and Powell, 2004). Much of the more recent research has focused on the properties of the broader alliance network of firms and the position that firms take in this network (Rowley, et al, 2000; Gilsing et al, 2008). Surprisingly, the contribution of engaging in international alliances to innovative performance has received only scant scrutiny. The few studies that have paid attention to the international dimension have suggested that international alliances can serve a "radar function" by linking firms to diverse partners and accessing novel information in a world that is dynamic and not very transparent (Duysters and Lokshin, 2007). For example, Duysters and Lokshin (2007) find that innovative firms are more likely to possess a broader portfolio of international alliances than non-innovators or imitators. The study by Lavie and Miller (2008) lends further support for this argument. Their results show that moderate levels of international partner diversity (measured as a composite of several national-level differences like geographical, cultural, institutional and economic diversities) contribute to improved (financial) performance. They argue that when the international diversity of partners is neither too low nor too high, firms are able to understand partners' background and accordingly adopt collaborative routines that are effective in bridging national differences.

Complexity of Alliance Portfolios and Innovative Performance

The alliance literature has paid attention to the fact that difficulties in managing alliances can weaken the innovative process associated with alliances. Early research in this area, primarily at the dyadic level (individual alliances), has claimed that managerial complexity, difficulty in coordination of alliance activities and lining up of alliance operations with the strategic goals of partners generally undermine alliance performance (Park and Ungson, 2001). Task complexity, resulting from the increasing scope of activities undertaken within an alliance and organizational complexity resulting from the increase in the number of partners will have negative consequences for alliance performance (Killing, 1988). In addition, Robson et al., (2008) conclude that organizational complexity which arises due to physical, cultural and institutional differences between partners weakens the beneficial effect of trust in cross-border strategic alliances resulting in such negative consequence as lack of coordination of the various endowments in alliances, which leads to sub-optimal performance. Scope complexities will increase the probability of the termination outcome in the alliance because of greater uncertainty regarding the performance of individual tasks and the coordination of tasks and contractual hazards (Reuer and Zollo 2005, Oxley and Sampson 2004).

Increasingly, the alliance literature is adopting a portfolio approach to analyze the effect of alliances on firms' performance. This approach is to a large extent motivated by the recognition that firms are ever more involved in various strategic alliances with heterogeneous partners at the same time (Gulati and Singh 1998, Hoffmann, 2007; Wassmer 2008, Ozcan and Eisenhardt 2009). Complexity issues identified at the dyadic level have their repercussions for firms that have sizable alliance portfolios and therefore have to deal simultaneously with various partner types who often exhibit conflicting alliance objectives. Consequently, alliance scholars have examined the evolution of diverse and complex alliance portfolios (Ozcan and Eisenhardt, 2009); the strategies that firms employ in order to deal with greater diversity and the resulting complexity in alliance portfolios, and the optimal configuration of a portfolio (Bamford and Ernst, 2002; Heimeriks and Duysters, 2007; Heimeriks et al. 2009; Hoffmann, 2005; 2007; Marino et al. 2002; Vassolo et al, 2004); and the contribution of complex alliance portfolios to firms' performance. On the last topic, studies have confirmed that firms which possess heterogeneous alliance portfolios tend to be more innovative (Duysters and Lokshin, 2007; Sampson, 2007) and generate better financial performance (Baum et al. 2000; Lavie, 2007; Lavie and Miller, 2008; Ozkan and Overby, 2009.

On the other hand, if alliances cover similar technologies and there is redundancy in the alliance portfolio, performance may be negatively affected, and more cessations are observed (Vassolo et al, 2004). In addition, as the complexity of managing a heterogeneous portfolio of alliances increases, coordination among alliances and effective allocation of resources becomes challenging (Hoffmann 2005, 2007; Gulati, 1998, Hoang and Rothaermel, 2005). Management of conflicting demands of multiple and heterogeneous partners as well as monitoring and controlling of the performance of a large-scope portfolio may make alliance activity less effective (Gomes-Casseres, 1996; Medcof, 1997; Gemünden and Ritter 1997, Bamford and Ernst 2002). This may leave the firm with a reduced ability to appropriate the innovative potential from its technology-sourcing portfolio (Bolton and Dewatripont, 1994). Combinations of R&D alliances with varied objectives and partners (e.g. a public research institutions and suppliers), each requiring R&D allocation and management attention, have been found to be detrimental to productivity (Belderbos, et al. 2006).

Obviously, the level of complexity and its associated cost are likely to be even higher when firms simultaneously engage in M&A activity while maintaining sizable alliance portfolios. Effective integration of (sizeable) of targets demands substantial management attention and reorganization of the R&D activities. The management of the technology alliance portfolio also requires substantial managerial oversight, and redundancies with the knowledge base of the partner (target) have to be addressed. From the perspective of international knowledge sourcing and the importance of diversity, redundancies may result when a firm engages in M&As (alliances) in a given geographic region when it already has many alliances (M&As) in that region. Redundant knowledge may thus add to the problems of monitoring and coordination characteristic of complex technology sourcing portfolios.

Present study

The review above suggests that the extant literature has primarily investigated the effect of a single technology sourcing strategy, either technology alliances or technology-based M&As on firm performance. However, firms in practice choose to pursue external technology sourcing strategies that combine M&As and alliances. Surprisingly, the question of which technology-sourcing strategy has a larger impact on firm innovative performance and whether a strategy pursuing both types of technology souring is superior to a single sourcing strategy has not received attention in prior studies. In this paper, we examine the effect of such joint M&A and alliance strategies, with a focus on geographic diversity and potential redundancy.

Drawing on prior studies, we may expect that international knowledge sourcing is more effective if it takes the form of alliances. Partners from different countries are likely to be relatively unfamiliar with each other and each other's external environment. In such a context, alliances are likely to be the most efficient mechanism for joint technology development and transfer of knowledge. M&As on the other hand are most likely to be effective if they involve national external technology sourcing activities and national partners or targets. This is because M&As ensure the broadest possible transfer of knowledge, while familiarity among partners suggests that learning costs are likely to be small.

Given the international scope of firms' technological sourcing strategies, and given the international variability in the effectiveness of different modes, firms with partners from diverse countries will have a portfolio of governance modes. However, the literature on the complexity of alliance portfolios indicates that a complex portfolio presents itself with challenges and that redundancies may occur when two technology sourcing strategies target the same knowledge base.

Against this background, the present study aims to answer the following questions. Are alliances more effective when partners are international? Are M&As more effective when they are made within the focal firm's country or region? Do alliances and M&As in the same region contribute to knowledge redundancies and hence to sub-optimal innovative performance, or is there a complementarity in innovation performance between M&A and alliance strategies? Does the combination of large numbers of alliances and M&As increase complexity of the technology-sourcing portfolio to such extent that it has an adverse impact on firm's innovative performance? We examine this by analyzing the joint effects of M&A and alliance activity of leading firms in EU industries and by differentiating technology sourcing strategies targeting intra-country, EU, non-EU, developed country, and emerging economy partners.

3. DATA

Database and selection of firms

We constructed a dataset including the leading firms in a broad spectrum of 65 European manufacturing and a few selected (telecommunications, IT services, retailing) services industries. Firms were selected based on their manufacturing volume or services presence in the EU in 2007 and could be headquartered in the EU or elsewhere. The top 5 firms by size in their sectors were selected. For these firms we collected data on patent applications with the European Patent Office (as a measure of innovative performance), information on technology alliances and M&As, and financial indicators such as R&D expenditures. In total 104 EU-headquartered firms and 61 non-EU firms were identified as leading firms with available information on patent activity and R&D. [2]

The number of firms by country and by industry is shown in tables 1 and 2, and Appendix A lists all firms in the analysis with their industries and patent applications during 2000-2007. The largest number of firms is based in Germany (26) followed by France (21) and the UK (19). Italian firms are less well represented, while 5-8 firms are headquartered in small and internationalized economies such as The Netherlands, Finland and Sweden. US firms make up more than half of the non-EU Firms that are leading in EU industries (34). Several other leading firms are based in Japan (15) and Switzerland (6). One firm (SAB Miller, in South Africa) is not headquartered in an industrialized country. The firms are active in a wide range of industries (Table 2) and are roughly evenly spread across sectors. The services firms are less well represented, which is due to the nature of the selection criteria, but also due to the limited role that patents play in services sectors. The ICT and telecommunication sectors are notable exceptions. The non-EU firms are relatively well represented in high tech industries such as computer and office equipment, pharmaceuticals (with aerospace the exception), while they are much less present in low tech industries (e.g. wood products and wood sawing, paper, sugar, fruit & vegetables).

INSERT TABLE 1 and TABLE 2

Patent data

We draw on patent data to establish past and current innovative output of the firms. There are numerous advantages to the use of patent indicators as measures of firms' technological activities (Pavitt, 1985; Basberg, 1987; Griliches, 1990). Patent data are available in a consistent and longitudinal manner and provide 'objective' information in the sense that patents have been processed and validated by patent examiners based on novelty and utility of use. Drawbacks are that patent propensities vary across industries and firms; and patented inventions differ in their technical and economic value (Mansfield, 1986; Levin et al, 1987; Arundel and Kabla, 1998). In the analysis, we will seek to control for differences in patent propensities. A partial solution to the heterogeneity in patent valuations is to use forward citations. However, given the recent period that we are examining and because a number of

[2] This implied that low technology industries with little or no patenting activity are relatively less well represented, as are privately held firms that do not report R&D expenditures.

years post-publication are required to assess the importance of patents by the intensity with which they are cited in other patents, we cannot use this method in the current analysis. We used European patent data (applications) for all firms. This ensures data consistency and comparability as patent systems differ in their application standards and granting procedures (Ahuja and Lampert, 2001). Due to long patent grant time lags at the European Patent Office, we opted for the use of patent application data rather than patent grants.[3]

For each leading firm we collected patent data at the consolidated firm level for the years 2000-2007. We constructed patent datasets of firms at the consolidated level, i.e. all patents of the parent firm and its consolidated (majority-owned) subsidiaries are collected. For this purpose, yearly lists of consolidated subsidiaries included in corporate annual reports, 10-K reports filed with the SEC in the US and, for Japanese firms, information on foreign subsidiaries published by Toyo Keizai in the yearly 'Directories of Japanese Overseas Investments', were used. The consolidated subsidiaries are in almost all cases majority owned. The consolidation was conducted on an annual basis to take into account changes in the group structure of the firms over time, including -importantly- divestments and M&As. Using consolidated patent data is important since a large share of firms' patented inventions are developed and applied for in firms' subsidiaries.[4]

Alliances

To examine the trends and patterns in technology alliances, we make use of the SDC (Securities Data Company) Platinum databases -a well known data source for empirical studies on strategic alliances and M&A (Schilling, 2008). This database is richer than the MERIT-CATI database, as it codes more information on the alliances and because it also covers M&As.[5] The SDC Platinum database covers the period 1980-2008, although the coverage of alliance activity in earlier years has been less systematic. The database covers alliances and M&As by firms across all sectors and includes more than 85,000 strategic alliances and more than 670,000 M&As.

[3] For example, for EPO patents applied in 1995, the average granting lag was 5.01 years, with 25% of grants having a granting lag of 6 years or longer.
[4] On average 20 percent of the sample firms' patents use a subsidiary name or variant of the current parent firm.
[5] In addition, the MERIT-CATI database has not been updated in recent years. Both databases are noted for a certain US-bias in the information they contain, due to their partial reliance on US based information sources (Schilling, 2008).

Our main focus is on technology alliances. Here we employ a strict definition and include only those alliance for which we have explicit information that technology development and technology sharing were among the objectives of the alliance. We include alliances as technology alliances if they satisfy one of the following criteria:

- The alliance includes cross technology transfer: alliances in which more than one participant transfers technology to another participant or to the alliance
- The alliance includes a research and development agreement
- The alliance includes a cross licensing agreement: alliances in which more than one participant grants a license to another participant

Hence, we do not include simple one-way technology licensing, as this is essentially a market-based mode of technology acquisition. Likewise we do not include joint ventures if these are not associated with technology transfer as these joint ventures, more often than not, have joint production or marketing objectives rather than the pooling of R&D resources. This definition is stricter than the one used in much prior work (see Schilling, 2008), but patterns of this well-delineated definition of technology alliances ensures a focus on technology sourcing strategies. For the EU firms in our dataset, technology alliances on average make up about 15 percent of total alliances (cf. Belderbos et al, 2010).

We distinguish alliances by the origin of the partners. The geographic origin of the partner is taken as the location of the participant-partner in the alliance, irrespective of whether this partner is independent or part of a larger group or ultimately owned by a parent firm based in another country. We take this focus because it can be assumed that the technological capabilities of the direct partner firm are most important in the alliance.

Technology Based M&As

We used the Zephyr database on M&AS (published by Bureau van Dijk) and the Thomson SDC Platinum (shortly SDC) databases which are the commonly used sources for M&As. Zephyr is particularly focused on M&As of European firms, while SDC is more globally oriented, and the two databases complement each other well to get maximum coverage. In addition, the consolidation exercise in which we drew on annual reports helped to identify some further M&A activity. We count the number of majority stake or full M&As in which the firms in the sample were acquirers or the dominant party in a merger. We follow Ahuja and Katila (2000) by defining a technology-based M&A as an M&A where the target firm has

(EPO) patent applications. In case a target firm holds patents but also has subsidiaries with patent activities, the M&A is counted only once.

Financial data

Our primary source of financial data on the firms was Compustat, subsections North America as well as Global. As Compustat has less than full coverage of European firms, we augmented these data with information retrieved from Worldscope and Annual reports. As for R&D data, we could also draw on the European R&D Scoreboard, which ranks firms by R&D expenditures since 2003. We used exchange rate information from the IMF Financial Statistics to represent figures that were in domestic currencies in dollar terms

4. TECHNOLOGY-BASED M&As AND TECHNOLOGY ALLIANCS, 2000-2007

Technology Alliances

Figure 1 and Table 3 show the importance for EU Firms of technology alliances with partners from different regions and countries and the trend therein, following the strict definition set out above. The total number of alliances has varied between 40 and 70. In the most recent years, alliance activity has been increasing. US firms have by far been the most prominent technology alliance partners for EU firms, with shares of more than 50 percent in the most recent years during which the absolute number of alliances registered a strong increase. Partners from other EU countries take up roughly 20 percent of alliance activity (with the exception of 2005). Technology alliances involve same-country partners less frequently, which a share of less than 10 percent (with the exception of the years 2000 and 2007). The share of Japanese firms has been declining very rapidly since 2002 and has been surpassed by emerging economies (in particular China and India). Overall, technology alliance activity by EU firms is distinctly international and externally oriented, with on average around 60 percent of the alliances formed with partner firms outside of the EU.

INSERT FIGURE 1 and TABLE 3

For the non-EU firms in the sample (with Japanese and US firms most prominent) we see higher numbers of alliances with a maximum of close to 130 (in 2000) (Figure 2 and Table 3.) Given the smaller number of non-EU firms in the sample, this implies a higher alliance intensity. This is partly related to the greater presence of the non-EU firms in medium tech and high tech industries (see Table 2). Alliance activity shows a decline in 2003-2006 and a resurgence in 2005-2007 - a pattern that is much more pronounced than the trend in alliances by EU firms in Figure 1. Figure 2 shows a relatively large share of alliance partners based in the same (home) country, at around 50 percent. This is largely due to the importance of US partners for US firms. US partners place second as they are also important partner firms for Japanese and European firms (based outside the EU), but the number of alliances with US firms has fallen in 2007. Partners from the EU place third, with a share between 10 and 20 percent and a relatively stable number of on average 10 alliances yearly. The share of Japanese partner firms for the non-EU firms in the sample shows a similar decline as that for the EU firms in Figure 1. The data show a greater increase in the role of partners from emerging economies (mainly China and India) in the most recent year (2007).

INSERT FIGURE 3 and TABLE 4

Technology based M&As

Figure 3 shows the number of technology based M&As by the EU firms in the sample by country and region of the target firm. The number of M&As has ranged between a low of 6 (2003) and a high of 28 (2007). While intra-country targets were most common in 2000-2002, by 2007 M&As targeting firms form other EU countries, US and other developed economies (e.g. Switzerland, Canada) became more important. Hence, M&A activity has become more externally oriented over the years. In contrast, firms from Japan, as well as those from emerging economies, have rarely been the target of EU firms'. Table 6 provides some more detail on the main technology based M&As in the period. M&A activity involved some mergers and acquisitions of major patent holding firms, such as the Aventis-Sanofi merger, the merger between Alcatel and Lucent, and the acquisition of Schering by Bayer.

INSERT FIGURE 4 and TABLE 5 and TABLE 6

Figure 4 and Table 7 illustrate the technology based M&As of the non-EU firms in the sample. The number of M&As has generally been somewhat lower than the number of M&As by the EU firms, which contrasts with the pattern of technology alliances. There is no rise in the number of M&As in recent years and the largest number of M&As (23) took place in 2005. M&As with intra-country (mainly US) targets have been most frequent (between 50 and 90 percent of M&A activity), followed by M&As with EU targets. Targets from other countries or regions have not been of importance. The largest M&A in terms of patent holdings of the target firm has been the acquisition of Union Carbide by Dow Chemical in 2001 (Table 8). Other major M&As were the acquisition of Gillette by Procter & Gamble, the acquisition of the Swedish pharmaceutical firm Pharmacia by Pfizer, and the acquisitions of Amersham (GE), Advanced Cardiovascular (Abott) and Symbol Technologies (Motorola).

INSERT FIGURE 5 and TABLE 7 and TABLE 8

5. EMPIRICAL MODEL AND VARIABLES

The empirical model relates a measure of innovative performance (the number of patent applications of the firm in a given year) to prior technology-based M&A and technology alliance activity of the firm, controlling for R&D expenditures and other firm and environmental features. The dependent variable, the number of patent applications with the European Patent Office, is a count variable with only non-negative integer values. In this case, nonlinear count data models are preferred to standard linear regression models as they explicitly take into account the non-negativity and discreteness of the dependent variable. Negative Binomial count data models, which control for over-dispersion in the dependent variable, are used (Cameron and Trivedi, 1998). We used fixed effects panel data estimators in all regression models to control for unobserved (time-invariant) firm characteristics such as general managerial capabilities that could affect technological performance. Hence, the effects of M&As and technology alliances should be interpreted as relating to the 'within' changes in innovative performance and indicate to what extent increases or decreases in M&A and alliance activity of a firm affect patent output.

We analyze innovative performance (patent applications) during the period 2001-2007 (seven years).[6] The panel is almost balanced, with on average more than 6 observations per firms and a total number of observations of 917. Of these, 560 are for EU firms and 357 for non-EU firms. In the analyses, we will examine whether there are differences between EU and non-EU firms in the effects of M&As and alliances, by also estimating coefficients that are specific to EU and non-EU firms.

The first key explanatory variable is the number of technology alliances in which the firm has engaged. In assessing the effect of alliances, we take a moving window approach, assuming that 'ongoing' alliances are likely to have an impact on innovative performance. We assumed an average life span of alliances of 5 years, following conventional assumptions in alliance research (Kogut 1988, 1989; Gulati, 1995, 1999; Stuart, 2000; Lavie, 2007). The variable *technology alliances* measures the number of technology alliances established by the firm in the years t-5 through t-1.

The variable *technology-based M&As* measures the number of M&As of the firm in t-1 and t-2. A window of 2 years was chosen, as M&As often have short-term rationalization effects, leading to a strong impact in the first few years.[7] The patent activities of the target are counted as output of the acquirer in the year t, subsequent to the merger or acquisition. Since the analysis includes the R&D budget at the consolidated level (i.e. the R&D budget of the merged firm) as an important control factor, acquisitions and mergers can only increase patent output if they increase the (patent) productivity of R&D**.**

To examine the impact of intra-country and international technology sourcing strategies through alliances and M&As, we distinguish alliances and M&As by country and region of the alliance partners or target firms. We distinguish *EU versus non-EU* partners/targets, *intra-country vs. EU and non-EU* partners/targets, and *EU vs. emerging economy and developed*

[6] One year (2000) had to be excluded because the M&A data were not available with the required lag (see below). We use the filing year at the European Patent Office as indicative of the year of innovative output. Substituting the year of priority filing of a patent equivalent at other patent offices (priorty filings can predate EPO filings) did not qualitatively change the empirical results.
[7] We experimented with including M&A variables with various lags. The stylized pattern found was one of a strong and similar impact of M&As in t-1 and t-2.

country partners/targets. In order to assess possible substitution or complementarity between technology-based M&As and technology alliances, we include interactions between the M&A and alliances variables. The *interaction between alliances and M&As* tests whether intensive engagement in both types of strategies reduces their positive effect due to increasing demands on management time and increasing complexity. The *interaction between region-specific alliances and M&As* tests whether these strategies are alternative routes to international knowledge sourcing, or whether they complement each other.

The empirical models control for other (time varying) firm-level factors that are likely to impact on firms' innovative performance. First, we control for differences in the scale of the firms' *R&D expenditures*, by including the dollar value of R&D expenditures in year t-1. In other words, the analysis examines as to what extent alliances and M&As improve the efficiency of R&D, controlling for the *level* of R&D. Second, we control for differences in the prior patent activity of the firm. We include a measure of patent-R&D productivity, taking the one-year lagged ratio of the number of firm patents to R&D expenditures. This variable controls for firms' past technological activities and absorptive capacity, as well as for differences in the propensity to apply for European patents. Finally, the empirical models include time dummies (2001 as base category) to account for time-specific factors affecting the innovative performance of the firms

Table 9 shows means and standard deviations of the variables and describes the definition of the variables and appendix B contains a correlation table.

INSERT TABLE 9

5. EMPRICAL RESULTS

Results from our basic specification indicate that for our complete set of firms acquisitions do not have any significant impact on performance, while alliances have a significantly positive effect (Table 10, columns 1 and 2). This is in line with the existing evidence on the innovative contributions of M&As and alliances: while the contribution of M&As to innovative performance is far from clearly understood, most studies by and large confirm the positive influence of alliances. We also find that a highly diversified portfolio of alliances and M&As can be detrimental to performance: the coefficient for the interaction term of alliances and acquisitions is negative and significant. This is consistent with the notion that increases in a firm's portfolio of alliances and acquisitions can increase the cost, and reduce the effectiveness, of managing the portfolios and may create knowledge redundancies. Alliances and M&As are substitutes in the innovative performance function and intensive engagement in one technology sourcing strategy reduces the effectiveness of the other.

INSERT TABLE 10

When we look at the effect of EU vs. Non-EU alliance partners and acquisition targets, we get a more nuanced picture (Tables 10, columns 3 and 4). Acquisitions of EU firms have a significantly positive impact, while acquisition of non-EU firms, surprisingly, have a significantly negative impact innovative performance. Engagement in technology alliances with both EU and non-EU firms have a positive sign, but only the coefficient of alliances with EU firms is significant in several specifications. Taken together, these findings suggest that EU firms in particular are important targets and partners for effective technology acquisition and knowledge integration. At the same time, the results suggest that there are knowledge sourcing redundancies in the firms' M&A and alliance portfolios targeting the EU. The interaction term between EU acquisitions and EU alliances is negative and significant.

Separating out *intra-country* M&As and alliances from the variables provides further insights (columns 5 and 6). The significance of both EU (but not intra-country) and non-EU (but not intra-country) acquisitions improve, while in contrast intra-country acquisitions have a significantly negative impact. This appears to suggest that there are only limited technological gains from acquisitions with same-country targets, and that acquisitions may be driven more by other strategic considerations such as diversification or reducing domestic market competition. The results for alliances show, as in the case of M&As, that EU alliances are much more significant if intra-country alliances are separated out. Alliances with non-EU partners and intra-country alliances have no significant effect on the other hand.

In columns 7 and 8 of Table 10, the non-EU alliance and M&A variables are split between developed countries and emerging economies. Technological M&As in the developed regions outside of the EU have a significantly negative effect on performance, while those in emerging economies have no significant effect. The results for alliances show that alliances with non-EU developed region partners have a clear positive impact on innovative performance. This contrasts with a significantly negative effect of alliances with partners in emerging economies. It may be that firms use these alliances to trade market access in emerging economies for access to technology, such that alliance activity is focused on adaptation efforts and diverts resources from research efforts that are most likely result in patent activities.

INSERT TABLES 11a and 11b

To what extent are the above findings applicable to EU and non-EU firms? In order to answer this question we estimated more elaborate models in which the M&A and alliance variables are interacted with two dummy variables—one for EU firms and the other for non-EU firms. Hence, we estimate separate coefficients for the effects of M&As and alliances for EU and non-EU firms. The results are reported in Tables 11a and 11b. Compared to our earlier finding that the overall effect of acquisitions is neutral, we find that for EU firms acquisitions have a significantly positive impact, while for non-EU firms acquisitions have a significantly negative overall impact (Table 11a, columns 1 and 2). Alliances, on the other hand, exert a significantly positive performance effect for both EU firms and non-EU firms. The interaction effects between alliances and M&As are not significant for EU or non-EU firms.

If we split the M&A and alliance variables between EU and non-EU targets or partner firms, we observe that EU firms' intra-EU acquisitions exert a significantly positive effect on innovative performance (Table 11a, columns 3 and 4). For non-EU firms on the other hand, there are strongly contrasting effects of acquisitions in the EU (significantly positive) and acquisitions outside the EU (negative and significant). It appears therefore that the negative effect of acquisitions of non-EU targets that we have observed in the full sample is solely driven by the acquisitions of non-EU firms. With regard to alliances, partnerships with EU firms improve the performance of non-EU firms, but no such significant impact is found for alliances with non-EU firms. The effects of EU firms' alliances, whether they are with EU or non-EU partners, are not significant, though the sign of the coefficients is positive.[8] Furthermore, for EU firms, the joint use of M&As and alliances as technology sourcing tools reduces innovative performance, as revealed by the negative and significant coefficient of the interaction term of the two variables.

When we separate intra-country alliances and intra-country M&As we find that the positive contribution of M&As with EU target firms to innovative performance is restricted to cross-border M&As (Table 11b, columns 7 and 8). Intra-country acquisitions, as well as non-EU acquisitions, do not have any significant impact on the performance of EU firms. For non-EU firms, EU acquisitions have a positive impact but acquisition of targets in the home country and acquisitions in other countries have a significantly negative effect. As to the effect of alliances, the results confirm that for non-EU firms alliances with EU firms are an important means of knowledge sourcing.

Finally, we split the non-EU alliance and M&A variables into M&As and alliances with targets or partners in developed countries and in emerging economies (Table 11b, columns 5 and 6). We find that the effects of alliances and M&As with developed country partners are broadly similar to the effects of alliances and M&As with all non-EU targets or partners. An additional finding is that for non-EU firms, alliances with emerging economy partners significantly reduce innovative performance.

6. CONCLUSIONS

The development of technology assets is crucial in an environment of intensifying global competition and shortening product cycles. External knowledge acquisition and international knowledge sourcing have become cornerstones of many firms' R&D strategy as they allow a broader search for sources of new technology and competitive strength. Two important means of acquiring external technology are alliances and the acquisition of firms with technological resources ('technology-based acquisitions'). Although there is an abundant literature on the performance effects of M&As and the impact of alliances on innovative performance,

[8] We note that part of the explanation for the higher standard errors of the alliance and M&A variables when distinguished by target or partner country and region, is due to the relatively high collinearity between these variables (see appendix B).

surprisingly little attention has been given to the joint effects of these two technology sourcing modes on innovative performance.

In this paper, we examine to what extent strategic technology alliances and technology-based mergers and acquisition (M&As) improve the innovative performance of firms. We analyze the innovative performance (patent applications) of 104 EU firms that are leading in EU manufacturing and services industries between 2001 and 2007, and compare this to the performance of a sample (61) of non-EU firms with a strong presence in the EU. We consider M&As and alliances as part of a broad portfolio of technology sourcing mechanisms and focus on the effects of the geographic scope of (international) M&A and alliance activity. Specifically, we examine to what extent the two modes of (international) technology sourcing are complements or substitutes, and which strategy has the largest comparative impact on performance.

The pattern of technology alliances of EU firm appears distinctly international, with US firms as the most important partners, followed by firms from other EU countries. Although the number of alliances of EU firms has been increasing in recent years, alliances are used less frequently by EU firms as compared with the group of non-EU firms (which consist mainly of firms based in the US and Japan). These US and Japanese firms are more frequently engaged in alliances with their respective home country partner firms, while alliances with EU firms are relatively less important. The pattern of technology based M&As of EU firms shows a much greater EU orientation than the pattern of alliances, with EU-based targets responsible for 50-80 percent of M&A activity. EU firms are relatively more active in technology based M&As compared with the non-EU firms. The latter show a focus on US, and to a lesser extent, EU targets.

Results of fixed effects panel data analysis -controlling for various other firm specific characteristics affecting performance- suggest that both technology alliances and technology based M&As can improve innovative performance. The empirical results, however, show marked differences between the effects of the two sourcing modes for EU and non-EU firms, and important differences with respect to the location of the partner or target firm. Overall (for the full sample of firms), technology alliances improve innovative performance with the strongest effects observed for alliances with EU firms. Technology based M&As with EU targets have a positive impact, but in contrast, M&As with non-EU targets *reduce* innovative performance. Similarly, alliances with firms based in emerging economies reduce, rather than increase, innovative performance, while alliances with partners in developed countries have a positive performance effect.

Once differences in the effectiveness of the sourcing strategies for EU and non-EU firms are taken into account, a pattern occurs with primarily M&As contributing to the performance of EU firms, but with cross-border M&As within the EU having the most robust impact. The negative effect of M&As is confined to non-EU firms engaged in acquisitions outside the EU or inside their home countries; non-EU firms' acquisitions of EU firms, in contrast, contribute to innovative performance. In general, we observe that the technology sourcing strategies that are relatively less utilized by these two groups of firms, i.e. technology-based acquisitions in case of non-EU firms and technology alliances in case of EU firms, are also the strategies that are relatively less effective for the respective groups of firms.

While the analysis showed that technology based M&As and technology alliances can jointly improve innovative performance, the results also suggested that large and complex portfolios of M&As and alliances can be detrimental to innovation. This is consistent with the view that management and coordination complexities associated with large portfolios of sourcing strategies is likely to lead to redundancies and duplication, while the lack of resources to manage the portfolio can impair the firm's ability to implement and benefit from the sourcing strategies. Specifically, we found evidence that simultaneous and intensive engagement in alliances and M&As focused on one region (e.g. the EU) may reduce the effectiveness of each individual sourcing mechanism. This suggests that alliances and M&As can function as substitutes if they overlap in terms of knowledge sourcing objectives.

We conclude that technology based M&As and technology alliances can both improve innovative performance, but that redundancies and intensive simultaneous use of both sourcing modes have to be avoided. EU firms are not only accessing technology internationally through M&As and alliances; they also are an important *source* of technology sourcing by non-EU based firms. The results for EU firms suggest that restructuring through technology based cross-border M&As within the EU may be as effective as R&D collaboration and alliances to improve innovative performance and the productivity of R&D operations. This holds for cross-border M&As in the EU, but not for intra-country M&As, for which no positive performance effects are observed. This suggests that EU mergers and competition policy should pay close attention to the R&D efficiencies and the consequences for innovation in evaluating M&As in the EU. At the same time, technology alliances with emerging economy partners (in particular India and China), which are on the rise in recent years, appear to be neutral, if not detrimental, to innovative performance. It may be that firms use these alliances to trade market access in emerging economies for access to technology, such that alliance activity is focused on adaptation efforts and diverts resources from research efforts that are most likely result in patent activities. The results suggest that further internationalizing R&D collaboration in terms of the geographic scope of the partners is not without risks and costs.

Our research has a number of limitations, which suggest a need for further research on this subject. First, we examined innovative performance in terms of patent applications with the European Patent Office. This is a natural choice given that the focus of this study is on the comparative effectiveness of international technology sourcing strategies of EU firms. On the other hand, it may potentially lead to bias if the analysis does not sufficiently control for the potential characteristic of collaborations with EU partner firms and EU target firms to exhibit a greater propensity to file for patents at the European Patent Office (as compared with non-EU partners and targets). In further work, we aim to analyze the effects of technology sourcing strategies using patents that are filed in Europe, the US and Japan ('Triadic' patents) to investigate whether such bias exists.[9] An alternative approach is to examine the financial performance of firms rather than innovative performance. Second, while an advantage of our sample is that it includes firms from a variety of industries, a drawback of this approach are that the limited number of firms per industry does not allow investigating industry differences in the role of technology based M&As and technology alliances. Potentially, some of these industry differences may influence the differential findings for EU and non-EU firms, as the distribution of the two groups of firms over industries is not identical. Investigating this in detail will require the construction of even larger databases. Third, the analysis did not take into account the importance and characteristics of alliance partners (e.g. in terms of their knowledge base and the intensity of the collaboration) and the importance of M&As (the knowledge stock of the targets). Examining these aspects in more detail may provide further insights into the potential difficulties in 'digesting' (integrating) large or heterogeneous target

[9] In a first robustness check, we estimated models on only those patents for which we could determine the existence of a patent family including US patent applications. This reduced patent numbers by about 40 percent. We found little systematic change in the empirical results, with again the most robust effect a positive influce of acquisitions of EU targets.

firms, and the role of technology overlap in reducing the effectiveness of sourcing strategies to develop new technologies.[10]

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Table 1. Number of firms by country of headquarters

EU	Number of firms	Non-EU	Number of firms
Austria	3	Canada	1
Belgium	2	Japan	15
Denmark	3	Liechtenstein	1
Finland	6	Norway	3
France	21	South Africa	1
Germany	26	Switzerland	6
Great Britain	19	US	34
Ireland	2	***Total***	***61***
Italy	5		
Luxembourg	1		
Portugal	1		
Spain	2		
Sweden	5		
The Netherlands	8		
Total	***104***		

Table 2. Number of firms by Sector

Sector	EU firms	non-EU firms	Sector	EU firms	non-EU firms
Manufacture of steel; steel tubes	2	0	Oils and fats	2	2
Non- ferrous metals	3	1	Dairy products	2	1
Clay Products	1	1	Fruit and vegetables	2	0
Cement, lime and plaster	2	0	Grain milling and starch	2	2
Articles of concrete and cement	2	0	Pasta	1	0
Glass	1	2	Bread, pastry and biscuits	2	1
Ceramics	3	0	Sugar	3	0
Chemical Products	4	1	Confectionery and ice cream	2	1
Paint & ink	3	1	Animal feed	1	3
Pharmaceuticals	3	2	Alcohol, spirits, wine and cider	2	1
Soap, detergents and toiletries	4	1	Beer	2	1
Manufacture of metal products	1	3	Soft drinks and water	2	2
Agricultural machinery	2	2	Tobacco	2	2
Manufacture of machine tools	4	1	Textiles	2	0
Computer and office equipment	0	4	Leather	2	0
Insulated wires and cables	3	1	Footwear	0	0
Electrical machinery	3	2	Clothing	1	0
Batteries and accumulators	1	2	Wood sawing	2	0
Electronic valves and tubes	2	1	Wood boards and wood products	2	0
Telecommunications equipment	4	1	Paper, pulp and articles of paper	4	0
Television and radio receivers	2	3	Publishing	3	0
Measuring & testing instruments	4	1	Rubber products and rubber tyres	3	2
Domestic electric appliances	3	1	Plastics	4	1
Lighting equipment and lamps	3	1	Musical instruments	1	2
Motor vehicles	4	2	Toys and sports goods	1	1
Motor vehicles parts	2	1	Services	0	0
Shipbuilding	2	1	Telecommunication services	5	0
Railway, locomotives and stock	3	1	IT services	1	4
Cycles and motor cycles	3	2	Retailing	1	0
Aerospace	5	0			
Medical instruments	3	2			
Optical instruments	1	3			
Clocks and watches	1	2			

Note: Because a firm can have a leading position in more than one industry, the numbers in the table add up to more than 165

Figure 1. EU Firms' Technology Alliance Partners by Country/Region

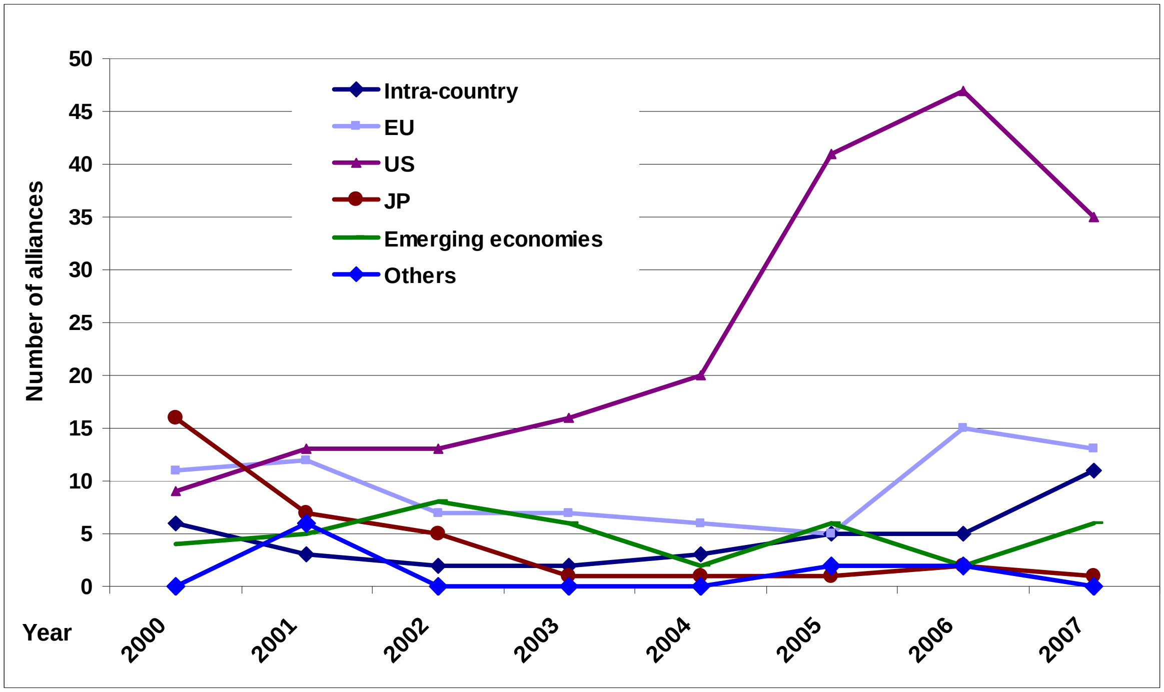

Table 3. EU firms' Shares of Technology Alliance Partners Based in Different Countries/Regions

Year	Intra-country	EU	US	JP	Emerging economies	Others	Total	Number of Tech-Alliances
2000	14.0	25.6	20.9	37.2	9.3	0.0	100.0	40
2001	6.5	26.1	28.3	15.2	10.9	13.0	100.0	44
2002	5.9	20.6	38.2	14.7	23.5	0.0	100.0	33
2003	6.5	22.6	51.6	3.2	19.4	0.0	100.0	30
2004	10.3	20.7	69.0	3.4	6.9	0.0	100.0	31
2005	8.3	8.3	68.3	1.7	10.0	3.3	100.0	58
2006	6.8	20.5	64.4	2.7	2.7	2.7	100.0	70
2007	16.7	19.7	53.0	1.5	9.1	0.0	100.0	65

Figure 2. Non-EU Firms' Technology Alliance by Country/Region, 2000-2007

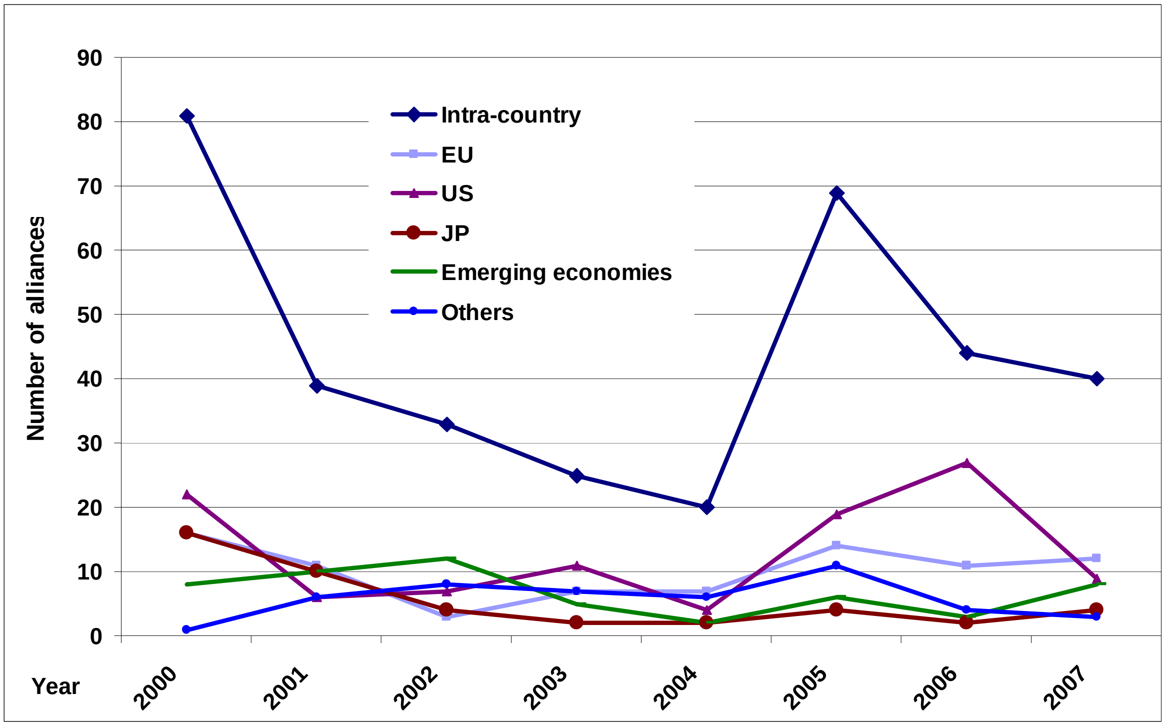

Table 4. Non-EU firms' Shares of Technology Alliance Partners Based in Different Countries/Regions

Year	Intra-country	EU	US	JP	Emerging economies	Others	Total	Number of Tech-Alliances
2000	56.3	11.1	15.3	11.1	5.6	0.7	100.0	127
2001	47.6	13.4	7.3	12.2	12.2	7.3	100.0	78
2002	49.3	4.5	10.4	6.0	17.9	11.9	100.0	63
2003	43.9	12.3	19.3	3.5	8.8	12.3	100.0	53
2004	48.8	17.1	9.8	4.9	4.9	14.6	100.0	37
2005	56.1	11.4	15.4	3.3	4.9	8.9	100.0	119
2006	48.4	12.1	29.7	2.2	3.3	4.4	100.0	89
2007	52.6	15.8	11.8	5.3	10.5	3.9	100.0	75

Figure 3. EU Firms' Technology-based M&As by Country/Region or Target

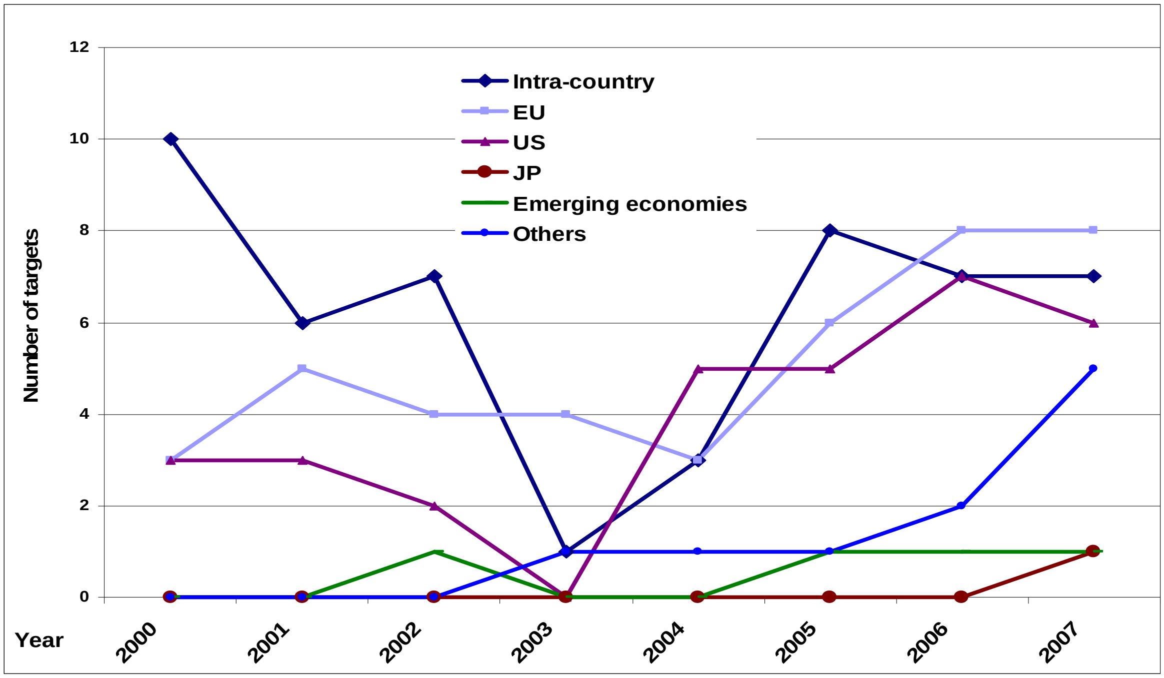

Table 5. Shares of EU firms' Technology-Based M&As by Countries/Regions of Targets

Year	Intra-country	EU	US	JP	Emerging economies	Others	Total	Number of Tech-M&As
2000	62.5	18.8	18.8	0.0	0.0	0.0	100.0	16
2001	42.9	35.7	21.4	0.0	0.0	0.0	100.0	14
2002	50.0	28.6	14.3	0.0	7.1	0.0	100.0	14
2003	16.7	66.7	0.0	0.0	0.0	16.7	100.0	6
2004	25.0	25.0	41.7	0.0	0.0	8.3	100.0	12
2005	38.1	28.6	23.8	0.0	4.8	4.8	100.0	21
2006	28.0	32.0	28.0	0.0	4.0	8.0	100.0	25
2007	25.0	28.6	21.4	3.6	3.6	17.9	100.0	28

Table 6. Major M&As by EU firms

Acquirer	Target	Year	Patents applications of target
Alcatel	Lucent Technologies	2006	4392
Bayer	Schering Corp.	2006	2475
Sanofi	Aventis	2004	1744
EADS	Airbus	2006	1075
Ineos	National Starch & Chemical	2001	803
Safran	Sagem	2005	790
BASF	Engelhard	2006	468
Basell	Lyondell	2007	254
Siemens	Flender Holding	2005	60
Telefonica	O2	2006	15

Note: Patent applications of target firm at the time of acquisition.

Figure 4. Non-EU Firms' Technology-based M&As by Country/Region or Target

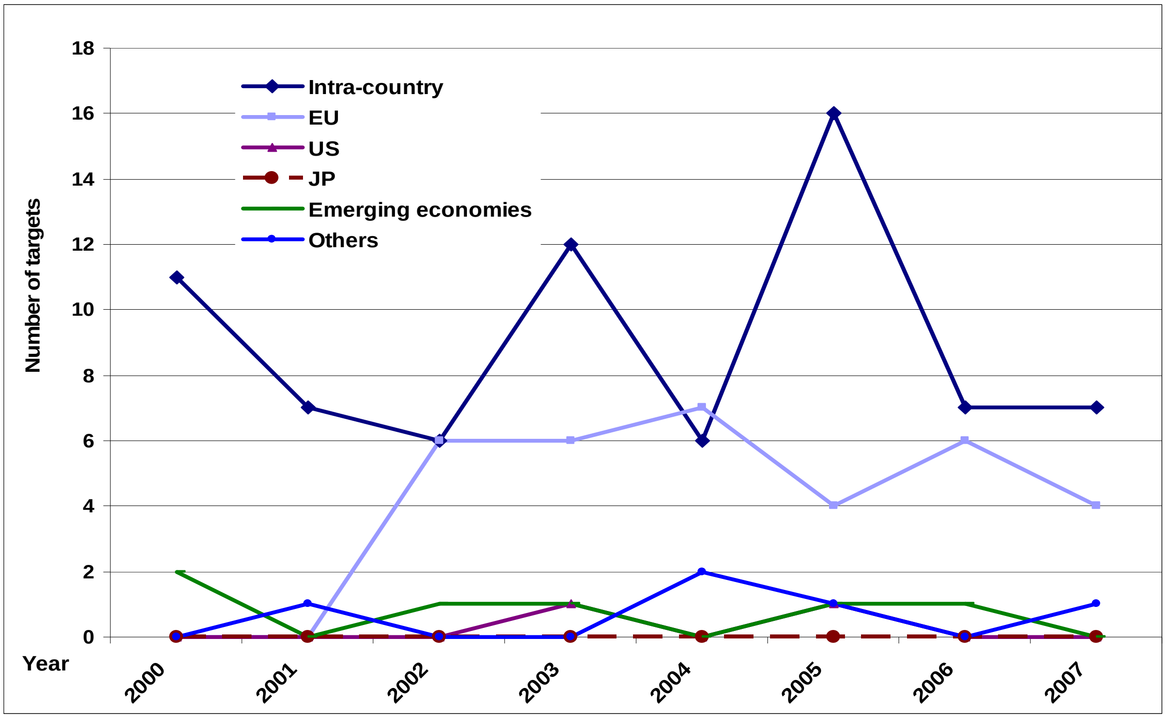

Table 7. Shares of non- EU firms' Technology-Based M&As by Countries/Regions of Targets

Year	Intra-country	EU	US	JP	Emerging economies	Others	Total	Number of Tech-M&As
2000	84.6	0.0	0.0	0.0	15.4	0.0	100.0	13
2001	87.5	0.0	0.0	0.0	0.0	12.5	100.0	8
2002	46.2	46.2	0.0	0.0	7.7	0.0	100.0	13
2003	60.0	30.0	5.0	0.0	5.0	0.0	100.0	20
2004	40.0	46.7	0.0	0.0	0.0	13.3	100.0	15
2005	69.6	17.4	4.3	0.0	4.3	4.3	100.0	23
2006	50.0	42.9	0.0	0.0	7.1	0.0	100.0	14
2007	58.3	33.3	0.0	0.0	0.0	8.3	100.0	12

Table 8. Major M&As by non-EU firms

Acquirer	Target	Year	Patents applications of target
Dow Chemicals	Union Carbide	2001	1844
Pfizer	Pharmacia	2003	1710
Procter & Gamble	Gillette	2005	700
Motorola	Symbol Technologies	2006	530
General Electric	Amersham	2004	334
Abbott Laboratories	Advanced Cardiovascular	2002	232
Sun Microsystems	Storage Technology	2005	146
Danaher	Kaltenbach & Voigt GmbH	2004	139
Johnson Controls	York International	2005	73
Oracle	Siebel System	2006	59

Note: Patent applications of target firm at the time of acquisition.

Table 9. Variable definitions and descriptive statistics

Variable	Definition	Mean	Std. Dev.	Mean EU firms	Mean non-EU firms
Acquisitions	Sum of technological acquisitions in t-1 and t-2	.44	1.15	.38	.55
Alliances	Sum of Technology alliances in t-1 through t-5	4.10	8.72	2.16	7.16
Acquisitions EU	Sum of technological acquisitions in the EU in t-1 and t-2	.22	.69	.26	.16
Alliances EU	Sum of Technology alliances in the EU in t-1 through t-5	.77	1.59	.67	.93
Acquisitions Non-EU	Sum of technological acquisitions outside the EU in t-1 and t-2	.22	.68	.12	.38
Alliances Non-EU	Sum of Technology alliances outside the EU in t-1 through t-5	3.46	7.76	1.56	6.45
Acquisitions Intra-country	Sum of intra-country technological acquisitions in t-1 and t-2	.21	.65	.15	.32
Alliances Intra-country	Sum of intra-country Technology alliances in t-1 through t-5	1.68	4.98	.21	3.99
Acquisitions EU (except intra-country)	Sum of technological acquisitions in the EU except intra-country in t-1 and t-2	.13	.52	.11	.16
Alliances EU (except intra-country)	Sum of Technology alliances within the EU but except intra-country in t-1 through t-5	.65	1.37	.47	.93
Acquisitions non-EU (except intra-country)	Sum of technological acquisitions outside the EU except intra-country in t-1 and t-2	.10	.40	.12	.06
Alliances non-EU (except intra-country)	Sum of Technology alliances outside the EU but except intra-country in t-1 through t-5	2.04	4.49	1.56	2.80
Acquisitions developed countries	Sum of technological acquisitions in developed countries, excluding EU in t-1 and t-2	.20	.64	.09	.36
Alliances developed countries	Sum of Technology alliances in developed countries, excluding EU in t-1 through t-5	3.10	7.11	1.33	5.89
Acquisitions Emerging economies	Sum of technological acquisitions in emerging countries in t-1 and t-2	.03	.16	.03	.03
Alliances Emerging economies	Sum of Technology alliances emerging countries, in t-1 through t-5	.411	1.05	.27	.63
Acquisitions x Alliances	Interactions term of all alliances and all acquisitions	3.34	16.61	2.75	4.27
Acquisitions EU x Alliances EU	Interactions term of EU alliances and EU acquisitions	.31	2.74	.46	.07
Acquisitions Non-EU x Alliances Non-EU	Interactions term of non-EU alliances and non-EU acquisitions	1.64	8.09	.80	2.97
Patents/R&D$_{t-1}$	EPO patent applications divided by R&D expenditures, in t-1	.35	.82	.35	.35
Log(R&D)$_{t-1}$	Logarithm of R&D expenditures in t-1	5.43	2.18	5.05	6.01

Table 10: Fixed Effect Negative Binomial Regression Analysis of Innovative Performance, 2001-2007 (All firms)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Acquisitions	-0.021	0.014						
	(0.018)	(0.027)						
Alliances	0.006**	0.007***						
	(0.003)	(0.003)						
Acquisitions EU			0.080***	0.101***			0.083***	0.095***
			(0.026)	(0.027)			(0.026)	(0.029)
Alliances EU			0.019	0.035**			0.023	0.024*
			(0.014)	(0.016)			(0.015)	(0.015)
Acquisitions Non-EU			-0.077***	-0.081**				
			(0.024)	(0.038)				
Alliances Non-EU			0.004	0.003				
			(0.004)	(0.004)				
Acquisitions Intra-country					-0.111***	-0.093**		
					(0.028)	(0.037)		
Alliances Intra-country					0.003	0.003		
					(0.005)	(0.005)		
Acquisitions EU (except intra-country)					0.128***	0.138***		
					(0.032)	(0.034)		
Acquisitions Non EU (except intra-country))					0.006	0.018		
					(0.032)	(0.037)		
Alliances EU (except intra-country)					0.041**	0.041**		
					(0.018)	(0.018)		
Alliances non-EU (except intra-country)					-0.003	-0.002		
					(0.007)	(0.007)		
Acquisitions non-EU developed economies							-0.096***	-0.075**
							(0.026)	(0.035)
Alliances non-EU developed economies							0.007*	0.007*
							(0.004)	(0.004)
Acquisitions emerging economies							0.015	0.020
							(0.083)	(0.084)
Alliances emerging economies							-0.058**	-0.057**
							(0.026)	(0.026)
Acquisitions x Alliances		-0.004*				-0.001		-0.002
		(0.002)				(0.002)		(0.002)
Acquisitions EU x Alliances EU				-0.014**				
				(0.007)				
Acquisitions Non-EU x Alliances Non-EU				-0.001				
				(0.003)				
Patents/R&D$_{t-1}$	0.075**	0.078**	0.071**	0.074**	0.073**	0.074**	0.075**	0.076**
	(0.031)	(0.031)	(0.031)	(0.031)	(0.031)	(0.031)	(0.031)	(0.031)
Log(R&D)$_{t-1}$	0.115***	0.121***	0.107***	0.118***	0.122***	0.124***	0.123***	0.127***
	(0.040)	(0.040)	(0.040)	(0.040)	(0.040)	(0.040)	(0.040)	(0.040)
Constant	1.479***	1.440***	1.569***	1.501***	1.496***	1.485***	1.495***	1.472***
	(0.273)	(0.274)	(0.273)	(0.275)	(0.277)	(0.278)	(0.276)	(0.277)
Observations	917	917	917	917	917	917	917	917
Number of firms	165	165	165	165	165	165	165	165
log likelihood	-3034	-3033	-3024	-3022	-3020	-3019	-3021	-3020

Standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1. Time dummies are included in all regressions.

Table 11a: Fixed Effect Negative Binomial Regression Analysis of Innovative Performance, 2001-2007. EU versus non-EU firms

	(1)	(2)	(3)	(4)
EU firms:				
Acquisitions	0.048**	0.070**		
	(0.019)	(0.030)		
Alliances	0.012*	0.014*		
	(0.007)	(0.007)		
Acquisitions EU			0.066**	0.076**
			(0.032)	(0.036)
Acquisitions non-EU			0.038	0.126**
			(0.032)	(0.057)
Alliances EU			0.027	0.021
			(0.020)	(0.023)
Alliances non-EU			0.002	0.005
			(0.009)	(0.010)
Acquisitions x Alliances		-0.002		
		(0.002)		
Acquisitions EU x Alliances EU				-0.002
				(0.008)
Acquisitions non-EU x Alliances non-EU				-0.007*
				(0.004)
Non-EU firms:				
Acquisitions	-0.102***	-0.105**		
	(0.028)	(0.052)		
Alliances	0.007**	0.007**		
	(0.003)	(0.003)		
Acquisitions EU			0.112***	0.112**
			(0.043)	(0.045)
Acquisitions non-EU			-0.172***	-0.211***
			(0.033)	(0.054)
Alliances EU			0.045**	0.045**
			(0.021)	(0.021)
Alliances non-EU			0.002	0.001
			(0.004)	(0.004)
Acquisitions x Alliances		0.000		
		(0.003)		
Acquisitions EU x Alliances EU				-0.015
				(0.046)
Acquisitions non-EU x Alliances non-EU				0.004
				(0.004)
Patents/R&D$_{t-1}$	0.073**	0.073**	0.073**	0.073**
	(0.031)	(0.031)	(0.031)	(0.031)
Log(R&D)$_{t-1}$	0.103**	0.102**	0.106***	0.096**
	(0.040)	(0.041)	(0.040)	(0.041)
Constant	1.577***	1.584***	1.619***	1.692***
	(0.276)	(0.282)	(0.278)	(0.283)
Observations	917	917	917	917
Number of firms	165	165	165	165
log likelihood	-3024	-3024	-3012	-3010

Standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1. Time dummies are included in all regressions.

Table 11b: Fixed Effect Negative Binomial Regression Analysis of Innovative Performance, 2001-2007. EU versus non-EU firms

	(5)	(6)	(7)	(8)
EU firms:				
Acquisitions EU	0.063**	0.053		
	(0.032)	(0.036)		
Alliances EU	0.028	0.021		
	(0.020)	(0.023)		
Acquisitions intra-country			0.018	0.011
			(0.041)	(0.045)
Acquisitions EU (except intra-country)			0.160***	0.152***
			(0.053)	(0.056)
Acquisitions non-EU (except intra-country)			0.032	0.039
			(0.033)	(0.037)
Alliances intra-country			0.014	0.008
			(0.036)	(0.040)
Alliances EU (except intra-country)			0.041	0.038
			(0.033)	(0.034)
Alliances non-EU (except intra-country)			0.000	-0.000
			(0.010)	(0.010)
Acquisitions non-EU developed countries	0.047	0.058		
	(0.041)	(0.045)		
Acquisitions emerging economies	-0.012	-0.007		
	(0.111)	(0.111)		
Alliances non-EU developed countries	0.001	-0.000		
	(0.010)	(0.010)		
Alliances emerging economies	-0.012	-0.017		
	(0.037)	(0.039)		
Acquisitions EU x Alliances EU		0.005		0.003
		(0.008)		(0.008)
Non-EU firms:				
Acquisitions EU	0.111**	0.115**		
	(0.044)	(0.045)		
Alliances EU	0.039*	0.039*		
	(0.021)	(0.021)		
Alliances intra-country			0.004	0.004
			(0.006)	(0.006)
Acquisitions EU (except intra-country)			0.113***	0.115***
			(0.043)	(0.044)
Acquisitions non-EU (except intra-country)			-0.176**	-0.178**
			(0.081)	(0.081)
Acquisitions intra-country			-0.172***	-0.171***
			(0.038)	(0.038)
Alliances EU (except intra-country)			0.042**	0.042**
			(0.021)	(0.021)
Alliances non-EU (except intra-country)			-0.005	-0.005
			(0.010)	(0.010)
Acquisitions non-EU developed countries	-0.176***	-0.174***		
	(0.035)	(0.035)		
Acquisitions emerging economies	-0.096	-0.103		
	(0.133)	(0.134)		
Alliances non-EU developed countries	0.005	0.005		
	(0.005)	(0.005)		
Alliances emerging economies	-0.058	-0.059*		
	(0.035)	(0.036)		
Acquisitions EU x Alliances EU		-0.016		-0.010
		(0.047)		(0.046)
Patents/R&D$_{t-1}$	0.075**	0.075**	0.071**	0.071**
	(0.031)	(0.031)	(0.031)	(0.031)
Log(R&D)$_{t-1}$	0.120***	0.119***	0.110***	0.109***
	(0.041)	(0.041)	(0.040)	(0.041)
Constant	1.548***	1.565***	1.611***	1.622***
	(0.281)	(0.282)	(0.279)	(0.280)
Observations	917	917	917	917
Number of firms	165	165	165	165

Standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1. Time dummies are included in all regressions.

Appendix A. Firms in the analysis: industry and total number of patent applications (2000-2007)

Company Name	Number of Patent applications	Sector Description	Country Code
3M	4228	Medical instruments	US
AARHUSKARLSHAMN	8	Oils and fats	SE
ABB	2645	Manufacture of electrical machinery	SZ
ABBOTT LABORATORIES	1080	Medical instruments	US
AGCO	80	Manufacture of agricultural machinery	US
AIR LIQUIDE	1027	Chemical Products	FR
AKER SOLUTIONS	38	Manufacture of metal products	NO
AKER YARDS	30	Shipbuilding	NO
AKZO NOBEL	651	Paint & ink	NL
ALCATEL LUCENT	5255	Insulated wires and cables	FR
ALCOA	271	Manufacture of metal products	US
ALSTOM	1081	Manufacture of electrical machinery	FR
ALTRIA	387	Tobacco	US
AMER SPORTS	19	Toys and sports goods	FI
ARCELOR MITTAL	128	Manufacture of steel + steel tubes	LU
ARCHER DANIELS MIDLAND	95	Oils and fats	US
ASSOCIATED BRITISH FOODS	27	Grain milling and manufacture of starch	GB
ASTRAZENECA	1683	Pharmaceuticals	GB
BAE SYSTEMS	480	Measuring, checking, testing instruments	GB
BASF	5650	Chemical Products	DE
BAYER	4625	Chemical Products	DE
BEIERSDORF	691	Soap, detergents and toiletries	DE
BMW	1572	Motor vehicles	DE
BOMBARDIER	290	Railway, locomotives and stock	CA
BOREALIS	525	Plastics	DK
BOSCH	9749	Manufacture of machine tools	DE
BRIDGESTONE	1132	Rubber products and rubber tyres	JP
BRITISH AMERICAN TOBACCO	105	Tobacco	GB
BRITISH TELECOM	951	Telecommunication services	GB
BUNGE	69	Oils and fats	US
CA	231	IT services	US
CADBURYSCHWEPPES	3	Confectionery and ice cream	GB
CAMPINA	86	Dairy products	NL
CANON	4555	Computer and office equipment	JP

Appendix A (continued)

Company Name	Number of Patent applications	Sector Description	Country Code
HEWLETT PACKARD	3995	Computer and office equipment	US
HILTI	565	Manufacture of machine tools	LI
HITACHI	5213	Insulated wires and cables	JP
HOLCIM	30	Clay Products	SZ
HONDA	3047	Cycles and motor cycles	JP
HUSQVARNA	66	Manufacture of machine tools	SE
IBM	2380	IT services	US
ICI	180	Paint & ink	GB
IMPERIAL TOBACCO	11	Tobacco	GB
INBEV	35	Beer	BE
INDESIT	90	Domestic electric appliances	IT
INEOS	385	Chemical Products	GB
INFINEON TECHNOLOGIES	1461	Insulated wires and cables	DE
JAPAN TOBACCO	621	Tobacco	JP
JOHN DEERE	1159	Manufacture of agricultural machinery	US
JOHNSON CONTROLS	510	Manufacture of electrical machinery	US
JOHNSON MATTHEY PLC	225	Non- ferrous metals	GB
KELLOGG	56	Grain milling and manufacture of starch	US
KERRY GROUP	22	Fruit and vegetables	IE
KONINKLIJKE FRIESLAND FOODS	86	Dairy products	NL
KRAFT FOODS	147	Bread, pastry and biscuits	US
KTM	7	Cycles and motor cycles	AT
LAFARGE	118	Cement, lime and plaster	FR
LAGARDERE	41	Publishing	FR
L'OREAL	2833	Soap, detergents and toiletries	FR
LVMH	49	Clocks and watches	FR
LYONDELL-BASELL	514	Plastics	
MATT HOHNER AG	4	Musical instruments	DE
MOTOROLA	1515	Telecom; television and radio transmitters	US
NEC	3875	Computer and office equipment	JP
NESTLE	888	Dairy products	SZ
NIKON	825	Optical instruments	JP
NIPPON SHEET GLASS	515	Glass	JP
NOKIA	6660	Telecom; television and radio transmitters	FI
NORDDEUTSCHE AFFINERIE	14	Non- ferrous metals	DE
NORSK HYDRO	222	Non- ferrous metals	NO
NOVARTIS	2267	Pharmaceuticals	SZ
NUTRECO	17	Animal feed	NL
OLYMPUS	1557	Optical instruments	JP

Appendix A (continued)

Company Name	Number of Patent applications	Sector Description	Country Code
ORACLE	178	IT services	US
OWENS ILLINOIS	81	Glass	US
PANASONIC	10865	Television and radio receivers	JP
PERNOD RICARD	5	Alcohol, spirits, wine and cider	FR
PFIZER	2212	Pharmaceuticals	US
PFLEIDERER	24	Wood boards and other wooden products	DE
PHILIPS	14116	Television and radio receivers	NL
PIAGGIO GROUP	44	Cycles and motor cycles	IT
PIRELLI & C	461	Rubber products and rubber tyres	IT
PPG INDUSTRIES	487	Paint & ink	US
PREMIER FOODS	2	Fruit and vegetables	GB
PROCTER & GAMBLE	3691	Soap, detergents and toiletries	US
PSA	1454	Motor vehicles	FR
QUIKSILVER	6	Toys and sports goods	US
REED ELSEVIER	17	Publishing	GB
ROLAND	14	Musical instruments	JP
ROLLS-ROYCE GROUP	727	Aerospace	GB
SABMILLER	4	Beer	SA
SAFRAN GROUP	1095	Aerospace	FR
SAFT	70	Batteries and accumulators	FR
SAINT-GOBAIN	1022	Articles of concrete and cement	FR
SAME DEUTZ-FAHR	15	Manufacture of agricultural machinery	IT
SANITEC	32	Ceramics	FI
SANOFI-AVENTIS	1085	Pharmaceuticals	FR
SANOMAWSOY	2	Publishing	FI
SAP	1112	IT services	DE
SCA	570	Paper, pulp and articles of paper	SE
SCHNEIDER	132	Insulated wires and cables	DE
SIEMENS AG	16187	Manufacture of electrical machinery	DE
SMURFIT KAPPA	48	Paper, pulp and articles of paper	IE
SONAE INDUSTRIES	20	Wood boards and other wooden products	PT
SONY	8393	Television and radio receivers	JP
ST MICROELECTRONICS	1740	Electronic valves and tubes	US
STORA ENSO	85	Wood sawing	FI
SUDZUCKER	73	Sugar	DE
SUN MICROSYSTEMS	956	IT services	US
SWATCH	334	Clocks and watches	SZ
TATE & LYLE	61	Grain milling and manufacture of starch	GB
TELEFONICA	24	Telecommunication services	ES

Appendix A (continued)

Company Name	Number of Patent applications	Sector Description	Country Code
TESCO	1	Retailing	GB
THALES	1052	Measuring, checking, testing instruments	FR
THOMSON	3979	Television and radio receivers	FR
THYSSENKRUPP	1015	Manufacture of steel + steel tubes	DE
UMICORE	248	Non- ferrous metals	BE
UNILEVER	1973	Soap, detergents and toiletries	NL
UPM-KYMMENE	37	Wood sawing	FI
VILLEROY & BOCH	12	Ceramics	DE
VODAFONE	526	Telecommunication services	GB
VOLKSWAGEN	1265	Motor vehicles	DE
WHIRLPOOL	552	Domestic electric appliances	US
WIENERBERGER	35	Clay Products	AT
YAMAHA CORPORATION	638	Musical instruments	JP
YAMAHA MOTOR CORPORATION	762	Cycles and motor cycles	JP
ZUMTOBEL	227	Lighting equipment and lamps	AT

Notes: AT: Austria, BE: Belgium, DE: Germany, DK: Denmark, ES: Spain, FN: Finland, FR: France, GB: United Kingdom, IE: Ireland, IT: Italy, JP: Japan, LU: Luxembourg, NL: The Netherlands, NO: Norway, PT: Portugal, SA: South Africa, SE: Sweden, SZ: Switzerland, and US: United States.

Appendix B. Correlation Matrix

Variable	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1. Acquisitions	1.00																			
2. Alliances	0.15	1.00																		
3. Acquisitions EU	0.84	0.09	1.00																	
4. Alliances EU	0.15	0.80	0.13	1.00																
5. Acquisitions Non-EU	0.83	0.16	0.40	0.12	1.00															
6. Alliances Non-EU	0.14	0.99	0.08	0.73	0.16	1.00														
7. Acquisitions Intra-country	0.83	0.16	0.68	0.14	0.71	0.16	1.00													
8. Alliances Intra-country	0.07	0.87	-0.02	0.54	0.13	0.90	0.14	1.00												
9. Acquisitions EU (except intra-country)	0.77	0.06	0.81	0.05	0.47	0.06	0.01	0.45	1.00											
10. Alliances EU (except intra-country)	0.14	0.82	0.10	0.96	0.13	0.77	0.15	0.61	0.04	1.00										
11. Acquisitions non-EU (except intra-country)	0.53	0.10	0.27	0.13	0.63	0.09	0.18	-0.04	0.19	0.10	1.00									
12. Alliances non-EU (except intra-country)	0.18	0.88	0.17	0.77	0.13	0.86	0.12	0.55	0.09	0.74	0.21	1.00								
13. Acquisitions developed countries	0.82	0.16	0.41	0.11	0.97	0.16	0.74	0.15	0.49	0.12	0.52	0.12	1.00							
14. Alliances developed countries	0.14	0.99	0.07	0.71	0.16	1.00	0.16	0.91	0.06	0.76	0.07	0.84	0.16	1.00						
15. Acquisitions Emerging economies	0.27	0.04	0.08	0.05	0.37	0.04	0.06	-0.02	0.05	0.07	0.62	0.09	0.14	0.04	1.00					
16. Alliances Emerging economies	0.15	0.74	0.13	0.64	0.12	0.74	0.11	0.53	0.09	0.64	0.13	0.78	0.11	0.68	0.06	1.00				
17. Acquisitions x Alliances	0.63	0.38	0.53	0.40	0.53	0.36	0.54	0.19	0.38	0.37	0.43	0.45	0.50	0.36	0.23	0.32	1.00			
18. Acquisitions EU x Alliances EU	0.33	0.27	0.48	0.42	0.07	0.23	0.31	0.04	0.27	0.36	0.10	0.41	0.06	0.23	0.04	0.29	0.69	1.00		
19. Acquisitions Non-EU x Alliances Non-EU	0.56	0.33	0.26	0.24	0.68	0.33	0.52	0.27	0.23	0.26	0.47	0.28	0.66	0.33	0.28	0.21	0.78	0.13	1.00	
20. Patents/R&D$_{t-1}$	-0.04	-0.08	-0.02	-0.08	-0.05	-0.08	-0.06	-0.07	0.00	-0.08	-0.02	-0.07	-0.06	-0.08	0.01	-0.06	-0.03	0.00	-0.05	1.00
21. Log(R&D)$_{t-1}$	0.20	0.52	0.13	0.49	0.21	0.50	0.22	0.38	0.06	0.48	0.14	0.50	0.21	0.49	0.04	0.44	0.25	0.15	0.25	-0.32