

Technology alliances in emerging economies: persistence and interrelation in European firms' alliance formation

Citation for published version (APA):

Belderbos, R. A., Gilsing, V., & Jacob, J. (2011). *Technology alliances in emerging economies: persistence and interrelation in European firms' alliance formation*. UNU-MERIT, Maastricht Economic and Social Research and Training Centre on Innovation and Technology. UNU-MERIT Working Papers No. 026

Document status and date:

Published: 01/01/2011

Document Version:

Publisher's PDF, also known as Version of record

Please check the document version of this publication:

- A submitted manuscript is the version of the article upon submission and before peer-review. There can be important differences between the submitted version and the official published version of record. People interested in the research are advised to contact the author for the final version of the publication, or visit the DOI to the publisher's website.
- The final author version and the galley proof are versions of the publication after peer review.
- The final published version features the final layout of the paper including the volume, issue and page numbers.

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Working Paper Series

#2011-026

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European firms' alliance formation**

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UNU-MERIT Working Papers

ISSN 1871-9872

**Maastricht Economic and social Research Institute on Innovation and Technology,
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Technology Alliances in Emerging Economies: Persistence and Interrelation in European Firms' Alliance Formation

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June 2011

ABSTRACT

We analyze patterns and determinants of technology alliance formation with partner firms from emerging economies, with a focus on European firms' alliance strategies. We examine to what extent European firms' alliance formation with partners based in emerging economies is persistent, that is: to what extent prior collaborative experience determines new alliance formation, and we compare this pattern with alliance formation with developed country partners. Second, we examine to what extent prior engagement in international alliances with partners from developed countries increases the propensity to form technology alliances with partners based in emerging economies and vice versa (interrelation). We find that both persistence and interrelation effects are present, and that they are generally not weaker for emerging economy alliances. Alliance formation with Indian and Chinese firms is significantly more likely if firms have prior alliance experience with Japanese firms. The findings suggest that firms extend their alliance portfolio from developed to emerging economies, increasing the geographic diversity of their alliance portfolio and building on their prior international alliances experience.

JEL codes: M21, O32, O33, O52, O53

Keywords: Alliances, Persistence, Interrelation, Emerging economies

Acknowledgements

The authors are grateful to Pari Patel and Martin Shrolec for comments on earlier drafts and to Nico Rasters and Ibrahim Bolat for their assistance in earlier phases of this project. This research was funded by Europe FP7 Grant FP7-SSH-2007-1/217296 for the project "The changing nature of Internationalization of Innovation in Europe: impact on firms and the implications for innovation policy in the Europe".

1. INTRODUCTION

In recent years, the innovation strategies of firms are characterized by an increasing importance attached to external sources of knowledge (Archibugi and Coco, 2004; OECD, 2007; Patel and Pavitt, 1992; Belderbos et al, 2008) and a parallel decline in internal R&D departments (Chesbrough 2003; Howells et al., 2004). This trend is especially pronounced in research intensive industries (Bönte, 2003) and is accelerating due to technological convergence, declining transaction costs of acquiring external R&D inputs, and shortening product cycle times (Grandstrand et al. 1992; Narula, 2001). Strategic alliances are increasingly recognized as an important (quasi-market) mechanism to access such external knowledge (Narula and Hagedoorn, 1999; Hagedoorn, 2002; Schilling, 2008), and there is a growing literature in innovation management on alliance strategies and their impacts on performance (e.g. Powell et al., 1996; Gulati, 1999; Gilsing et al., 2008; Vanhaverbeke et al., 2009).

One of the findings in the literature on strategic alliances is that cross-border alliances are important and that geographic diversity of alliance portfolios can improve alliance performance (Lavie and Miller, 2008; Duysters and Lokshin, 2007). Recently, important drivers of such internationalization of R&D activities and R&D alliances have been the intensified global innovation competition and increasing R&D costs that push firms to search for lower cost technology development options through abroad, the rapid development of science and engineering talent pools at low cost in emerging economies such as China and India, and the improved climate in emerging economies for multinational firms' R&D activities due to reforms in intellectual property right regimes (e.g. OECD, 2007). As a result, emerging economies have become increasingly important in multinational firms' R&D activities and their international technology alliance activity. In this paper, we show that

during 2004-2008, more than a third of global technology alliance formation involved firms from emerging economies.

Against this background, it is surprising that the alliance literature has primarily focused on alliances between partners from developed countries. We still have only a limited understanding of the pattern of technology alliances between developed-country and emerging-economy firms. A number of case studies have suggested that alliances with Western multinationals were instrumental in the global emergence of such well known companies as China's Haier (Duysters et al., 2009) and Huawei Technologies (Zhang, 2009) or India's Tata (Duysters et al., 2009). However, the factors driving Western firms to form alliances with emerging-economy firms have not received due attention in the literature.

In this study, we conduct an analysis of technology alliance formation with partner firms from emerging economies, with a focus on European firms' alliance strategies. We first examine the changing patterns of global technology alliance formation and the involvement of emerging country firms. Focusing on European firms, we examine their role in global technological alliance formation and the changing composition of their alliance partners over time. We then empirically analyze the drivers of European firms' technology alliance formation (1999-2008) with emerging country firms, in comparison with the drivers of alliance formation with firms based in developed countries. Our data are drawn from SDC's Platinum database and include more than 2800 firms.

Our analysis is informed by the general idea in the literature that prior collaborative experience with a specific partner (Gulati, 1995) or collaboration experience in general (Duysters and Heimeriks, 2007) can positively influence alliance formation with new and/or existing partners. Such persistence in, and interrelation between, alliances has been found to show diverging patterns across types of alliances partners, such as customers, suppliers, or competitors (Belderbos et al., forthcoming). In this paper, we build on this idea and study two

key issues. First, we consider to what extent prior collaborative experience with partners based in developed countries or emerging economies influences alliance formation with partners based in these same regions. This is indicative of a *persistence* effect of prior collaboration and collaborative experience. Second, we examine to what extent prior engagement in international alliances with partners from developed countries increases the propensity to form technology alliances with partners based in emerging economies and vice versa. This would be indicative of an *interrelationship* between alliance formation with partners from emerging and developed economies, suggesting that international alliances in developed countries reinforce incentives to establish alliances in emerging economies and vice versa, leading to an increase of the geographical diversity of alliance portfolios.

We analyze patterns of alliance formation with emerging country partners, and in an extension, we also examine alliance formation with partner firms in the two most important emerging economies in terms of their involvement in international R&D networks: China and India. By considering the degree of persistence and interrelationship among international alliances we contribute to an understanding of the development of global alliance portfolios, which still forms an understudied issue in the literature that has focused on performance effects of portfolios (Wassmer, 2010).

The following section describes the theoretical background to our empirical study. In Section 3 we describe the database. Section 4 then presents the trends in technology alliances both globally and for European firms specifically. Section 5 describes the variables and empirical model, and in Section 6 we present the results of the multivariate analysis. We conclude in Section 7.

2. THEORETICAL BACKGROUND

In the literature on alliances it has been established that alliances may contribute to the development of dynamic capabilities and, in this way, can support firms in strengthening and renewing their competitive advantage over time (Teece et al., 1997; Eisenhardt and Martin, 2000). More specifically, recent studies on alliances suggest that they can serve a "radar function" by linking firms to diverse partners and accessing novel information in a world which is dynamic and lacks transparency (Duysters and Lokshin, 2007; Faems et al., 2005). Alliances offer flexibility to the firm in that it can 'cherry pick' the most desired knowledge available with a partner (de Man and Duysters, 2005). Persistent use of alliance strategies may allow companies to maintain a focus on their core domains through in-house specialization while external collaboration may provide them with a window on newly emerging (technological) opportunities that fall beyond their core areas of expertise (Ahuja, 2000).

Although in alliance studies the empirical focus has included international alliances (e.g. Hagedoorn, 1993; 2002; Ahuja, 2000), the role and importance of geographic heterogeneity among international alliance partners have received only limited attention until now, especially with regard to partners from emerging economies. Duysters and Lokshin (2007) argue that diverse sources of knowledge offer flexibility and reduce risk in an uncertain technological and market environment, and find that broad international alliance portfolios are associated with strong innovation performance. Lavie and Miller (2008) show that moderate levels of international partner diversity - measured as a composite of several national-level differences like geographical, cultural, institutional and economic diversity - contribute to improved firm performance. Too much diversity, however, may reduce firms' ability to understand partners' background (Lavie and Miller, 2007). Furthermore,

international alliances may also carry an additional source of uncertainty as the risk of opportunistic behavior by partners may be higher, especially in case of alliances with partners from emerging companies (Hoskisson, et al., 2000).

Studies on alliance capabilities have demonstrated that the more alliance experience a firm has, the more capable it may become in dealing with inter-firm differences as well as in mitigating risks of opportunistic behavior (Heimeriks and Duysters, 2007; Kale and Singh, 2007). Furthermore, it has been suggested that the more experience a firm has with engaging in international alliances, the more it may develop collaborative routines and capabilities that help it to overcome cross-cultural differences and to mitigate the associated higher risks of opportunism (Barkema et al., 1997). International alliance experience is not only relevant during the process of collaboration itself but also before it, during the phase of partner selection. In this phase, firms need information about their potential international partners and the resources they possess (Gulati, 1995). The ability to find and interpret information on potential partners, and to carefully discriminate among them, is also strongly enhanced by collaborative experience (Gulati, 1999; Duysters and Heimeriks, 2007). Overall, this suggests that the more international alliance experience a firm has, the more it may be able to generate value from such partnerships (Krishnan et al., 2006). Prior international alliance experience also signals the success of the firm in generating positive alliance outcomes, thereby increasing the likelihood to win the interest and trust of other potential partner firms. Prior international alliance experience not only contributes to the ability of extracting value from international alliances but also helps generating new international partnering opportunities. The more alliance experience a firm has, the more it becomes structurally embedded in an alliance network, providing it with network-level information on new partnering opportunities, beyond its direct partners (Granovetter, 1985). In a similar vein, this mechanism brings information regarding a firm's capabilities and reputation to the potential

partners, enhancing their ability to assess the firm's attractiveness. In this way, alliance experience, through structural embeddedness, contributes to a persistent pattern of collaboration between partners that are connected, directly and/or indirectly (Gulati and Garguilo, 1999).

Taken together, these arguments suggest that a firm's specific pattern of international alliance experience contributes to persistence of its international alliance strategy. Hence, firms with prior experience in dealing with alliance partners from a specific region (developing or emerging economies) are more likely to form new alliances with partners from within these regions.

A second, related issue is that the more a firm has built up alliance experience within developed economies or emerging economies, the higher the likelihood that it may increasingly receive redundant information of which the novelty value may yield diminishing returns. To address this, a firm may decide to expand its alliance portfolio through increasing internationalization (Lavie and Miller, 2007). This suggests that the more a firm has alliance experience with partners from developed economies, the more likely it is that it engages in alliance formation with firms from emerging economies, and vice versa. Such a geographic diversification strategy increases the degree of diversity in a firm's technology alliance portfolio, and enables it to access technological expertise in developed countries as well as to connect with the growing technological capability levels and opportunities for exploitation of technologies from emerging economies. This implies an *interrelationship* between international alliance activities in developed countries and the formation of alliances with firms based in emerging economies, and versa. More specifically, we expect that prior experience in international alliances with partners from developed countries increases the propensity to form technology alliances with partners based in emerging economies and vice versa.

We will explore these relationships in section 5 below. First, we describe the empirical basis of our research after which we show the developments in alliance activities involving emerging country firms over the last 25 years.

3. DATA

For our empirical study, we make use of the SDC (Securities Data Company) Platinum databases - a well-known data source for empirical studies on strategic alliances (Schilling, 2008). This database is richer than the MERIT-CATI database, as it codes more information on alliances.¹ We focus on the period 1984-2008, since the coverage of alliance activity in the early 1980s in the database has been less systematic. To examine global trends in technology alliance activity and the role of emerging economies, we select only those alliances in the SDC database that have explicit technology development or technology sharing objectives, or that have a broad functional scope of activities (joint ventures; Schilling, 2008). Hence, we do not include simple one-way technology licensing, as this is essentially a market-based mode of technology acquisition. Specifically, we define 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;
- The alliance is a joint venture with a broad functional scope.

We then differentiate the alliances with respect to the country of incorporation of the participants. We distinguish European firms (all current Europe-27 countries plus Iceland, Lichtenstein, Norway and Switzerland), firms based in the US, Japan and the most alliance-

¹ In addition, the MERIT-CATI database has not been updated in recent years.

active emerging economies, with China and India as the main countries of interest. Over the period 1984-2008, the database covers more than 50,000 technology alliances according to this definition. The main patterns of alliance activity are described in the next section. We will report results aggregated over 5 year periods to highlight major trends in a more compact manner.

In our analysis of the determinants of technology alliance formation with firms based in emerging economies as compared to alliance formation with developed country firms, we focus on alliance strategies of European firms. Here we limit the analysis to alliances established in the most recent 5-year periods, 1999-2003 and 2004-2008, the periods in which alliance activity in emerging economies became more widespread. We selected in each period those European firms that formed at least one international technology alliance in the period. This ensures that our dataset focuses on alliance-active firms, consistent with our emphasis on the role of persistence and interrelation. We aggregate over 5 year periods because covariates (explanatory variables) are not available every year and in order to increase the number of positive cases of alliance formation with emerging economy firms. About 68 percent of the European firms represented in the SDC database engaged in international technology alliances in one of the two periods. This resulted in a sample of 1938 firms with information available on firm size and prior alliance activity, of which 273 are observed in both periods. Further detail on the data is provided in Section 5.

4. TRENDS IN GLOBAL AND EUROPEAN FIRMS' TECHNOLOGY ALLIANCES, 1984-2008.

Figure 1 shows the main trends in technology alliance activities, for five five-year periods—1984-1988, 1989-1993, 1994-1998, 1999-2003 and 2004-2008. Globally, alliance activities were minimal until the beginning of the 1990s. However, since 1990 they have gathered

considerable momentum reaching a peak of about 7000 alliances in 1995. Thereafter, the number of technology alliances declined, but remained rather stable at around 4000 alliances until the burst of the IT bubble in 2001. Alliance activities picked up again by 2005, and the number of alliances has fluctuated around 3000 in recent years.

When we distinguish alliances by the home countries or home region of the participating firms—Europe, USA, Japan, other developed, China, India and other emerging economies—it is clear that the US has been the major player throughout the period. While European firms have been the second most active ones until 1992, thereafter they have been surpassed by emerging economy firms. The increasing number of alliances involving emerging economy firms is largely due to the growing alliance activity by firms from China and India. In terms of the distribution of firms involved in alliances, US firms have been responsible for on average 36 percent of technology alliance activity (Table 1), while the share of European firms in recent years has hovered around 19%. Over time, the shares of European and US firms in global technology alliances remained rather steady, but the shares of Japanese firms have been strongly declining to reach just over 5 percent during the latest period. In sharp contrast, the share of emerging economy firms, driven by the increasing number of firms from India and China engaging in alliances, has increased about five-fold between the five periods to reach close to 35% in the most recent period. Chinese firms have traditionally been the most important among emerging economy firms, but in recent years, Indian firms too are becoming an important force in global technology alliances. Following China and India are Hong Kong, Malaysia, Singapore and Russia, all of which account for close to or above 2% of global technology alliance activity; the share of firms from other emerging economies is quite small (1% or less).

Restricting attention to European firms, figure 2 and table 2 show their most important technology alliance partners. The most common partners of European firms are

based in Europe (both domestic and other European countries) followed by US firms and increasingly emerging economy firms. The fluctuations in the number of these alliance partners reflect the overall trend in the number of technology alliances. Across the five periods, the proportion of partner firms from Europe has shown considerable fluctuations reaching a peak of 60.4% during 1999-2003 before falling to 47% during the latest period. The share of American firms has been declining but recorded resurgence during the latest period to reach over 21%. The proportion of alliances partners from Japan has been steadily declining reaching 3% during the most recent period. On the other hand, during the same period the share of partner firms from emerging economies stood almost eight times higher at 25.4%. Looking at alliances within Europe during the last three periods, the proportion of alliance partners from the home country (intra-country alliances) surpassed the proportion of cross-border alliances within Europe. In recent years (2004-2008), intra-European alliances as well as alliances with US firms have been on the decline while those with emerging economy firms have been growing, and alliance formation has been roughly equally distributed among the four groups recently. The remaining partners come from the rest of the world and Japan.

We conclude that overall technology alliance activity by European firms is distinctly international and externally oriented, with on average around 50% of the partner firms coming from outside of Europe and about 75% based outside the home country. The recent two periods demonstrate an increasing importance of partners based in emerging economies, resulting in a further geographic diversification of the alliance activity of European firms.

The emerging economy alliance partners are dominated by Chinese firms whose alliances with European firms increased rapidly in the mid-1990s coinciding with the global surge in alliances, and Indian firms, who in recent years have entered into even greater numbers of alliances with European firms than their Chinese counterparts. Russian firms rank

third among partners from emerging economies, but their alliances are much smaller in number compared to those of Chinese and Indian firms. Among the top 10 emerging country alliance partners of European firms, Africa and Latin America are represented by South Africa and Brazil, respectively, while all the other countries are located in Asia (including Russia).

The sectoral composition of international alliances for the latest two periods is shown in Figures 3a and 3b. The figures show a concentration of alliances in a few major sectors, which are, in declining order of importance, are business services, finance, insurance & real estate, transport & communications, pharmaceuticals, chemicals, motor vehicles, and electronics. The relative importance of these sectors remained relatively stable with the notable exception of pharmaceuticals, which in the last period became the second most alliance active industry after business services.

Comparing the importance of partners from developed countries versus those from emerging economies across sectors, we observe that during 1999-2003 emerging economy firms were important partners of European firms only in a few low-technology industries such as food & beverages, leather products and wearing apparel. However, during the latest period there was marked increase in the share of emerging economy firms as partners of European firms across a variety of sectors. In addition to increasing their share as partners to European firms in the aforementioned low-technology industries, emerging economy firms became important partners, if not the leading partners, in several medium technology industries like motor vehicles and machinery, as well as finance & insurance. On the other hand, developed country firms continue to remain the dominant partners in technologically advanced manufacturing industries, in particular pharmaceuticals as well as in business services.

In the next sections, we explore the firm-level drivers of alliances formation with partners in emerging economies, and compare these to the drivers of alliance formation with partner firms based in developed countries.

5. VARIABLES AND EMPIRICAL MODEL

In our analysis of alliance formation by European firms, the dependent variable is measured as the total number of alliances established with partner firms based in emerging economies and developed countries during the periods 1999-2003 and 2004-2008. We estimate similar models for alliance formation in emerging economies and developed countries to examine differences and similarities. In an extension, we focus more in particular on alliance formation with firms based in China and India.

The key explanatory variables relate to persistence (prior alliance formation with firms based in the same region) and interrelation (prior alliance formation with firms based in a different region). We include two dummy variables to examine these influences. The variable *alliance experience - developed countries* takes the value 1 if the firm had formed technology alliances with firms based in developed countries in the prior 5-year period, and zero otherwise. Similarly, the variable *alliance experience - emerging economies* takes the value 1 if the firm engaged in alliance formation with firms based in emerging economies in the prior 5-year period. In addition to these dummy variables we control for the total number of prior alliances that the firm formed in the prior 5-year period (*number of prior international alliances*), and a dummy variable measuring whether the firm had prior domestic alliance formation (*alliance experience - home country*). In the analysis of alliance formation with firms based in the most important emerging economies, India and China, we examine the role of prior alliance formation in these countries (*alliance experience - India, China*) and we

differentiate between the US and Japan as partner countries in prior alliance formation (*alliance experience- US, Japan*).

The analysis includes a range of control variables. First, the European firms could be independently owned, or part of a larger group and ultimately owned by a (multinational) parent firm. We make a distinction between European and non-European parent firms. This distinction is possible because the SDC database allows examining the country of the ultimate owner of the participants in alliances. *Non-European MNC* takes the value 1 if the firm belongs to a non-European parent; *European MNC* takes the value 1 if the firm belongs to a European parent based in another European country. Second, we control for firm size. We distinguish between small and medium size companies (less than 500 employees), large firms and very large firms. We include two dummy variables *Large firm* and *Very large firm*, which take the value 1 if the firm's number of employees ranges between 500 and 5000, and is larger than 5000, respectively. Third, the analysis takes into account home country and industry-specific factors that influence the propensity to engage in technology alliances, by including dummy variables representing the home country and sector of each European firm. Finally, we include a dummy variable for the second period to control for systematic differences in the propensity to engage in alliance formation over time.

Table 4 provides summary statistics of the variables. The number of European alliances with partners based in developed economies is larger than the number of alliances with emerging economy firms (3320 versus 1187, under 'Sum' in Table 4). The descriptives also confirm that alliances with Chinese firms are more frequent than alliances with Indian firms in the sample period. The alliance experience variables show a similar pattern: for about a 28 percent of the firm observations there is alliance experience in developed countries, but this is limited to just over 15 percent of the sample in case of emerging country alliances. The total number of prior international alliances is on average 1.3, but the variable

is characterized by a strong dispersion, with the maximum number of alliances in the sample reaching 108. The ownership variables indicate that close to 5 percent of the sample firms are EU multinationals and 3.4 percent are affiliates of non-EU multinational firms. In terms of size, close to half of the firms fall into the very large firm category, close to one third are large firms, and small and medium size firms make up just under 20 percent of the sample. The dependent variables show considerable dispersion, partly because many firms engage in one or a limited number of alliances with a specific target region, while they are not active in alliances with the other. We therefore employ a Poisson model with clustered and robust standard errors that corrects for overdispersion and allows for correlation between observations for the same firms (Cameron and Trivedi, 2008).

6. EMPIRICAL RESULTS

The estimation results on alliances with developed countries and emerging economies are reported in table 5. The first and third columns report estimations with the control variables only, and the second and fourth columns add the prior alliance variables. Both for alliance formation with firms based in developed countries and for alliances with firms from emerging economies, the effect of firm size is broadly in line with the understanding that small and medium sized firms have a much stronger ‘local’ orientation in alliance formation or a smaller propensity to form technology alliances in general: both the large firm and very large firm dummy variables are significant and positive, with the coefficient for very large firms substantially larger than the coefficient for large firms. Affiliates of EU multinationals are less likely to establish alliances with developed country firms, perhaps because alliance formation is centralized at EU headquarters. The coefficient of the second period (2004-2008) dummy is significantly negative in the model examining alliances with developed countries, reflecting the fall in the number of alliances with firms from these countries. In

contrast, the second period dummy variable is positive and significant in the model explaining alliance formation with firms from emerging economies, demonstrating a strong positive trend in alliance formation across European firms. Both the set of home country dummies and industry dummies (not shown) are jointly significant, indicating systematic country and industry variation in the propensity to form alliances.

If we examine the effects of prior alliance engagement (columns 2 and 4 in Table 5) we see that alliance experience in a given region—in both emerging and developed countries—has a strong positive impact on alliance formation with that region. This is indicative of a *persistence effect* of prior collaboration and collaborative experience that is similar across. The results also show a strong pattern of *interrelation*: prior alliance formation with partners from developed economies increases the propensity to engage in technology alliances with partners from emerging economies, and vice versa. The coefficients are smaller than the coefficients of the persistence effects, but they are of a comparable magnitude for both emerging country and developed country alliance formation. These results suggest that firms increase the geographical diversity of alliance portfolios driven by a broadening of alliances portfolios to involve both developed countries and emerging economies. General international alliance experience (the frequency of past international alliance formation) does have a positive impact on both types of new alliance formation, with the effects being slightly larger for alliance formation with developed country partners. In contrast, home country alliance experience does not exert a significant impact, suggesting that it is cross-border alliance experience that is the most relevant for expansion of alliance portfolios into emerging economies. Chi square tests comparing the explanatory power of models (1)-(2) and (3)-(4) indicate that the inclusion of the prior alliance variables significantly improves the fit of the model.

In an extension of the analysis, we examine the determinants of alliance formation with partner firms based in the two most important emerging economies with the most frequent involvement in international technology alliances: India and China. The results are presented in Table 6. The results again show that large and very large firms have a greater propensity to form technology alliances. In case of alliance formation with partners from India, however, there is no significant difference between small and medium sized firms and large firms. The persistence effect (columns 2 and 3) is strong and significantly positive for China, but prior alliance engagement in India does not have a significant influence on new alliance formation there. The latter may be partly due to the fact that very few firms in the sample period had prior alliance experience with Indian partner firms, since European alliances with India were not common until recently. As to the evidence on interrelationships, the results show no significant effect of experience in developed countries in general. If we apply a more fine-grained decomposition of alliance experience, on the other hand (columns 3 and 6), we observe that past alliances with Japanese firms significantly increase the propensity to form alliances with both Chinese and Indian firms. In addition, emerging country experience (excluding China and India) increases the propensity to engage in alliances with Indian firms, while Indian experience increases the propensity to engage in alliances with Chinese firms. Chi square tests comparing the explanatory power of models (1)-(3) and (4)-(6) indicate that the inclusion of the (fine-grained) prior alliance variables significantly improves the fit of the model.

The results can be interpreted as follows. While alliance diversification into emerging economies offers new opportunities for European firms, such a strategy involves considerable risk due to unfamiliarity with the region and the business practices of local firm. As a result, firms most prepared to form alliances with firms from emerging economies like China or India are those that have alliance experience in the developed country located in Asia (Japan),

from which Asian investment strategies can be implemented and which has some basic commonalities in business practices and culture. Similarly, earlier alliance experience in emerging countries in the Asian region facilitates alliance formation in India and China.

7. CONCLUSION AND DISCUSSION

Rapidly rising competitive pressures from globalization and the ensuing search for broader sources of new knowledge have increased the internationalization of R&D and external knowledge acquisition in general and directed these towards emerging economies in particular. While international technology alliances are a well known (quasi-market) mechanism to gain such external knowledge, very little is known about its application by Western firms in emerging economies.

In this paper, we examined the trends and patterns in international collaborative R&D arrangements through strategic technology alliances and joint ventures by firms based in Europe, and analyze the factors driving alliances with partner firms in emerging economies. We draw on the extensive database on alliance available from SDC containing more than 50,000 technology alliances established by European firms.

Since the early 1990s, emerging-economy firms led by Chinese firms have become important partners of European firms' technology alliance activity. In the most recent period (2004-2008), the number of alliances with Indian firms increased rapidly, surpassing the number of alliances established with Chinese firms. Technology alliance activity by European firms is distinctly international and externally oriented, with on average around 50% of alliances formed with partner firms outside of the Europe and about 75% outside of the home country. The shares of emerging economy firms as partners have risen to more than a quarter in 2004-2008.

In a multivariate analysis, we examined the determinants of alliance formation with firms based in emerging economies, and compared these to the determinants of alliance formation with firms from developed countries. We focused on the role of alliance experience in the same region (*persistence*) and alliance experience in other regions (*interrelationship*) in alliance formation. Our sample consists of more than 1800 European firms engaged in international technology alliance activities and we analyzed the number of alliances established in two periods, 1999-2003 and 2004-2008, taking into account factors such as firms' sector, size, ownership and country of origin.

The results of the multivariate analyses confirmed our expectations about the influence of persistence and interrelation in international alliance activities. First, there is evidence of persistence in alliance strategies with partners from both emerging economies and developed countries, with a comparable magnitude. Second, prior alliance activity in developed countries increases the propensity to engage in alliance activity in emerging economies, and this effect is observed vice versa. Hence, firms extend their alliance portfolio across both developed and emerging economies, increasing the geographic diversity of their alliance portfolio and building on their prior international alliances in both regions. In an extension of the analysis focusing on alliance formation with Chinese and Indian firms, we find that persistence effects are limited to alliances with Chinese firms. Lack of persistence in alliances with India may be because alliances with Indian firms are only a recent phenomenon. Results on interrelationships are more nuanced, in the sense that not all developed-country alliance experience, but only prior alliance engagement with Japanese firms enhances the alliance propensity with Chinese and Indian firms.

The results on the interrelationship between developed country and emerging country alliances are indicative that firms see the diversity benefits of broader alliance portfolios as superseding any conflict in alliance portfolios (Wassmer, 2009). This also suggests that there

is no substitution of technological collaboration within developed economies by technological collaboration with partners from emerging economies – an issue that may reassure policymakers in Europe emphasizing the importance of intra-EU R&D partnerships. Our results are in line with the notion that the rise of alliance formation with partner firms in emerging economies is a search for complementary knowledge and expertise, which is likely to lead to an increase in alliance portfolio diversity. Given that emerging country firms are less often at the frontier of technology development, this knowledge is likely to be more applied in nature and related to technology adaptation to increase the chances of success in exploiting technology advantages in emerging economies.

The findings on the specific role of prior alliance experience with Japanese partners in alliance formation with Indian and Chinese firms is in line with the recognition in the alliance literature that similarities in management culture and practices play an important role in the choice of partners (Geringer, 1991; Dacin, et al, 1997; Zutshi and Tan, 2009). Thus, our results are consistent with this view in that region-specific experience and knowledge exert an important influence in the choice of partners as European firms expand their alliance portfolio into emerging economies.

More generally, our findings are in line with the idea that there is persistence in, and interrelation between, alliance strategies with different partner types. Whereas this has been demonstrated for vertical collaboration (i.e. with customers and suppliers) and for horizontal collaboration (i.e. with competitors) (Belderbos et al., 2011), our findings indicate that this also applies when distinguishing between partner types from developed and emerging economies. In this way, we contribute to the literature by shedding some more light on how diversity in alliance portfolios comes into being. Whereas there is growing agreement in the alliance portfolio literature that diversity carries positive performance effects (e.g. Lavie and Miller, 2008), how such portfolio diversity originates remains an underaddressed issue in the

literature thus far (Wassmer, 2010). Here, our study demonstrates that prior international alliance experience, be it in either developed economies, emerging economies or both, forms an important antecedent for growing diversity in a firm's alliance portfolio.

The findings of the study also provide interesting suggestions for further research. First, the analysis can be expanded to include a wider range of firm characteristics and host and home country factors. Inclusion of a wider range of firm characteristics such as R&D intensity would however reduce the sample substantially as our large sample of firms includes many unlisted companies for which such data are unavailable. Expansions of the analysis to a broader set of individual partner countries would allow studying the role of home and host country characteristics in alliance formation, such as the relative technological capabilities and market opportunities. Second, future work should examine the performance consequences of alliance formation with emerging economy partners, and the increased diversity of alliance portfolios. Prior work has related innovativeness to a more diverse portfolio of international alliance partners (Duysters and Lokshin, 2010; Lavie and Miller, 2008). Given the potentially specific nature of technology alliances with firms based in emerging economies related to the relatively lower level of technological capabilities of such partner firms, the impact on innovative performance is an interesting subject of research. Third, the relationship with other external technology sourcing strategies, in particular M&A activity, as a possible complement or substitute for technology alliance activity would be a fruitful subject of examination. We envisage further analysis to examine the complex impact of this portfolio of (international) technology sourcing strategies in terms of instruments and partners, on effective innovation and market outcomes.

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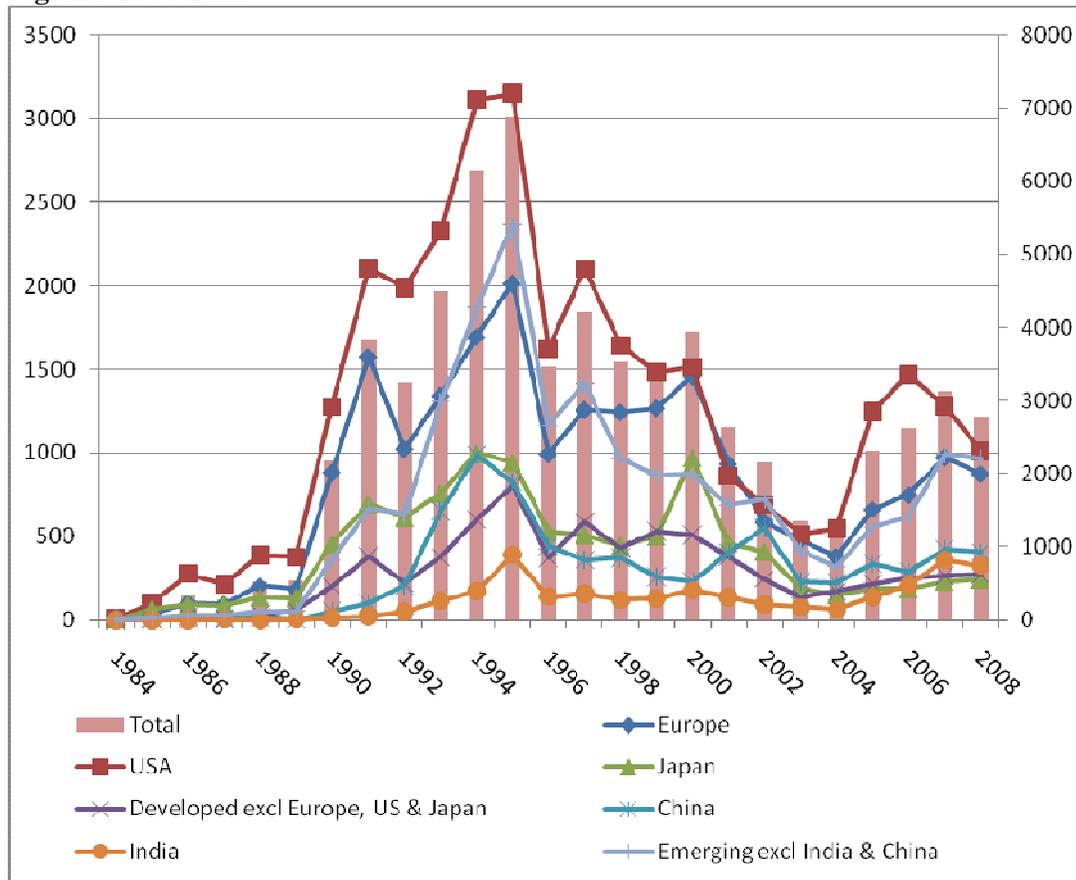
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Figure 1. Global trends in technology alliances. Number of alliances of firms - by major regions: 1984-2008



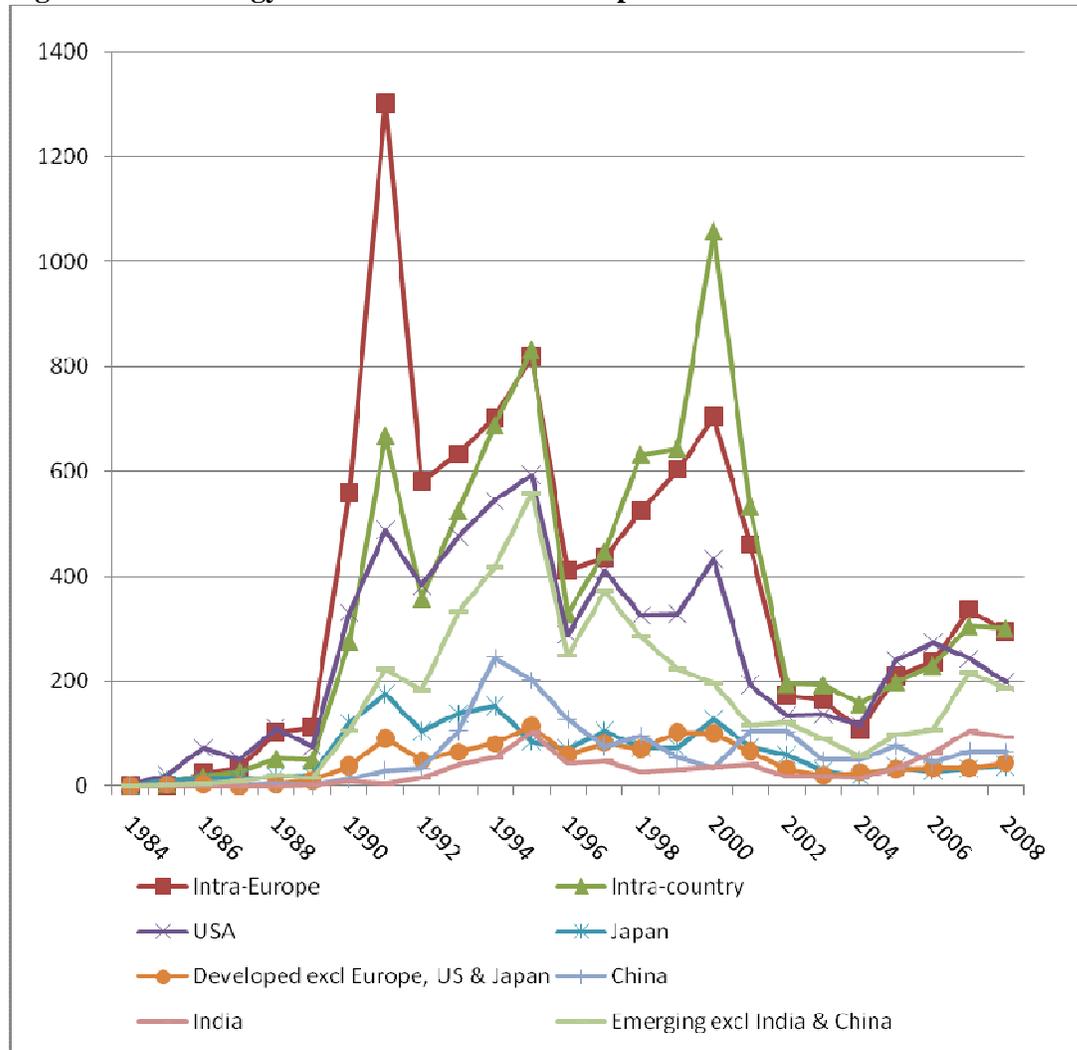
Note: Total alliance is measured on the right Y-axis; other alliance numbers on the left Y-axis. The total of regional alliances can be higher than total number of alliances if alliances involve firms located in more than one region.

Table 1. Global trends in technology alliances, by major regions: percentage share of firms

Period	1984-1988	1989-1993	1994-2008	1999-2003	2004-2008
Developed countries, of which	92.84	82.05	69.52	73.29	65.14
Europe	21.83	24.38	19.05	23.68	19.54
USA	50.19	40.12	33.65	24.17	34.38
Japan	17.46	11.99	9.45	16.77	5.42
Excl Europe, US & Japan	3.36	5.56	7.36	8.67	5.80
Emerging economies, of which	7.16	17.95	30.48	26.71	34.86
China	1.87	3.89	6.95	7.30	9.20
India	0.22	0.75	2.17	2.65	5.44
HongKong	0.52	1.52	1.96	2.46	3.09
Malaysia	0.11	1.36	3.53	1.75	2.69
Singapore	0.15	1.20	2.65	3.07	2.57
Russia	0.07	1.11	1.26	0.72	1.61
South Korea	1.42	1.24	1.63	1.86	1.15
Thailand	0.04	0.69	1.84	0.83	1.09
Brazil	0.19	0.22	0.52	0.58	0.70
South Africa	0.00	0.30	0.72	0.39	0.49
Excl top 10 emerging countries	2.57	5.66	7.26	5.10	6.83
Total	100.00	100.00	100.00	100.00	100.00

Note: Emerging economies sorted in decreasing order of importance based on their 2004-2008 share in total alliances.

Figure 2: Technology Alliance Partners of European Firms: 1984-2008



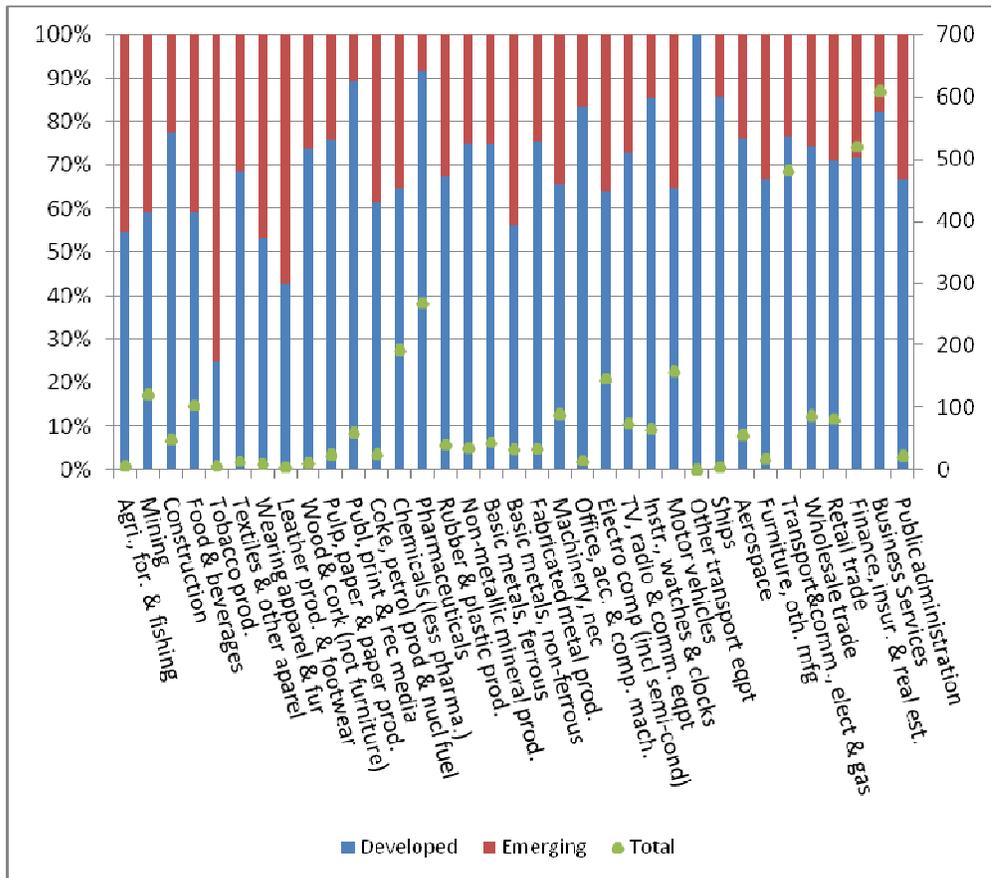
Note: Intra-country is alliances with firms from the same home country, and Intra-Europe is alliances with firms from other European countries. Values reflect the total number of alliance partners from each region.

Table 2. Technology Alliance Partners of European Firms: percentage in total

Period	1984-1988	1989-1993	1994-2008	1999-2003	2004-2008
Developed-countries, of which	75.93	65.81	50.52	51.01	51.00
Domestic (intra-country)	16.77	21.46	24.85	33.30	23.59
Intra-Europe	25.62	36.45	24.56	26.74	23.43
USA	39.60	20.05	18.36	15.58	21.18
Japan	8.85	6.41	4.14	4.60	3.03
Excl Europe, US & Japan	1.86	2.91	3.47	4.08	3.36
Emerging economies, of which	7.30	12.73	24.62	15.69	25.41
India	0.00	0.81	2.33	1.84	6.13
China	1.71	2.08	6.32	4.39	6.08
Russia	0.16	1.61	2.41	1.01	2.61
Hong Kong	0.47	0.57	1.00	0.70	1.03
Singapore	0.16	0.48	1.16	0.85	0.77
South Korea	0.93	0.57	1.01	1.08	0.67
Brazil	0.16	0.14	0.54	0.90	0.57
Malaysia	0.47	0.65	1.64	0.65	0.53
South Africa	0.00	0.19	0.72	0.37	0.49
Thailand	0.00	0.54	1.21	0.24	0.44
Excl top 10 emerging economies	3.26	5.08	6.28	3.67	6.08
Total	100.00	100.00	100.00	100.00	100.00

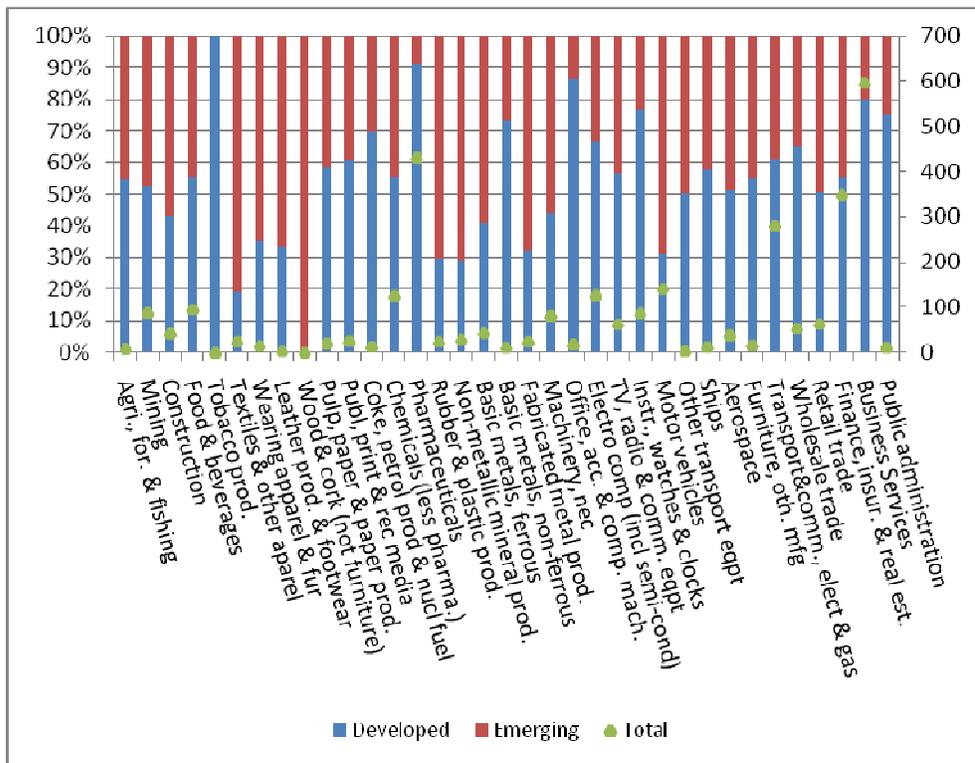
Note: Intra-country is alliances with firms from the same country, and Intra-Europe is alliances with firms from other European countries. Emerging economies are sorted in decreasing order of importance based on their 2004-2008 share in total European technology alliances.

Figure 3a: Sectoral Patterns of EU International Technology alliances with Developed Countries and Emerging Economies: 1999-2003



Note: Total alliance is measured on the right Y-axis; percentage share of developed economies and emerging economies in total alliances per sector on the left Y-axis. EU intra-country alliances are excluded in this graph.

Figure 3b: Sectoral Patterns of EU International Technology alliances with Developed Countries and Emerging Economies: 2004-2008



Note: Total alliance is measured on the right Y-axis; percentage share of developed economies and emerging economies in total alliances per sector on the left Y-axis. EU intra-country alliances are excluded in this graph.

Table 4. Descriptive Statistics

Variables	Mean	Std.Dev	Min	Max	Sum	Firms
<u>Dependent Variables</u>	-	-	-	-	-	
Alliances in:						
Developed economies	1.506	2.047	0	33	3,320	1622
Emerging economies	0.538	1.070	0	14	1,187	691
China	0.148	0.501	0	6	327	216
India	0.0884	0.341	0	4	195	161
<u>Explanatory Variables:</u>						
Alliance Experience in:						
<i>Developed economies</i>	<i>0.283</i>	<i>0.450</i>	<i>0</i>	<i>1</i>	<i>623</i>	<i>510</i>
Home country	0.186	0.389	0	1	410	361
Intra-Europe	0.186	0.389	0	1	410	370
USA	0.156	0.363	0	1	344	293
Japan	0.0694	0.254	0	1	153	130
Excl. Europe, US & Japan	0.0508	0.220	0	1	112	107
<i>Emerging economies</i>	<i>0.151</i>	<i>0.359</i>	<i>0</i>	<i>1</i>	<i>334</i>	<i>280</i>
China	0.0667	0.250	0	1	147	125
Excl China	0.127	0.333	0	1	279	244
India	0.0272	0.163	0	1	60	58
Excl. India	0.146	0.353	0	1	321	269
Excl. India & China	0.118	0.323	0	1	261	228
<u>Control Variables</u>						
Total International Alliance experience	1.305	4.207	0	108	2,877	558
EU MNC	0.0531	0.224	0	1	117	113
SMEs	0.190	0.393	0	1	420	401
Large firm	0.294	0.456	0	1	648	590
Very Large firm	0.516	0.500	0	1	1,137	947
period dummy (2004-2008)	0.446	0.497	0	1	983	983

Table 5. Drivers of EU firms' alliances with partners from Developed and Emerging economies

Dependent variable	(1) Developed	(2) Developed	(3) Emerging	(4) Emerging
Constant	0.0492 (0.228)	-0.0732 (0.197)	-0.853*** (0.237)	-0.972*** (0.220)
Non-EU MNC	-0.209 (0.154)	-0.0759 (0.151)	-0.336* (0.184)	-0.166 (0.178)
EU MNC	-0.244*** (0.0710)	-0.106 (0.0706)	-0.191 (0.160)	-0.0432 (0.160)
Large firm	0.127* (0.0735)	0.0279 (0.0611)	0.243** (0.118)	0.166 (0.115)
Very Large firm	0.555*** (0.0775)	0.286*** (0.0654)	0.861*** (0.110)	0.615*** (0.112)
period 2004-2008	-0.280*** (0.0495)	-0.213*** (0.0490)	0.304*** (0.0742)	0.364*** (0.0823)
Total international alliance experience		0.0238*** (0.00549)		0.0177*** (0.00583)
<i>Alliance Experience in:</i>				
Developed- economies		0.400*** (0.0674)		0.203* (0.107)
Emerging-economies		0.160** (0.0808)		0.343*** (0.117)
Home country		0.106 (0.0752)		0.110 (0.0967)
home country dummies	included	included	included	included
industry dummies	included	included	included	included
Observations	2,205	2,205	2,205	2,205
pseudo r-squared	0.0853	0.143	0.143	0.169
log likelihood	-3555	-3330	-2027	-1965
chi-2	665.63***	1115.9***	3117***	3567***

Notes: Cluster-robust standard errors in parentheses. Omitted firm size dummy is SME.

Table 6. Drivers of EU firms' alliances with partners from China and India

Dependent Variable	(1) China	(2) China	(3) China	(4) India	(5) India	(6) India
Constant	-2.400*** (0.410)	-2.493*** (0.421)	-2.459*** (0.417)	-3.346*** (0.538)	-3.448*** (0.550)	-3.551*** (0.555)
Non-EU MNC	-0.645* (0.389)	-0.378 (0.374)	-0.359 (0.371)	-0.200 (0.404)	-0.105 (0.400)	-0.0878 (0.399)
EU MNC	-0.250 (0.330)	-0.0771 (0.331)	-0.0652 (0.329)	0.304 (0.367)	0.419 (0.369)	0.448 (0.377)
Large firm	0.495* (0.270)	0.427 (0.267)	0.442* (0.267)	0.301 (0.260)	0.280 (0.262)	0.315 (0.262)
Very Large firm	1.340*** (0.238)	1.068*** (0.245)	1.069*** (0.244)	0.615*** (0.231)	0.468* (0.241)	0.466* (0.242)
period 2004-2008	0.312** (0.131)	0.400*** (0.135)	0.392*** (0.137)	1.157*** (0.169)	1.193*** (0.169)	1.185*** (0.168)
Total International alliance experience		0.0166*** (0.00406)	0.0123*** (0.00403)		0.0244* (0.0130)	0.0214 (0.0150)
<i>Alliance experience in:</i>						
Developed economies		0.102 (0.192)			-0.0912 (0.204)	
Intra-Europe			0.00217 (0.199)			0.0670 (0.219)
USA			0.104 (0.218)			-0.135 (0.219)
Japan			0.406* (0.218)			0.498** (0.241)
Developed excl Europe, US & Japan			-0.200 (0.216)			-0.399 (0.361)
China		0.589*** (0.219)	0.510** (0.242)			-0.257 (0.352)
Emerging excl China		0.206 (0.204)				
India			0.386* (0.232)		-0.0824 (0.376)	-0.121 (0.359)
Emerging excl India					0.306 (0.240)	
Emerging excl India & China			0.0806 (0.225)			0.478** (0.228)
Home country		-0.0125 (0.173)	-0.0671 (0.193)		0.234 (0.203)	0.183 (0.207)
home country dummies	included	included	included	included	included	included
industry dummies	included	included	included	included	included	included
Observations	2,205	2,205	2,205	2,205	2,205	2,205
pseudo r-squared	0.184	0.210	0.214	0.146	0.155	0.162
log likelihood	-840.7	-813.6	-809.3	-590.7	-584.6	-579.9
chi-2	12860***	30807***	30607***	16164***	17033***	16727***

Notes: Cluster-robust standard errors in parentheses. Omitted firm size dummy is SME.

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