The role of cumulative alliance experience and frequent engagement in alliances in firm innovation: An analysis of the UK Bio-pharmaceutical Sector

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Abstract
We explore the multifaceted role of alliance experience in firm innovation. Using panel data and a case analysis, the paper argues that while cumulative alliance experience has a marginally diminishing contribution to likelihood of firm innovation, frequent engagement in alliances plays an enhancing role. An exploratory case analysis shows a link between frequent engagement in alliances and the development of processes for alliance management which can collectively reflect alliance capabilities. Our contribution derives from a longitudinal analysis of an original dataset that maps the UK-biopharmaceutical sector over the initial period of its development and by shedding light on the factors that can compel firms to form alliance capabilities.

Jelcodes: M19, Z00
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Keywords: Strategic Alliances, Alliance Capabilities, Firm Innovation, Panel Data, Bio-Pharmaceutical Sector

JEL Codes: C33, M10, O32, D74
1. Introduction

As the popularity of strategic alliances has increased and such alliances have become an integral component in business development, attention in the research community has moved towards an exploration of their role in firm performance and innovation. Formal and informal interactions with external actors, have long being argued to play a fundamental role in firm innovation (Chesbrough, 2006; Colombo et al., 2011; Frankort et al., 2012; von Hippel, 1988). However, it is accepted that alliances carry coordination costs and risks of misappropriation, and these frequently diminish chances of success or preclude full acquisition of anticipated benefits (de Man & Duysters, 2005). A body of literature finds a positive relationship between alliance extent and firm innovation performance, and other work identifies diminishing and even negative returns (Hoang & Rothaermel, 2005; Rothaermel & Deeds, 2006; Sampson, 2005). As a result, a strand in the literature examines the factors that can impact firm effectiveness in benefiting from alliances (Schreiner et al., 2009). Extent literature has attempted to explain cross-firm variation in alliance performance by exploring the role of alliance experience accumulation and the effectiveness of specific practices and routines for alliance management (for example, the establishment of dedicated alliance functions) that reflect alliance capabilities (Heimeriks & Duysters, 2007; Kale et al., 2002; Kale & Singh, 2007; Kale & Singh, 2009; Sampson, 2005). However, much the greater part of current theorising has been constructed via the use of cross-sectional data, and this has restricted analysis of the factors that might influence improvements in firms’ abilities to benefit from alliances over time.

Based on a unique longitudinal firm level dataset, this paper makes several contributions by investigating the alliance experience – innovation performance association from various
angles. First, mirroring consideration of the role of experience in relation to other organisational activities, we explore whether cumulative alliance experience makes a marginally diminishing contribution to the likelihood of firm innovation over time. Second, on the basis of our longitudinal approach, we are able to examine how frequent engagement in alliances impacts on the likelihood of firm innovation over time: here, we offer a dynamic approach that is lacking in the current literature (Draulans et al., 2003; Rothaermel and Deeds, 2006). Further, we establish a link between frequent engagement in alliances as a factor compelling firms to establish standardised practices and routines for alliance management and the creation of alliance capabilities. The latter sheds more light on the factors that could underpin development of such capabilities that goes beyond current understanding resonating on experience accumulation.

Our arguments are explored in the context of a unique, bespoke and specially assembled dataset. The dataset comprises all of the 110 firms to be found in the UK bio-pharmaceutical sector in the period 1991 to 2001. The paper uses longitudinal econometric analysis available for panel datasets to empirically explore its hypotheses. Secondary (and complementary) to the econometric analysis, the paper also deploys a case analysis to shed more light on the link between frequent engagement in alliances and the content of alliance capabilities.

The remainder of this paper is structured as follows. Section 2 sets-out the theoretical background to the study. Sections 3 and 4 review the existing literature relating to the roles of alliance experience accumulation and alliance capabilities in shaping firm returns from alliances. These sections also present our empirical hypotheses. Section 5 discusses our sample, data sources, and methodological considerations, and details the variables
identified in our empirical research. Section 6 is dedicated to estimation and results.

Section 7 presents our results and corroborates core arguments via the use of case study material. Section 8 presents our conclusions and highlights some of the implications of the study.

2. Theoretical Background

To explain heterogeneity with respect to firm’s abilities to benefit from alliances, the alliance literature resonates with knowledge and capability based theories of the firm (e.g. Kogut and Zander, 1992; Helfat and Peteraf, 2003). Here, we adopt a perspective informed by both evolutionary theory of the firm (Nelson & Winter, 1982) and dynamic approaches to the resource based view (RBV) (Helfat & Peteraf, 2003; Helfat et al., 2007). These theory-based approaches take a dynamic view of organisational development, emphasising the role of experience and knowledge accumulation in supporting improved management and coordination of organisational tasks and activities. Given their dynamic and longitudinal orientation such theoretical perspectives are closely aligned with our own analytical approach informing our exploration of the roles of experience accumulation and frequent engagement in alliances in firm alliance capability development, as this is observed on enhanced likelihood of firm-level innovation.

Evolutionary theory argues that by repetitively engaging in organisational tasks, organisations gradually create routines, or semi-automatic patterns of action that guide coordination of actions and activities (Nelson and Winter, 1982). In turn, organisations experience efficiency improvements as they engage in an autonomous process of learning-by-doing, and ultimately develop capabilities in the management of organisational activities.
As firms follow different paths in accumulating and developing experience, heterogeneities develop across firms in their capabilities to carry out similar organisational activities. Organisational capabilities are higher order routines and explain cross-firm variation in competitive advantage (Winter, 2000; 2003); they have been defined as: ‘...a fairly large-scale unit of analysis, one that has a recognizable purpose in terms of the significant outcomes is supposed to enable, and that is significantly shaped by conscious decision both in its development and deployment’ (Dosi et al., 2000: 4; Winter, 2000; 2003).

Capabilities are founded on experience accumulation, but both evolutionary theory and dynamic RBV recognise that there can be a deliberate and conscious process of organisational learning, as firms make investments in time, resources and other efforts to further improve their capabilities (Zollo & Winter, 2002). Dynamic capabilities refer to the aggregate set of processes and practices used to improve existing capabilities with the view of sustaining competitive advantage (e.g. Teece & Pisano, 1994), while organisational capabilities can be improved even in the absence of dynamic capabilities, through reflection on newly acquired experience (Helfat & Peteraf, 2003).

Dynamic approaches to RBV suggest that an evolutionary path to organisational capabilities exists with capabilities emerging and improving through several developmental stages (Helfat & Peteraf, 2003). First, comes a ‘capability founding’ stage: organisations realise the need to develop a capability to meet a desirable objective and to orchestrate joint organisational action to assist in meeting such objectives. Second, is a ‘capability development’ stage: improvements to capabilities arise from a range of factors, including further experience accumulation, investments in capital, organisational processes and learning mechanisms. Experience accumulation is crucial to both ‘founding’ and
‘development’ stages of a capability development. A third stage of ‘capability maturity’ is also identified, during which capabilities may be replicated, retrenched, renewed, redeployed or recombined with other capabilities. In the following we revisit the literature on strategic alliances and firm performance and embarking from the above theoretical platform, we argue that the extant literature has not explicitly considered the extent to, and means by which frequent engagement in alliances can potentially underlie the development of alliance capabilities within firms.

3. Alliance Experience and Firm Returns from Alliances

Alliance experience accumulation has been identified as a fundamental antecedent to alliance capability (for a review, see for example Kale and Singh, 2009). It can improve firms’ abilities to derive benefits from alliances, allowing them to build capability in terms of coordinating inter-organisational relationships and joint tasks, cross-partner knowledge sharing arrangements, dealing with unforeseen contingencies in alliances, and identifying ways to overcome and resolve inter-partner conflict (Anand & Khanna, 2000; Rothaermel & Deeds, 2006; Sampson, 2005). Alliance experience is found to enhance the performance of alliances between recurrent partners, as firms use their experience and routines developed during first interactions to manage their subsequent collaborations (Zollo et al., 2002). Partner-specific experience is found to have greater returns on firm performance compared to general (i.e. non-partner specific) alliance experience (Gulati et al., 2009). However, other evidence suggest that firms can use experience and lessons gained from joint ventures with one partner to improve their alliance management practices in joint ventures with
different partners (Anand & Khanna, 2000). Similar findings are also reported for other types of alliances with respect to firm innovation outputs (Sampson, 2005).

Consistent with arguments explicated above, we argue that alliance experience accumulation will have a positive effect on a firm’s likelihood of innovation. Relationships with external partners have long being recognised as stimulating firm innovation (e.g. von Hippel, 1988), while recent contributions to the innovation literature argue that such relationships and alliances might form the main locus of firm innovation activities (Chesbrough, 2006; Powell et al., 1996). We argue that by accumulating alliance experience, firms gradually establish more fruitful conditions for effective knowledge sharing with their partners, and generate a basis for circumventing or resolving alliance conflicts. Effectiveness of communication between a firm and its alliance partners allows firms to exchange, share and combine knowledge from alliances, and thus increase the likelihood of innovation.

**Hypothesis 1: Alliance experience accumulation positively affects a firm’s likelihood of innovation**

The above resonates with the literature on experience or learning curves (e.g. Dutton & Thomas, 1984; Lieberman, 1984) and the transferability of the principles of organisational learning to other organisational tasks (Argote et al., 1990; Levitt & March, 1988) and to other tasks with a high varied component such as alliances where different partners may be involved. This literature suggests that there are limits to the extent of efficiency improvements arising from experience accumulation with its effect on innovation performance tapering-off (e.g. Lieberman, 1984). One likely explanation for this is that the
value of lessons learned from cumulative experience depreciate over time as knowledge becomes increasingly obsolete (e.g. Argote et al., 1990). Past knowledge may depreciate as task requirements change over time. Further, past lessons may dissipate as a result of employee turnover or a failure to store intelligence in a way that might permit its re-application or embedding in organisational routines and practices (Dutton & Thomas, 1984; Levitt & March, 1988).

Research in the alliance literature has demonstrated a positive and linear relationship between alliance experience and firm-level indicators of financial (Anand & Khanna, 2000) and innovation performance (Shan et al., 1994). Only a slim body of work explores diminishing returns to alliance experience. Hoang and Rothaermel (2005) find alliance experience of small firms to positively impact the performance of their joint projects with large firms, but the alliance experience of large firms has no significant effect on their joint alliance project performance. The benefits of alliance experience differ between such firms as a result of their positioning at different points along the alliance experience curve. In a similar vein, Sampson (2005) studies diminishing returns to cumulative alliance experience in the telecom equipment industry, and provides empirical evidence (connected with patenting performance) to support the notion that the value of cumulative alliance experience depreciates over time.

Embarking on this literature we propose that there is a gradually diminishing contribution of cumulative alliance experience, reflecting autonomous learning, to enhancing the efficiency of knowledge exchanges in alliances. This can be due to a range of reasons. Unless firms make appropriate investments in retaining and leveraging lessons learned from their experience, its effects will increasingly dissipate. Moreover, past lessons concerning the
management of alliances may be of diminishing relevance with respect to current alliances: firms tend to establish alliances on different areas, activities and with different partners over time, and inevitably encounter different challenges in the progression of their alliance partnerships. As a consequence, we derive the following hypothesis:

**Hypothesis 2: The effect of cumulative alliance experience on likelihood of innovation exhibits diminishing marginal returns: as alliance experience accumulates, its contribution to the likelihood of firm innovation decreases**

4. **Alliance Capability Development**

Deciphering, coding and measuring capabilities is notoriously difficult (Godfrey & Hill, 1995). Perhaps as a result, the alliance literature has, in the main, paralleled the existence of alliance capabilities with practices for alliance management (Kale et al., 2002; Kale & Singh, 2007; Kale & Singh, 2009). A notable exception is found in the work of Rothaermel and Deeds (2006). They explore the existence of an inverted U-shaped relationship between cumulative alliance experience and new product development. They argue that, as the inflection point of the inverted U-shaped curve corresponds to the level of experience beyond which firms start experiencing inefficiencies in alliance management, it can reflect the level of alliance capability.

A stream within the alliance literature explores the link between cumulative alliance experience, the development of dedicated alliance management functions, and other processes and practices for upgrading alliance management routines (Kale et al., 2002; Heimeriks and Duysters, 2007; Kale and Singh, 2007). This relationship can be rather complex. Some evidence suggests that the effect of dedicated alliance functions on firm
success from alliances is over and above that of cumulative alliance experience, suggesting a complementing relationship between the two (Heimeriks & Duysters, 2007). Other research suggests that dedicated alliance functions embody and absorb firm experiential learning in alliances and become a mechanism for leveraging cumulative alliance experience (Kale et al., 2002). This indicates a direct link between experiential learning and firm investments in specialist processes for deliberate learning and capability development in alliances, such as dedicated alliance functions.

Kale and Singh (2007) were the first to detail how firms proactively learn from their alliance experience by externalising, codifying, diffusing and internalising individual and group-level alliance know-how. Alliance practices are also internalised through training, mentoring programmes and external consulting. Such learning processes aim at introducing new alliance management practices and/or at improving existing ones in response to dissatisfaction with existing performance (Zollo & Winter, 2002).

The notion that the presence of a dedicated alliance function reflects the presence of firm-specific alliance capabilities has being challenged in recent literature. First, anecdotal evidence suggest that firms establish dedicated alliance functions only after a lengthy engagement in alliances, and after initiating a substantial number of agreements (Kale & Singh, 2009), and therefore such functions cannot reflect alliance capabilities, particularly when capabilities are at the initial stages of their development. Some research indicates that firms – especially those motivated by perceived market signaling requirements – may establish dedicated alliance functions as a result of mimeticism or isomorphism (Heimeriks, 2010). Indeed, isolated mechanisms for the institutionalisation of learning from cumulative alliance experience (e.g. dedicated alliance functions), may prove to be less effective than
mechanisms designed to integrate and embed alliance knowledge and experience into the organisation (Heimeriks, 2010).

Despite some tentative and tangential work, extant literature doesn’t explore the underlying reasons that can lead firms to realise the need to leverage their alliance experience in developing a capability and to engage efforts and resources in processes for deliberate learning from alliances. We contend that frequent engagement in alliances can be one underlying factor and we turn to evolutionary theory and dynamic RBV to assist in elaborating our argument. Specifically, we suggest that frequent engagement in alliances may compel firms in founding an alliance capability development lifecycle (Helfat and Peteraf, 2003). By engaging in alliances frequently, firms expand, augment and renew their stock of cumulative alliance experience. Frequent engagement in alliances induces firms to invest in developing higher order routines and practises to initiate purposeful and directed organisational learning. Developing processes for alliance management and practices for their further improvement requires managerial commitment, commitment that is highly demanding in terms of time and employee resources (Dosi et al., 2000; Winter, 2000; 2003). As a result, firms need to justify the allocation of resources to building dedicated routines for alliance management: frequent task reoccurrence can trigger and motivate firms to engage resources in such a direction, justify investments to external stakeholders building momentum for internal support and commitment.

The role of frequent engagement in alliances in developing alliance capabilities remains little explored in empirical literature, as there is a dearth of longitudinal studies (Draulans et al., 2003; Rothaermel & Deeds, 2006). At the cross-sectional level, there is only limited research that links expanding alliance portfolios to the development of alliance capability, as
it can be reflected in alliance management practices. Expanding alliance portfolios are
associated with the use of more alliance management practices and processes, and these in
turn, are linked to higher firm performance (Heimeriks et al., 2009). Our longitudinal
approach, capturing the tendencies of firms to engage in alliances more frequently over
time, complements such accounts which are based on the role of stock measures of alliance
experience in firm performance (Kale et al., 2002; Heimeriks and Duysters, 2007; Kale and
Singh, 2007).

Therefore we propose that firms that engage in alliances frequently are more likely to
innovate compared to those firms that (a) engage in alliances irregularly or sporadically, or
that (b) retain a static engagement in alliances over time. Firms engaging in alliances more
frequently over time have a stronger motivation to improve the efficiency of their alliances,
making them more likely to recoup innovation returns from alliances.

**Hypotheses 3:** Frequent engagement in alliances positively affects the likelihood of
firm innovation over time

5. Sample and Methods

*Sample*

We test our hypotheses on a sample of 110 firms drawn from the UK bio-pharmaceutical
sector in the period 1991 to 2001. The period 1991 and 2001 is perceived to be particularly
apposite for our analysis as it exhibits several critical features: a) a general upsurge in
alliances (not only in the UK bio-pharmaceutical sector, but also in other sectors and
territories (Kang & Sakai, 2000), b) the emergence of alliances as an integral component in firm R&D strategies in the pharmaceutical industry (Hagedoorn, 2002; Powell et al., 1996), and c) the presence of significant variation - visible in terms of identifiable peaks and troughs in alliance activity - especially towards the end of the period (such variation is a feature of alliance activity reported by studies using other data sources (Hagedoorn, 2002) to those of this work). Moreover, as this marks the first period of intensive use of alliances it provides an apposite setting to explore the impact of cumulative alliance experience and of any factors underpinning the development of alliance capabilities during the very first instances of firms engaging with alliance. To identify our sample, we used two editions of the UK biotechnology directory (Coombs & Alston, 2000; 2002). The directory lists all firms in the sector that undertake research using biotechnologies, and it provides a more comprehensive account compared to the use of SIC classifications (Walsh, 2004). To construct our working sample, we used the ‘Who Owns Who’ directory to identify all firms that were active in 2003. We identified 110 firms that publish accounts in the FAME database².

For the sample of 110 firms, we collected data on alliances from ReCap.com and BioScan, the two most popular sources of alliance data in empirical research on this sector (e.g. Deeds & Hill, 1996; Schilling, 2009). These databases report alliances established in the biopharmaceutical sector for innovation purposes, including R&D alliances, research alliances, and alliances for technology licensing and product development³.

Innovation is crucial to firm prosperity and survival in the bio-pharmaceutical sector and patents are perceived as an appropriate proxy for innovations due to the strong links between this sector and the science base (e.g. Pavitt, 1984). Moreover, patents are an
appropriate indicator to capture firm-level returns from innovation related alliances (Sampson, 2005; Shan et al., 1994). We collected data on patents granted to the 110 firms in our sample between 1991 and 2001 by the UKPTO through the publicly-available database Esp@cenet; via use of boolean searches, a comprehensive list was assembled. Since our research focuses on UK-based firms, the UKPTO is perceived to be an appropriate source for the collection of patent data. Filing patent applications at national patent offices is less costly (in terms of application and renewal fees) and less time consuming when compared with international patent applications. As International applications also involve costs of unfamiliar IP regulations and legal frameworks, many firms - at least those with constrained resources - are more likely to patent at national patent offices than internationally (Archambault, 2002). Finally, information on firm accounts was obtained from FAME, and information on investments in R&D was gathered from Thomson’s Analytics and the UK DTI’s R&D Scoreboard.

Methods

The empirical exploration in this paper relies fundamentally on econometric analysis but the paper also employs a case study to shed further light on and nuance some of its arguments. However, the case analysis should be seen as secondary to the econometric components, and is included only as an illuminating complement. To explore the role of frequent alliance engagement in firm innovation (as reflected in firm propensities to patent), we employ discrete dependent variable models for panel data. Patents take positive integer values, making count dependent variable models, such as the Poisson and Negative Binomial, appropriate (Greene, 2003). We suggest that experiencing superior performance can be reflected in an increase in firm likelihood to patent, so since our main contribution is to
explore whether frequent alliance engagement is linked to the creation of alliance capabilities, we employ discrete dependent variable models as they are more suited to our objectives. In discrete dependent variable models, the dependent variable is a dummy variable that takes the value of one when an event occurs (gaining a patent in this case) and is set to zero otherwise. In such models one can capture the factors that affect the abilities of firms to perform over a threshold level, or to innovate (Long, 1997). Following other studies in the current literature that have explored the role of firm alliance experience on alliance project success (Hoang & Rothaermel, 2005) we employ the Logit model.

Due to the longitudinal dimension of panels, we can explore factors that affect firms’ changing abilities to innovate over time, as well as factors that can explain cross-firm variation in innovation abilities. This results from the two different specifications available for panels, i.e. fixed and random effects. The first relies on variation within-firms over time, and the second on a combination of ‘within’ and ‘cross-sectional’ variation in deriving its estimates. The former, *dynamic* consideration of panels is of particular interest in this paper, as it is desirable to capture information relating to whether frequent alliance engagement over time relates to substantial changes inside firms (i.e. changes that alter firm abilities, or likelihood of innovation). The fixed effects specification has a further appeal compared to random effects. Its estimates are not based on the assumption of strict exogeneity of the independent variables, as is the case for random effects (Baltagi, 1995; Greene, 2003). This is desirable, as one could argue that firm decisions to form alliances are not independent of past innovation outputs or other firm-specific unobserved factors that affect firm ability to innovate (Colombo & Garrone, 1996; Lavie et al., 2011).
To explore further the relationship between frequent alliance engagement and the development of alliance capabilities, we report on the findings of an in-depth case study that explores the link between frequency of engagement in alliances and the development of practices and processes to manage alliances as the latter may reflect alliance capabilities.

The case study focuses on a UK bio-pharmaceutical firm that has intensified its engagement in alliances particularly after the early 1990s when it started to invest in biotechnology R&D. The case study was conducted in 2005 and entailed detailed reflection on the factors that underpin the creation of practices, processes and structures, that were established with the view of improving efficiency in alliance management. The range of practices and processes identified were matched with those identified in existing literature on alliance capabilities (Heimeriks & Duysters, 2007; Kale et al., 2002; Kale & Singh, 2007; Kale & Singh, 2009). The case is based on interviews with senior managers (intellectual property and alliance directors) with expertise in alliances and in appropriating knowledge from alliances. Both senior managers have a long working experience with the case firm and the interviews focused on alliances that involve cooperation in research. All materials and associated analyses were reviewed and approved by the interviewees.

**Variables**

*Patents (dependent variable)*

To test our hypotheses we create a dummy variable that is equal to 1 for each firm that is granted a patent at year t (a zero is allocated otherwise). To track the firm’s innovation activities over time, we used patent filing dates. Filing dates have certain advantages over publication dates: first, they better reflect the time of originating innovations; and, second,
they are not influenced by regulatory changes or fluctuations in resource availability in patent offices over time, as these can delay publication dates (e.g. Jaffe, 1986). Patents are widely used to capture firm returns from innovation alliances (Hagedoorn & Schakenraad, 1994; Sampson, 2005; 2007; Shan et al., 1994). Discrete dependent variable models have been used to capture determinants of firm success from alliances (Hoang & Rothaermel, 2005).

**Alliance Experience**

Extensive research has explored the role of alliance experience in improving a range of outcome variables such as firm financial returns from alliances (Kale et al., 2002), alliance project success (Hoang & Rothaermel, 2005), returns to firm innovation performance (Sampson, 2005; 2007), and number of products under development (Deeds & Hill, 1996; Rotheaermel & Deeds, 2006). Studies have operationalised alliance experience as a stock variable reflected either by the cumulative number of alliances formed in a firm’s history (Hoang & Rotheaermel, 2005; Kale et al., 2002; Kale & Singh, 2007; Rotheaermel & Deeds, 2006), or by the cumulated number of years of engaging in alliances (Rotheaermel and Deeds 2006). Only a handful of these studies consider diminishing (Sampson, 2005) or non-linear (Rotheaermel & Deeds, 2006) relationships between alliance experience and firm returns from alliances and most studies base their estimates on cross-sectional data (an exception is Kale et al., 2002).

Following the thrust of existing literature, we operationalise alliance experience at each year \( t \) as the stock of the cumulative number of alliances that firms have entered since their first alliance. To aid interpretation of results, and following recent contributions (Lavie et al.,
we used one year lagged values of the above variable to more accurately capture the effect of cumulative alliance experience. Our variable is left-censored to 1991, the start year for our sampling. Left-censoring is experienced elsewhere in alliance literature (e.g. Kale & Singh, 2007) and, as discussed in our results section, should not pose serious problems: a greater importance is afforded to relatively current alliances rather than those that are more distant. This is in line with empirical evidence identifying that recent alliance experience makes a higher contribution to efficient alliance management compared to past experience (Sampson, 2005). Further, any potential problems associated with left-censoring are mitigated in our study as 87% of total alliances formed in our sample between 1979 and 2001 fall within the 1991-2001 period.

To explore diminishing returns to alliance experience we resonate to the literature on learning curves (Dutton & Thomas, 1984; Lieberman, 1984). As is customary in that literature, we use the natural logarithmic transformation of cumulative alliance experience to test hypothesis 2. This operationalisation is also adopted in related studies in the alliance literature (Sampson, 2005). As a robustness check, we use both the linear and quadratic values of the cumulative number of alliances: again, this approach has been employed previously in relevant alliance literature (e.g. Deeds & Hill, 1996; Rothaermel & Deeds, 2006).

**Frequent Engagement in Alliances**

To explore the effects of frequent engagement in alliances on firm abilities to innovate, we use a flow measure of the total number of alliances that a firm simultaneously manages at any point in time. As alliances last for several years, this requires information on alliance
duration. Such information is not provided by either of the alliance data sources used in this study (RECap.com and BioScan). As lack of information on alliance duration is a problem encountered in other work, we follow tradition established therein and rely on the average duration of alliances (five years) (see Gulati, 1999; Kogut, 1988). Therefore, we operationalise frequent engagement in alliances by calculating the number of alliances a firm manages at any given point in time by considering that alliances last on average for five years. Increases in this variable reflect the propensity of firms to engage more frequently in alliances over time, and on average, to initiate more alliances than they terminate. As the use of a blanket measure for alliance duration might be considered simplistic, we cross-validate this information with alliance managers within the sector, and they considered it an acceptable approximation for the duration of most alliances. We also performed some robustness checks which are detailed in our analysis.

Control Variables

For parsimonious empirical models, we use the most appropriate control variables that have been employed in the literature on alliances and innovation. First, we account for the effects of well-established indicators of firm innovation, such as investments in R&D and firm size (Griliches, 1990). Investments in R&D account for the degree that firms invest resources in innovation generating activities, which in turn can influence their abilities to innovate. We used a measure of R&D intensity that captures the amount of R&D expenditures per employee. Firm size is captured by annual turnover and we include a natural logarithm to overcome the possible problem of skewed distributions. Second, and following relevant research (Zollo et al., 2002), we account for differences in the content of alliances as such content could influence innovation opportunities in alliances affecting firm-
level performance outcomes (e.g. Anand and Khanna, 2000). Therefore, we include a dummy variable to account for alliances that involve R&D, as opposed to those focused on manufacturing or technology licensing. The dummy variable takes the value of one for each year that a focal firm establishes an alliance that involves R&D, and the value of zero for each year that a focal firm establishes alliances without an R&D component.

6. Estimation and Results

Table 1 presents descriptive statistics and bivariate correlations. There are high correlations between the variables capturing aspects of alliance experience. To avoid multi-collinearity our hypotheses are tested in separate models.

The panel data set is unbalanced, due to either missing information or the inclusion of less-mature dedicated biotechnology firms (i.e. a third of firms in the sample were established after 1991). The unbalanced dataset includes firms observed for a maximum period of 10 years and others for as little as 4 years. On average, every firm is observed for approximately 7 years (this ranges from 6.6 to 7.4 years across the three estimated models). Again, on average, the firms in our sample engaged in 9.87 alliances between 1991 and 2001, while at any point in time they were simultaneously managing 7.58 alliances. Almost
a third of the firms in the sample have been successful in obtaining a patent at least once between 1991 and 2001 (34 firms or 30.91% out of the total 110).

We estimated both the Fixed and Random Effects specifications (FE and RE respectively) of the Logit model for panel data for all our three models (Baltagi, 1995; Greene, 2003). Results are obtained via the use of STATA® version 11. The Rho parameter is significant across all three models, indicating significant cross-firm heterogeneity. As the interpretative ability of the Hausman (1978) specification test for discrete dependent variable models is limited we compare the RE and FE specifications on a conceptual basis. Recalling the complex interrelationships between patents, R&D and alliances discussed in the methods section, the FE specification is to be preferred. In addition, the interest of this paper is to explore the role of factors such as frequent engagement in alliances in firm abilities to innovate over time. Clearly here, FE is the suitable specification as it relies on within-firm variance. Moreover, the residuals of the FE specification are corrected for potential heteroscedasticity (Baltagi, 1995; White, 1980).

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Insert Table 2 about here
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Table 2 presents Logit FE estimates for the models testing our hypotheses. Based on model Chi² statistics, all three models are significant at 5% levels and above. This suggests that our variables have a significant interpretative power with respect to the likelihood of firm innovation.
Among the control variables, firm size is positively and significantly associated with firm’s likelihood of innovation in Models 1 and 3. This suggests that firm size may enhance the likelihood of innovation (except in Model 2 that tests for diminishing returns to cumulative alliance experience). Investments in R&D per number of employees is negatively associated with firm innovation likelihood but is only significant in Model 2. Alliance content is insignificant across all three models.

We find support for all hypotheses. In Model 1, the cumulative number of alliances positively affects firm’s likelihood of innovation over time, with significance levels marginally below the 5% threshold. Our results are consistent with studies showing a positive relationship between cumulative alliance experience, firm innovation (Hagedoorn and Schakenraad, 1994; Shan et al., 1994) and financial performance (Anand and Khanna, 2000; Heimeriks and Duysters, 2007; Kale et al., 2002).

The FE estimates of Model 2 provide support for diminishing returns to firm innovation from cumulative alliance experience, with the corresponding variable being positive and highly significant. The results of Model 2 are consistent with findings testing similar hypotheses in cross-sectional settings in the US bio-pharmaceutical and the telecom equipment industries (Hoang and Rothaermel, 2005; Sampson, 2005). To unpack the extent of diminishing returns we estimate predicted probabilities at different levels of the core independent variable after holding the remaining variables at their average values (Baltagi, 1995).

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Insert Figure 1 about here

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Figure 1 plots the marginal predicted probability of obtaining a patent with respect to the natural logarithm of one-year lagged values of cumulative alliance experience. The figure shows that as cumulative alliance experience increases and beyond a certain point, the marginal predicted probability of obtaining a patent increases, but at a gradually diminishing level. Our results are robust to alternative operationalisations, as reflected by exploring concave relationships (inverted U-shaped). We used both the linear and quadratic values of cumulative alliance experience and estimates (FE and RE) confirm non-linear diminishing returns to likelihood of firm innovation.

Model 3 provides support for our third hypothesis. The coefficient of the core independent variable is positive and significant (marginally fails to pass the highest 1% level of significance). Model 3 suggests that firms which establish alliances more frequently, enhance their likelihood of innovation. To the best of our knowledge, there is a dearth of longitudinal studies in this literature to offer comparable results (see Draulans et al., 2003 and Rothaermel and Deeds, 2006). As a test of robustness, we estimated Model 3 by using 4 and 6 years as the average duration for alliances. The results remained robust to these different operationalisations.

Finally, all three model estimates are robust to different measures of the control variables. For example, all models lead to the same outcomes in terms of significance when controls are collapsed to dichotomous variables indicating above and below average firm size and intensity of investments in R&D per number of employees. A further robustness check is undertaken to examine whether our results are sensitive to the statistical assumptions of the distribution followed by the error term in the Logit and Probit specifications. The Probit
model only provides RE estimates for panel data (STATA 11) and these further confirm our results.

7. Discussion

Embarking from the evolutionally (Nelson and Winter, 1982) and dynamic resource-based perspectives (Helfat and Peteraf, 2003; Helfat et al., 2007), this study explored the multifaceted role of alliance experience in firm innovation. In alignment with evolutionary theory, we identified empirically that cumulative alliance experience is positively related to firm likelihood of innovation, providing evidence that is consistent with other studies (e.g. Shan et al., 1994; Sampson, 2005). Our results are aligned with other empirical evidence that supports the assertion that alliance experience improves firm efficiency in alliances. Such improved efficiency arises from firm learning in connection with (a) the establishment of effective communication channels, (b) interaction management and facilitation, and (c) effectuation of knowledge sharing systems (see Zollo et al., 2002; Anand and Khanna, 2000; Kale and Singh, 2009). Our results assist in providing a better understanding of the mixed empirical evidence relating to firm success from alliance arrangements (see the review from de Man and Duysters, 2005).

Our study contributes to a thin body in the alliance literature that provides empirical support for the occurrence of diminishing marginal returns between cumulative alliance experience and firm returns from alliances, measured either as success of alliance projects (Hoang and Rothaermel, 2005), or as firm patenting performance (Sampson, 2005). On the basis of our findings, we argue that beyond achievement of a certain level of cumulative
alliance experience, the marginal contribution of such experience to likelihood of innovation diminishes. We may posit that such a situation arises as a result of depreciation in the value of more distant experience, and dissipation of experiential learning (especially where there is an absence of systematic efforts to leverage and upgrade such learning). Sampson (2005) provides evidence of diminishing returns to cumulative alliance experience over time. Our findings are robust with respect to alternative empirical explorations of diminishing returns that test inverted U-shaped relationships (Rothaermel and Deeds, 2006). It is of potential value to identify the point where diminishing returns are established in our data. Relying on estimates of the curvilinear relationship, we estimate the inflection point at 127.515 points of cumulative experience, which corresponds to firms managing 18 alliances annually (average length of time per firm in the panel is 7 years on average). Our results imply that at such level of alliance activity, firms will experience no additional benefits by extending their alliance activity beyond this point. It should be noted that the maximum value of cumulative alliance experience in our data is 232 alliances, which corresponds to managing 33 alliances annually on average. As mentioned in the previous section, firms simultaneously manage on average 7.58 alliances, suggesting that the majority of firms in our sample are not exceeding the inflection point.

Finally, our results suggest that frequent engagement in alliances enhances the likelihood of firm innovation over time. They stem from an analysis of the changing likelihood of firm innovation over time as a result of increasing alliance activity. Such longitudinal explorations are currently almost absent in the alliance literature, and their potential contribution has been particularly welcomed (Draulans et al., 2003; Rothaermel and Deeds, 2006) as it might shed further light on the type of changes that can occur within firms over
time, in particular, with respect to enhanced innovation potential. Contributions within evolutionary theory (Winter, 2000; 2003) argue that frequent engagement in organisational tasks is linked to capability development, while the dynamic resource-based view (Helfat and Peteraf, 2003) argues that capabilities go through several stages during their development; experience accumulation compels firms to recognise the need to establish a capability, initiating a process of systematic learning and alliance management. Our results clearly pertain to this literature. To explore whether frequent engagement in alliances potentially contributes to the development of alliance capabilities we conducted a case analysis as a complement to our econometric analysis. The case analysis explores the link between frequent engagement in alliances and the development of novel or changed practices and processes for alliance management, i.e., those factors that normally sit within the “black-box” of alliance capability studies (Anand and Khanna, 2000; Heimeriks and Duysters, 2007; Kale and Singh, 2007).

The case analysis clearly reveals such a relationship. First, it shows that alliance management practices and routines are established after alliances become an integral part of firm R&D and innovation strategy and firms intensify their alliance activity. As the Alliance Director interviewed for our study stated: “...we have standardised approaches for contractual compliance [with respect to alliances]... it’s inconceivable to me that one wouldn’t have, and yet five years ago we didn’t... You’ve got one deal and you do it however you do it which largely depends on who you employ and who it’s [the alliance] with... I am not sure how many deals you need to have before you get yourself a standardised process but it’s probably substantially more than ten or twenty...”.

Second, several of the practices identified in the extant literature that are used to institutionalise and diffuse alliance
management learning (such as the use of alliance professionals, the use of alliance metrics, creation of databases to solicit potential alliance partners, and the establishment of processes to monitor alliance performance) are employed by the case firm (Heimeriks & Duysters, 2007; Kale & Singh, 2007). Ten years after intensifying alliance engagement, the firm developed a dedicated alliance management function to coordinate alliance activity and engage in monitoring and improving existing alliance management practices. The case analysis illustrates the relationship between frequent engagement in alliances and the realisation of the need to develop firm-specific capabilities for alliance management. It also reflects the time requirements for mobilising resources to create such capabilities, in parallel with evidence reported elsewhere in the literature (Kale & Singh, 2009). The case offers an appreciation of the types of investments that are required for the development of alliance capabilities, and also reflects the necessity to continuously review and develop such capabilities in order to confront new challenges and intensified competition.

8. Conclusions and Implications

Our research complements literature exploring the role of alliance experience in firm innovation performance. It suggests, first that cumulative alliance experience has a positive and marginally diminishing contribution to firm likelihood of innovation. It also suggests that frequent engagement in alliances enhances firm likelihood of innovation. In addition, a link is established between frequent alliance engagement and the various practices and processes that constitute alliance capabilities. This suggests a need to shift attention away from the role played by certain alliance management practices (such as dedicated alliance functions) that have dominated existing research, and an attempt to identify nascent factors that potentially lay the foundations for alliance capability development (Helfat and Peteraf,
This is particularly important as such practices may be established at later stages of an alliance capability development process (Kale and Singh, 2009), therefore, not appropriately reflecting the foundational stages of such a capability development process. This argument runs in parallel with existing research casting shadow on whether dedicated alliance functions are indeed reflecting superior effectiveness in alliances (Heimeriks, 2010).

Our research has several managerial implications. First, cumulative alliance experience improves firm likelihood of innovation at a diminishing rate. This suggests that firms need to direct efforts in leveraging such experience through systematic learning and management mechanisms, to assist in potentially overcoming inefficiencies. Second, the development of specialist practices and processes to manage alliances, should be preceded by a substantial period of intensification of alliance activity. Such a period of intensification can provide enough background to acknowledge the role of alliances as an integral part of firm innovation efforts and to motivate firms to mobilise resources for developing their alliance capability further. Our results connect with the expanding literature on alliance portfolio management (e.g. Hoffmann, 2007), as they suggest that progressively initiating more alliances than being terminated offers benefits to firms in terms of increasing their likelihood of innovation.

As our results are based on one sector and a specific time period and as our implications cannot be extended beyond this context, it would be useful for future research to explore our contentions in different sectors and time periods, and via the use of different types of data, such as longitudinal surveys and multiple case analyses. Such an approach might extend significantly our understanding of the role of frequent engagement in alliances in the development of firm-level alliance capabilities. Future research might also shed further light
on the effect of alliance experience on firm innovations that are not adequately reflected in patent data, and on the ways in which experience with different types of alliances contributes to firm innovation.

References


Table 1: Descriptive Statistics and Bivariate Correlations

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<td>5. Ln. Turnover</td>
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<td>0.289***</td>
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Table Note: Significance levels: ***p<0.01
Table 2: Logit Estimates: Dependent Variable, Patent Dummy

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<th>Independent Variables</th>
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Table Notes: 1) Significance levels: *p<0.1, ** p<0.05, *** p<0.01
2) The residuals of the FE specification are corrected for potential heteroscedasticity (White, 1980; Baltagi, 1995).
1 Heimericks (2010) distinguishes between institutionalising mechanisms for alliance management on one hand (i.e., those that codify alliance learning and standardise it in routine approaches), and integrating mechanisms on the other (i.e., those that diffuse and share within the organisation recent insights in alliance management).

2 FAME provides financial information relating to all UK listed companies.

3 Both databases are literature based, a factor that raises some concerns with respect to possible under-representation of alliances of smaller value or those involving smaller firms. Confidence is bolstered however, by recent research that demonstrates the results of empirical studies to be independent of the use of particular alliance databases (Schilling, 2009).

4 As explained in the results section, the results we obtained from both operationalisations are not substantially different.

5 Table 1 presents descriptive statistics for the one-year lagged values.

6 The Probit model provides an alternative specification to Logit. However, both models provide the same results in terms of significance levels, while the coefficients of one type of model can be transformed to those of the other by applying a simple formula (Long, 1997).

7 Quoting an Alliance Director interviewed for the case analysis.