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ALLIANCE SCOPE AND FIRM PERFORMANCE IN THE BIOTECHNOLOGY INDUSTRY

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We test the relationship between alliance scope and firm performance in the context of the biotechnology industry by means of a meta-analysis. Meta-analysis is a statistical technique that allows a systematic review of the existing research that is more rigorously systematic compared to conventional narrative reviews as it uses statistics to capture the strength of relationships. The analysis confirms that a relationship between alliance scope and firm performance does exist. Furthermore, results suggest that there is a statistically significant difference in firm performance between exploitation alliances and exploration alliances, confirming recent studies in the innovation and R&D management literature. Managerial implications and future research suggestions are provided.

Keywords: Alliances; biotechnology; firm performance; alliance performance; meta-analysis.

Introduction

There is general recognition of the proliferation of strategic alliances (e.g., Hergert and Morris, 2002) and in the biotechnology industry — or biotech — they are particularly common (Pisano, 2006). Within biotech, alliances are seen as fostering innovation (George *et al.*, 2001, 2002; Reepmeyer *et al.*, 2011) by providing firms with access to valuable resources, especially in the form of new knowledge (Deeds *et al.*, 2000; Powell *et al.*, 1996). The number of alliances within biotech is such that, for many scholars, biotech is the industry of choice (Deeds and

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DeCarolis, 1999; Powell *et al.*, 1996; Stuart *et al.*, 2007) as it is considered to be ideal for studying the effects of performance associated with alliances (Gulati and Higgins, 2003; Shan *et al.*, 1994; Yang *et al.*, 2014). However, despite significant research, inconsistent research findings leave the nature of the relationship between alliances and firm performance contested (Das and Teng, 2003).

This contestation arises from a lack of clarity as to the determinants of the alliance/firm performance relationship, and by the wide variety of approaches to assessing performance. This "opaqueness" is perhaps why performance in alliances has received relatively less attention than other aspects of alliances (Gulati, 1998). Yet the high failure rate of alliances means that performance remains as one of the most rewarding and under-explored lines of research (Gulati, 1998). Alliance scope — that is the range of activities included in the alliance — as manifest in the goals of either exploration or exploitation (March, 1991) is an important feature of alliances where this contestation is particularly evident (Durand *et al.*, 2008).

We contribute to clarifying the alliance–firm performance relationship in the biotechnology industry by means of a meta-analysis that tests the relationship between alliance scope and various firm-level performance measures. Meta-analyses aggregate "results across studies to establish facts" (Hunter and Schmidt, 1990:13) from existing empirical studies. Thus, we integrate existing empirical findings on alliance scope and its relationship to firm performance. The value of this method is that results are statistically derived to determine the strength of the relationship between alliance scope and firm performance based on data from extant empirical research.

The rest of the paper is structured in the following manner. The conflicting findings from empirical studies of alliance scope and firm performance in biotechnology industry are reviewed, motivating a testable hypothesis. Next, the method section outlines the meta-analysis used to test the hypothesis, which is followed by the results. Finally, the discussion and conclusion considers the scholarly and managerial implications for alliance use in the biotechnology industry.

Alliance and Firm Performance

In this study, the term "alliance" is broadly used to describe the "cooperative arrangements between two or more firms" (Ireland *et al.*, 2002:413). Alliances have become a vital part of strategy for biotechnology and pharmaceutical firms (Teece, 1992), as these firms are often unable to commercialise their products without assistance from alliance partners (Shimasaki, 2009). The importance of alliances is such that they are a topic of interest for managers and scholars alike (Deeds *et al.*, 2000; Oliver, 2001; Powell *et al.*, 1996; Stuart *et al.*, 2007).

In the context of alliances, firm performance refers to the degree to which partner firms achieve their objectives (Das and Teng, 2003). Performance is a common and recurring theme in the business and management literature (Neely *et al.*, 1995), however, the treatment of performance is probably among the most difficult issues confronting scholars (Venkatraman and Ramanujam, 1986). Its measurement is a complex issue even at the individual firm level (Parkhe, 2004). In the case of alliances, difficulties in data collection (Gillespie and Gulati, 2001; Gulati, 1998), partner firms having differing goals (Buckley and Glaister, 2002), and multiple levels of analysis (Olk, 2002), are some of the reasons that makes measuring performance difficult. This complexity is perhaps the reason that firm performance in alliances has received relatively less attention than other features of alliances. An important approach to understanding the relationship between alliances and performance is based on differentiating types of alliance, and the concomitant capabilities required (Rothaermel and Deeds, 2006). Hence, this paper focusses on the relationship between the scope of the alliance and firm performance.

Alliance scope as exploitation or exploration

The scope of an alliance refers to the choice of activities that compose the alliance. The activities can include, but are not limited to, R&D, manufacturing, and marketing. This choice can also be interpreted as the firm's motives for forming the alliance (Koza and Lewin, 1999). Broadly, this can be seen as producing two competing categories of exploration and exploitation (March, 1991). Exploration alliances involve searching, discovering, and experimentation, while exploitation alliances involve refinement, implementation, and execution (March, 1991). In the context of biotech, exploration alliances are formed with the motive, and the concomitant activities, to discover new compounds and proofs of concepts, whereas exploitation alliances are entered into with the aim to join competencies with the partner firms, such as up-scaling manufacturing and marketing and distribution (Pisano, 2006; Rothaermel and Deeds, 2004).

Exploration alliances have less certain outcomes and require longer time horizons as compared to exploitation alliances (March, 1991). Exploration alliances tend to precede exploitation alliances as they generate new opportunities, and at the same time, the potential for future exploitation (Rothaermel and Deeds, 2004). Exploration can be viewed as "the pursuit of knowledge" and exploitation as "the use and development of things already known" (Levinthal and March, 1993:105). This means that exploration alliances in biotech are typically formed during the earlier stages of the product development cycle. During this stage, higher levels of uncertainty, ambiguity, and complexity are much more demanding on the firm's managerial capabilities (Pisano, 2006; Rothaermel, 2001b). Exploitation on the

other hand typically occurs at later stages of product development and involves implementing and executing the ideas generated during the exploration stage, and involves much less uncertainty (March, 1991). Exploration alliances contribute towards the alliance's ability to create profit, whereas exploitation alliances bridge the gap between the ability and the realisation of profit (Durand *et al.*, 2008).

Although some researchers focus on the effect of firms engaging in both alliance types concurrently (e.g., Lin *et al.*, 2007), others have chosen to examine the relationship between exploration or exploitation alliances and performance (e.g., Durand *et al.*, 2008). Some studies suggest that there is a difference in the relationship between exploration alliance and performance, and between exploitation alliance and performance. For example, Chan *et al.* (1997) found that horizontal alliances add more value when the alliance involves the sharing of technical knowledge (i.e., exploration alliance), as compared with marketing alliances (i.e., exploitation alliance). This view is shared by Das *et al.* (1998), who argue that technology resources are more critical for firm performance than marketing resources because of a lack of alternate sources of supply.

While there are strong arguments for a correlation between exploration alliance and performance, others have found empirical evidence that contradicts these findings. For example, Hoang and Rothaermel (2005) found that alliance project success is lower when the alliance is initiated during the exploration stage of the R&D process. Although exploitation alliances have a positive impact on new product development process, exploration alliances do not have such an impact (Rothaermel, 2001b). Given the disparity in the empirical studies, it is difficult to draw a specific conclusion concerning the relationship between alliance scope and performance. However, what is clear from these empirical studies is that a relationship between alliance scope and performance exists.

Despite the differences between exploration and exploitation alliances, some scholars argue that most firms engage in exploration and exploitation activities concurrently. They typically have several projects at different stages along the product development chain (e.g., Rothaermel and Deeds, 2004). But, as exploration and exploitation are fundamentally different, this can create tension as they compete for a firm's resources (Nielsen, 2010), given that both types of alliance allow the firm to gain access to different but complementary resources (Contractor and Lorange, 1988). Nevertheless, maintaining a balance between exploration and exploitation is important for firm survival and prosperity (March, 1991).

Some researchers have examined the effects of alliance scope on performance when firms form both types of alliances at the same time. For example, a study by Lin *et al.* (2007) found firms that focus on both exploration and exploitation alliances at the same time do not always benefit. Lin *et al.* (2007), studied five U.S. industries, including the pharmaceutical industry, over a period of eight years, and

found that firm size, measured as current assets, mattered. Although large firms can benefit from focussing on exploration and exploitation alliances concurrently, small firms are better off focussing on either exploration or exploitation. Given that biotech firms are typically small in size (Pangarkar, 2003), with relatively small amounts of current assets (Pisano, 2006) the findings by Lin *et al.* (2007) suggest that, when considering the scope of alliances, biotech firms are better off focussing on either exploration or exploitation.

Nevertheless, there are other empirical studies that show a relationship between alliance scope — albeit exploration or exploitation — and performance. For example, a relationship between alliance scope and performance is supported by the findings of Durand *et al.* (2008) reported a positive relationship between exploitation alliances and performance. This is also confirmed by Mcgill and Santoro (2009), who found that a propensity to engage in later stage alliances is positively related to firm performance. Rothaermel's (2001a) study, based on 889 alliances between biotechnology firms and pharmaceutical companies, found there is a positive relationship between exploration alliances and new product development. This positive relationship was also found between exploitation alliances and new product development (Rothaermel, 2001a). Overall, it remains unclear if firms should focus on exploration or exploitation when considering the scope of alliances.

So far, this paper highlights the importance of alliances in the biotech industry. This is important as an understanding of the relationship between alliance and performance might affect the prosperity of the industry. Many researchers have undertaken the task and examined the relationship between alliance scope and firm performance. However, there are some disparities in their findings. The difficulties in being able to draw a conclusion regarding the relationship between alliances scope and performance leads to the research question: Is there a correlation between alliance scope and firm performance? Although the literature points to a relationship between alliance scope and firm performance, the aim of this paper is to assess the nature of the relationship between these two constructs. In addition, if the relationship exists, what is the strength of the relationship? This leads us to derive the following hypothesis:

H1: There is a positive relationship between alliance scope and firm performance in the biotechnology industry.

Method

Meta-analysis is an effective tool to address this research question by statistically standardising the effect sizes (ES) of findings from relevant primary studies so they can be interpreted in a consistent manner across all the variables and measures

involved (Lipsey and Wilson, 2001). The concept of standardisation allows for the comparisons of otherwise incommensurable studies.

In order to conduct a meta-analysis, relevant primary studies are first identified and their important characteristics coded. To identify the primary studies to be included in the meta-analysis, Business Source Premier, ABI/INFORM, Scopus and Google Scholar online databases were searched as they have extensive coverage of the alliance literature. A structured set of keywords was used with each database and the full articles were obtained.

To be included in the meta-analysis, the identified primary studies needed to pass five pre-determined selection criteria. First of all, the study must employ quantitative measures. Second, the primary study must allow for the calculation of ES(s); the study does not have to report a Pearson's product–moment correlation, but it must provide sufficient information to allow for its calculation. The third criterion is that at least one alliance partner is a biotech firm. The fourth criterion is that the alliance type(s) examined in the primary study can be identified by the reader, based on the information provided by the author(s) of the study. Finally, the primary studies must examine the relationship between alliance and at least one aspect of performance. For the purpose of this meta-analysis, wide varieties of proxies for performance are included. These include proxies of performance measured at the alliance level and/or at the firm level, and using financial and/or non-financial measures. Revenue and sales, spending growth, and capital market reaction are proxies for financial performance. Non-financial performance proxies include but are not limited to satisfaction, knowledge, product development, intellectual property, and human capital. A third indirect measure of alliance stability has often been used as a proxy for performance in the alliance studies. Studies that look at stability are included in the meta-analysis. Table 1 shows the k (number of correlations) and n (sample size) of the primary studies identified.

The second step is to calculate the ESs of the primary studies before analysing the overall strength of the effect. The ES statistic is the key to meta-analysis as it represents the quantitative findings in a standardised form allowing comparison and analysis across studies (Lipsey and Wilson, 2001). ES is calculated using

Table 1. The number of studies (k) and the sample size (n) of the primary studies.

Alliance scope	k	n
Exploration	37	6910
Exploitation	27	5370
TOTAL	64	12280

Fisher's r-to-z transformation, see Eq. (1). As the sample size in the primary studies vary, the ES based on larger sample size needs to be given a higher weight. This was done by taking into account the standard error of ES.

$$z_r = \frac{1}{2}\ln\left(\frac{1+r}{1-r}\right). \tag{1}$$

Independent researchers conducted the identified studies of alliance scope and performance. Although these studies have enough in common to be included in the same meta-analysis, there are no reasons to assume that they share the same true ES. Therefore, the studies are unlikely to be functionally equivalent, and one may not assume a common ES (Borenstein *et al.*, 2009). Therefore, in this paper, the random effects meta-analysis model was used to carry out the analysis.

To test whether there is a relationship between alliance scope and firm performance, the mean ES is calculated by taking into account both sampling error and random variance. The standard error of the mean ES is calculated to allow for an indication of the confidence interval, see Eq. (2). The value of random variance is calculated using the non-iterative procedure based on the method of moments, Eqs. (3) and (4). Heterogeneity analysis is subsequently performed to quantify the heterogeneity of the true ES.

$$SE_{zr} = \frac{1}{\sqrt{n-3}}, \tag{2}$$

$$v_{zr} = \frac{1}{(n-3)}, \tag{3}$$

$$w_{zr} = \frac{1}{v_{zr}}. \tag{4}$$

Although, a meta-analysis statistically summarises the findings of primary studies, if the population of primary studies is biased, the bias will be reflected in the output (Borenstein *et al.*, 2009). To address the problem of sampling bias, a file-drawer analysis is performed. The file-drawer analysis is a method to statistically determine how many more relevant primary studies would be needed before the observed effect would be non-significant. This gives an indication as to how confident one can be that the observed effects are not solely an artefact of bias (Borenstein *et al.*, 2009).

A key issue in meta-analysis is to determine the validity of comparing studies with similar, but not the same, measure. Since the studies used slightly different ways to measure alliance scope, it was necessary for us to establish that it was

valid to statistically compare them. In practical terms, this is the metaphorical question of whether we can compare apples and oranges. When seeking generalisability, multiple operationalisations can be acceptable in meta-analysis (Rosenthal and DiMatteo, 2001). By using different measures to assess the same theoretical concept in the face of possibly irrelevant factors, multiple operationalisations allows the investigation of the true relationship between different measures of the focal constructs (Webb *et al.*, 1981), and strengthen the findings by reducing the effect of a specific error variance (Beck, 1999; Cooper, 1998). Furthermore, such an approach is common is organisational meta-analyses (Camisón-Zornoza *et al.*, 2004; Damanpour, 1991; Orlitzky and Hirokawa, 2001; Orlitzky *et al.*, 2003). We achieved this by constantly checking the coding in terms of the inclusion criteria.

Results

Table 2 presents the results of the meta-analysis and provides support for the relationship between alliance scope and individual firm performance in the biotechnology industry. More specifically, a positive correlation — at the firm level — was found between exploration alliances and performance, and between exploitation alliances and performance. Furthermore, a stronger average ES (and correlation) was obtained for firm performance and exploitation alliances ($ES = 0.35, r = 0.34$) that was substantially larger than that of exploration alliances ($ES = 0.24, r = 0.23$). Upon closer inspection, although the 95% confidence intervals for the two ESs overlap, the difference between the two types of alliance scopes is actually statistically significant, with a z-test result of -2.32. Overall, this suggests that exploitation alliances are considered more valuable than exploration alliances; participating in an alliance that exploits existing knowledge is associated with outperforming those which pursue new knowledge.

The results of the file-draw analysis — also provided in Table 2 using the classic fail-safe N — is an indication of how confident one can be that the findings are not a consequence of sampling or availability bias, during the selection of relevant primary studies (Borenstein *et al.*, 2009). The file-draw analysis shows how many more primary studies would be needed in order to overturn the results of this meta-analysis. For both exploration alliances and exploitation alliances, the results of the file-draw analysis are relatively large, when compared to their respective k values. This indicates that the effect of sampling bias is unlikely to be large enough to influence the results. In addition, a similar outcome was obtained when publication biases were assessed through one-study-removed analyses, and through examination of funnel plots of standard errors of Fisher's z.

Table 2. Meta-analysis results of firm performance and alliance scope (exploration or exploitation).

Relationship between firm performance and…	k	n	Q (p-value)	True ES ($r^{\dagger}$)	SE	95% CI	z-test (p-value)	T (95% CI)	I^2 (95% CI)	File-drawer analysis
Exploration alliance	37	6910	522.37 (< 0.00)	0.24 (0.23)	0.05	0.14–0.33	5.02 (< 0.00)	0.27 (0.24–0.32)	93.11 (91.42–94.47)	138
Exploitation alliance	27	5370	422.79 (< 0.00)	0.35 (0.34)	0.06	0.24–0.46	6.21 (< 0.00)	0.28 (0.25–0.32)	93.85 (92.11–95.20)	164

$^{\dagger}r$ refers the mean ES in its r form.

Discussion

Scholars have sought to delve into the "black box" of alliance functions and alliance success (Bucic and Ngo, 2013) to develop a deeper understanding of the relationship between alliance scope and firm performance. While some researchers find a positive effect of firms engaging in both alliance types concurrently (Durand *et al.*, 2008; Lin *et al.*, 2007; Rothaermel, 2001a), others find there is a difference (Chan *et al.*, 1997; Das *et al.*, 1998; Hoang and Rothaermel, 2005; Rothaermel, 2001b). We contribute to this discussion by resolving these competing views.

The result — that alliances for the purpose of exploitation have a larger and positive correlation with performance than exploration alliances — stands in contrast to some of the early work on exploration and exploitation. The organisational learning literature asserts that firms who focus on exploration alliances may be ahead of their competitors (March, 1991) due to absorptive capacity (Cohen and Levinthal, 1990) and the associated performance effects from new technologies and products (Rothaermel and Boeker, 2008).

However, empirical studies find exploitation alliances to be positively correlated with firm performance (Hoang and Rothaermel, 2005) and that exploration experience leads to poorer R&D project outcomes (Hoang and Rothaermel, 2010). From a dynamic capabilities perspective, firms who engage in exploitative alliances gain access to complementary resources that strengthen and renew their existing capabilities (Ambrosini *et al.*, 2009). Our results confirm existing knowledge that exploitation alliances have more impact on firm performance, since the relationship is stronger for alliances whose scope is on exploitation rather than exploration. Importantly, this suggests that the risks and uncertainties associated with exploration are not fully offset by a commensurate increase in rewards. This may be a function of timing, with exploitation alliances being less "rewarding" in the near term (Yamakawa *et al.*, 2011).

However, our results call into question Hoang and Rothaermel's (2010) recent study that exploration alliances have negative performance effects; our meta-analysis results find a positive correlation between exploration alliances and firm performance, suggesting that there is an important role for explorations alliances too. Other work suggests that both exploration and exploitation are beneficial to the firm, and that exploration alliances should provide positive benefits, especially to larger firms who are better positioned to take advantage of learning and commercialisation (Rothaermel, 2001a; Yang *et al.*, 2014). Arguments about the value of large firms' exploration alliances are grounded in learning effects, which are thought to be more important in exploration alliances (Bucic and Ngo, 2013).

Our findings have important implications for managers too. Whereas, recent studies have suggested that exploitation alliances offer greater R&D and

innovation outcomes, both of which can drive firm performance, we offer some clarification. Whilst explorative and exploitative alliances require different alliance management (Tyebjee and Hardin, 2004), our results show that both are positive for firm performance. Furthermore, for managers in the biotech industry, where knowledge production is exponential, any moves away from explorative alliances should be considered with caution, since from an organisational learning perspective, explorative learning supports knowledge assimilation (Cohen and Levinthal, 1990), and is likely to lead to knowledge diversity that is necessary to orchestrate future innovation (Brännback, 2003). Thus, we reinforce existing views that firm must manage multiple alliances (Al-Laham *et al.*, 2008) — both explorative and exploitative — to renew their capabilities over time.

Conclusion

Meta-analysis was employed to make sense of the existing body of knowledge concerning alliance scope and firm performance in the context of the biotechnology industry. The value of a meta-analysis is that we can statistically summarise the findings from the existing empirical research, thus facilitating making sense from existing literature, which is central to the accumulation of knowledge (Hunter and Schmidt, 1990).

The results confirmed that a positive and significant relationship between alliance scope and firm performance does exist. The level of association between firm performance and exploration alliances, and between firm performance and exploitation alliances is not the same, and the difference is statistically significant, demonstrating the exploitation alliances have a stronger impact on firm performance. Three limitations must be considered when valuing the findings of our study. In doing so, we suggest directions for future studies too.

First, our study classified alliance scope in two categories — exploration versus exploitation. It is the case that further distinctions can be made based on the scope of the alliance. For example, by vertical and horizontal alliances (Chan *et al.*, 1997) or in-licensing and out-licensing (Reepmeyer *et al.*, 2011). Other categories might include country of origin, equity participation, structure, alliance experience, as well as their geographic location. It would be useful to know if using other categorisations leads to different results about alliance scope and firm performance.

An additional opportunity related to alliance scope is about firm characteristics. Recent literature suggests that large incumbents can benefit from exploration and exploitation alliances (Yang *et al.*, 2014), which might explain why there is a positive effect for both types of scope on performance. However, we found no

published research empirically testing such a theory, suggesting firm size and age effects on alliance scope and performance as an area for future research.

A second limitation is that whilst we examined the association between alliance scope and firm performance, no claims can be made about the causal relationship between these two constructs. A potential area for future study could be to test for causation of this relationship.

Finally, we recognise that our meta-analysis does not account of alliance formation timing effects that are likely to influence firm performance (Al-Laham *et al.*, 2008; Mauri and Mcmillan, 1999; Nigro *et al.*, 2013; Van Der Valk *et al.*, 2010). Although meta-analysis techniques can be used to analyse patterns over time (Borenstein *et al.*, 2009), alliance scholars predominantly report the time frames in which the data for collected, not each alliance by year of formation (e.g., Hoang and Rothaermel, 2005 report using a 21-year period from 1980 to 2000 inclusive). Such reporting practices mean the data required for meta-analysis over time is rarely available. Given the gap, we suggest that a change in reporting of alliance formation data might offer a future opportunity for testing alliance-performance relationships.

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