Technology Alliances: Disentangling Knowledge Resources to Target Financial Capital

Mohammad Saleh Farazi
New Jersey Institute of Technology
Martin Tuchman School of Management
saleh.farazi@gmail.com

Abstract

As all firms compete for scarce resources, many biotechnology firms strive to obtain higher amounts of financial capital through partnerships with big pharma companies. This paper takes a close look at the technological resources of the biotechnology firm and asks whether their ?depth? and ?breadth? impact the amount of financial capital the firm receives from its big pharma alliance partner. Results show that technological depth is associated with raising more financial capital, whereas breadth is related to less money. More interestingly, when combined with a well-developed technological project, both depth and breadth are positively related with the financial capital raised.
Technology Alliances: Disentangling Knowledge Resources to Target Financial Capital

Abstract

As all firms compete for scarce resources, many biotechnology firms strive to obtain higher amounts of financial capital through partnerships with big pharma companies. This paper takes a close look at the technological resources of the biotechnology firm and asks whether their “depth” and “breadth” impact the amount of financial capital the firm receives from its big pharma alliance partner. Results show that technological depth is associated with raising more financial capital, whereas breadth is related to less money. More interestingly, when combined with a well-developed technological project, both depth and breadth are positively related with the financial capital raised.
Technology Alliances: Disentangling Knowledge Resources to Target Financial Capital

Introduction

For a large and well-established pharmaceutical company, collaboration with dedicated biotechnology firms is one way to gain access to new and evolving pre-competitive knowledge which is necessary during periods of rapid technological change (Rothaermel and Deeds, 2004; Santoro, 2013). In return, for the less established and resource-constrained biotechnology firm, R&D alliances with a larger organization represent a way of gaining access to financial capital, the one resource that it lacks most, as well as valuable managerial and marketing capabilities (Ahuja, 2000; Mindruta, Moeen and Agarwal, 2016). Although such alliances mean that the biotech firm’s valuable and sometimes unique knowledge is put at risk of appropriation and leakage (Alvarez and Barney 2001; Diestre and Rajagopalan, 2012), they still represent a major strategic vehicle for most biotech firms (Clarivate Analytics, 2018). In fact, these firms enjoy some leverage due to the valuable technological knowledge they bring to the partnership and hence they continue to seek more financial capital and favorable partnership terms from the big pharma partners (Santoro, 2013).

Often pharmaceutical firms assess the prospects of their prospective biotech partners by evaluating their patent portfolios. Past research has considered a firm’s patent portfolio as an observable indicator of a firm’s research capability and a firm’s intellectual property (Adegbesan and Higgins, 2011; George et al., 2001). While management researchers have often regarded patents as a proxy for the biotechnology firm’s technological capabilities, they have reached mixing finding regarding the impact of patents on alliance-level outcomes (Zhang, Baden-Fuller and Mangematin, 2007). For example, Rothaermel (2002: 395) found that biotechnology firms that had accumulated more patents were more attractive alliance partners for incumbent pharmaceutical companies. However, in a study of the impact of technological resources of the biotech firm on the amount of financial capital it acquires from the pharma
Technology Alliances: Disentangling Knowledge Resources to Target Financial Capital

partner in alliance, Gopalakrishnan, Scilliooe and Santoro (2008) found that biotech firms that entered into alliances when they had fewer patents received a greater amount of financial capital from their pharmaceutical partner. This was on the contrary to their hypothesis and to the findings of other studies (e.g. Stuart, Hoang, & Hybels, 1999; Coombs, Mudambi, & Deeds, 2006).

To explain some of the inconsistent findings in the current literature regarding the role of the biotech firm’s technological resources on its ability to raise financial capital upon entering into an alliance with a big pharma, our paper decomposes the technological resources of the biotech firm into two key dimensions based on their underlying knowledge: breadth (or technological diversity) and depth (or technological focus). We give special attention to these two dimensions because it could be that those firms with fewer patents are deeply focused in one (or few) technological knowledge areas and hence possibly more attractive for a broad-based pharma partner. Also, there is a dearth of empirical studies on alliances that disentangle technological knowledge resources into its component parts (Haeussler & Patzelt, 2008; Moorthy & Polley, 2010). Our research adds to the literature by arguing that these two dimensions can each be leveraged to protect firm’s interests in alliance relationships.

When studying the technological depth and breadth of a biotech firm and its attractiveness for an incumbent partner, one needs to take into account how developed the technological project is. Past research has repeatedly confirmed that later-stage technologies, due to lower levels of uncertainty and less time-to-market, are more attractive for financiers, all else being equal (Aghion & Tirole, 1994). New technology firms use their scientific resources and stage of development of their technologies to bargain for additional financial capital from their partners at the time of forming vertical technology alliances (e.g. Deeds, Decarolis, & Coombs, 1997). Also, it is well understood that the financial capital in an alliance is also related to how it is
Technology Alliances: Disentangling Knowledge Resources to Target Financial Capital

governed. Alliances in which the “big pharma” invests equity in the biotechnology company are typically larger deals than those merely involving debt arrangements, such as licensing deals. Therefore, the research question we are addressing here can be formulated as the following: What is the relationship between a biotech firm’s depth or breadth of technological resources and the amount of financial capital it obtains from the big pharma partner? How do depth and breadth combine with the entry stage of technology development to enable the biotech firm to raise more funds in an alliance? And finally, does the governance structure of the alliance (whether equity-based or not) play a role in this relationship?

We believe our study contributes to the literature on strategic alliances and technology management in several ways: First, it helps explain contradictory findings of past research by showing that instead of total stock of patents, technological depth and breadth better explain how biotech firms differ in their ability to raise funds from big pharma partners. Second, we find that later-stage technologies as well as equity-based governance structures (where the big pharma buys equity stake in the biotech partner) are both positively related to the amount of financial capital the biotech firms receive upon entering the alliance. We therefore check for any combined effects: Our study shows that although technological depth enables firms to receive more funds and breadth inhibits them from doing so, both of these dimensions will help the firm to tap deep pockets if the technology in question is well-developed. Our paper therefore seeks to add to the literature by not only disentangling the notions of breadth versus depth but also by showing the moderation by the entry stage of technology development. Third, our study highlights the roles of depth and breadth of knowledge as drivers of alliance-level outcomes.

It is commonly believed that in most biotech-pharma alliances, the big pharma firm chooses among many potential biotech partners (Mason & Drakeman, 2014). Nevertheless, past research has also found that biotechnology firms with partners significantly larger than
Technology Alliances: Disentangling Knowledge Resources to Target Financial Capital

themselves can still have bargaining power to get their interests met (Dunne, Gopalakrishnan and Scillitoe, 2009). Therefore, although the objectives and insights of both partners are important, the focus of this study is on the biotech firm’s technological resources and how its depth and breadth are perceived by the pharma partner. Furthermore, the focus on studying biopharmaceutical alliances is motivated both by the importance and idiosyncrasies of this dynamic industry as well as by its suitability as a setting for research on technological depth and breadth: Based on industry insights, we believe that most biotech firms that primarily seek alliances with big pharma partners are resource-constrained to the extent that they cannot simultaneously invest in diversifying across and specializing within specific technology domains. Whether and when to allocate resources to increase the depth or the breadth dimension of technology remains a managerial question for biotechnology firms, for which the findings of our study serve as a basis.

Theoretical Background & Hypotheses

Our study adopts the Knowledge-Based View (Grant, 1996) and examines the impact of the depth and breadth of a firm’s technological resources on the amount of financial capital acquired from a pharma partner. Following past research that viewed technology alliances from a knowledge-based lens (see for example, Santoro & Bierly, 2006), we believe that biotech firms use their knowledge-based resources to bargain for additional financial capital. Knowledge-based explanations for the formation of strategic alliances have their roots in resource-based approaches to alliances (Grant & Baden-Fuller, 2004). Thus, the large number of alliances in R&D intensive sectors often stresses the importance of technology in the formation of such alliances (Hagedoorn, 1993; Santoro & Bierly, 2006).

While confirming that learning happens in all alliances and that some alliances are pursued primarily with the intention to acquire a partner’s knowledge, Grant and Baden-Fuller (2004)
argue that accessing knowledge rather than acquiring knowledge is the primary motivation for knowledge-based alliances. Their work provides an appropriate theoretical underpinning for our research setting where the primary intention of the incumbent pharmaceutical firm is to access (rather than acquire) the biotech firm’s knowledge.

**Technological Depth and Financial Capital**

With limited resources, it is usually best to focus on specific domains of knowledge (for example, in order to create core competencies) so that you can become leaders in those areas (Bierly and Chakrabarti, 1996). Hamel, and Prahalad (1994) have demonstrated the strategic importance of developing core products and a deep knowledge base in few critical areas. Many of the biopharma alliances are based on very specific therapeutic areas where the pharma partner seeks access to a specific technology, drug target or group of potential drugs (Dunne, Gopalakrishnan, and Scillitoe, 2009). Moreover, pharma firms dealing with technologically-deep biotech firms are somewhat less disadvantaged with respect to information asymmetry regarding the technology, because the biotech firm often has to pursue the technological path in which it is focused with little room for tangential extensions due to their limited financial resources (Gopalakrishnan, Scillitoe, & Santoro, 2008). Therefore, we can expect that biotech firms with deeper technological resources would seem more appealing to a potential pharma partner, as being technologically deep is often a sign of focusing limited resources on specific domains of excellence.

Established pharmaceutical firms typically have a broad knowledge base and are not specialized on a particular set of technology and products (Zhang, Baden-Fuller and Mangematin, 2007). This can lead them to find the specialized knowledge of their biotech partner as valuable. That is to say, the expected future value of a technology under development in a biotech firm with a deep knowledge can be perceived as high (Pateli, 2009), since accumulated expertise implies
Technology Alliances: Disentangling Knowledge Resources to Target Financial Capital

that the biotech firm has focused its limited resources on excelling in one or few particular areas. Specialized knowledge from a technologically deep biotech firm is particularly sought after, giving those firms more power to bargain for additional financial capital from the pharma partner. Following these notions we propose:

**Hypothesis 1:** The amount of financial capital a biotech firm receives in an alliance with a larger pharma partner is positively related to the depth of its technological resources.

**Technological Breadth and Financial Capital**

Firms with limited resources cannot simultaneously expand the depth and the scope of their knowledge (i.e., increase investment in knowledge-based resources while also increasing the diversity of the firm’s technology areas). With a broad knowledge base, the firm is in a better position to combine related technologies in a more complex manner, and is more flexible and adaptable in response to changing environment (Bierly & Chakrabarti, 1996; Kaplan & Vakili, 2015). Broad internal technological capabilities can also provide the biotech firm higher degree of flexibility during alliance negotiations. The development of advanced biopharmaceutical products requires knowledge in several different disciplines (Zhang et al., 2007). If the biotech firm has technological resources that are not broad enough, it will only be able to cover a few and initial steps of the product’s value chain. However, being technologically broad, particularly when partnering with a typically larger and broad-based pharma firm, can bring significant downsides too. For a typically small research-intensive firm, the cost of coordination and management of knowledge can be substantial. Also, if the biotech firm is technologically-broad, chances are higher that its pharma partner has expertise in one or few technology areas but it is difficult to assess the market value of the
technology, as only time and continuous development in one or few areas seems to resolve such uncertainty (McGill and Santoro, 2009). Thus, faced with unfavorable information asymmetry and prone to the biotech firm’s potential opportunistic behavior, the pharma partner applies a discount on the value of the technology and offers the biotech firm less financial capital (Aghion & Tirole, 1994; Lerner & Merges, 1998). A broad rather than deep biotech firm may be perceived by its pharma partner that despite limited resources, it has not focused its efforts on targeted technology areas:

**Hypothesis 2:** The amount of financial capital a biotech firm receives in an alliance with a larger pharma partner is negatively related to the breadth of its technological resources.

**Stage of technology development as a moderator for depth, breadth, and financial capital**

The stage of development of a technology can be an important indicator at the time of negotiating partnership terms to not only the firm possessing that technology but also to that firm’s potential partner (Deeds, Decarolis, & Coombs, 1997). A biotechnology project well-developed into the later stages of clinical trials faces far less uncertainty than those projects which are still in discovery phase (Gopalakrishnan, Scillitoe, & Santoro, 2008). The reduced uncertainty means higher prospects of profitability once and if the project eventually leads to a launched and successfully commercialized drug. Therefore, as the project moves further along the development chain, assessing its future value and the possible stream of revenues become easier as estimates are relatively less uncertain.

Being a biotech company with a particularly focused knowledge base and at the same time having developed a technology well into later stages of clinical trials would appeal to pharma
companies. When a technology deal is consummated at the later stages of development, the transfer of specific, basic underlying knowledge from the biotech firm to the pharma partner becomes much more difficult. Hence, a more focused (i.e. technologically deep) biotech firm is viewed by the pharma partner as capable of dealing with the whole technical trajectory without big pharma’s intervention, as the stock of related patents indicates the ‘deep’ biotech firm’s accomplishments. Following this notion, we propose:

**Hypothesis 3a:** In biotech-pharma alliances, the positive relationship between depth of technological resources of the biotech firm and the financial capital it receives from the pharma partner is positively moderated by the stage of development of the technology in question.

When an alliance is formed at the later stages of technology development, breadth of knowledge in the biotech firm can play a risk-reducing role. While there is still ambiguity about the commercial success of a later-stage technology, the project has incurred tremendous costs, including R&D expenditures, administrative costs and opportunity costs. Analogous to the diversification strategy in stock exchange markets, “technological breadth” provides the firm the luxury of other options for knowledge recombination should an existing path fail to pan out as expected. A ‘broad’ knowledge firm can easily utilize knowledge from any neighboring or distant technology areas, if necessary, to enhance the current technological trajectories. Following these notions, we propose:

**Hypothesis 3b:** In biotech-pharma alliances, the negative relationship between breadth of technological resources of the biotech firm and the financial capital it receives from the pharma partner is negatively moderated by the stage of development of the technology in question.

**Alliance Governance Structure as a moderator for depth, breadth, and financial capital**
The governance structure of an alliance stipulates the financial aspects of the relationship (which company will pay what, to whom, when, etc). It also articulates the intellectual property rights of each partner and specifies where the controlling power of the alliance lies (Bierly & Coombs, 2004). Two very broad categories are equity or non-equity based relationships. An equity governance structure is when an alliance agreement includes the placement of private equity by one firm into another based on the needs and interests of both parties (Janney & Folta, 2006). While equity-based alliances encompass a wide range of possibilities, they all have a financial aspect in common: The profit made from the success of a firm will be proportional to the amount of equity the firm owns. Therefore, when a biotech firm sells equity to a pharma partner, they are actually selling away the right of access to future profits.

Based on the above, it is reasonable to expect that an equity-based biopharma alliance will involve higher amounts of financial capital provided by the pharma company: The financier is given gained more control over the alliance, and will be given a specified share of future profits. Earlier research shows that equity-based alliances mitigate the problems associated with opportunism and information asymmetry (Gulati & Singh, 1998). More hierarchical relationships, such as equity alliances, protect a firm from partner’s opportunism and it “opens up the possibility of new inter-firm cooperative arrangements”(Gulati, 1995). Therefore, we would expect that from the point of view of the pharma firm with equity stake in a biotech partner, technological breadth would not imply a moral hazard or possibility for opportunism, and hence the negative relationship between technological breadth and financial contribution of the pharma partner is expected to be weakened. In the same line, while a biotech firm’s technological depth is particularly appealing, in an equity-based relationship the pharma partner should be willing to invest more because it is given more control over the whole project. Therefore:
Technology Alliances: Disentangling Knowledge Resources to Target Financial Capital

**Hypothesis 4a:** In biotech-pharma alliances, the **positive** relationship between depth of technological resources of the biotech firm and the financial capital it receives from the pharma partner is **stronger** when the alliance is governed by an equity-based structure.

**Hypothesis 4b:** In biotech-pharma alliances, the **negative** relationship between breadth of technological resources of the biotech firm and the financial capital it receives from the pharma partner is **weaker** when the alliance is governed by an equity-based structure.

**Research Methods**

**Data**

Our primary source of data was the Cortellis database (formerly: Recap) that tracks the alliances of US and non-US biotech and pharma companies. It consists of published company information submitted and reviewed by the Securities and Exchange Commission. We used Derwent Innovation Index as the main source of data on firm’s patents and their underlying technologies. We also used Compustat database to extract all relevant firm-level financial data of the partnering firms, such as their total assets in the years leading up to the alliance formation. Our sample comprises of 330 alliances formed during the period 2006-2009 all over the world, typically by a biotechnology firm as the technology provider and a larger pharmaceutical firm as the technology client.

In the biopharma industry, patents play a central role in a firm’s strategy as biotechnology appears to be a vital competence for innovation in drug development (Zhang, Baden-Fuller and Mangematin, 2007). Since a patent typically includes a description of a technical problem and a solution to that problem (Walker, 1995), patent data provides a consistent chronology of firms’
knowledge accumulation (Shan et al., 1994). Measures of depth and breadth of technological resources were constructed using information from the patents each biotech firm holds, as available in the Derwent Innovation Index. To capture the role of technological resources of the biotechnology firm leading up to the formation of the alliance, the number of patents in a three-year period were counted that included the two years leading up to the formation of the alliance and the first year of the alliance. Since we were interested in examining the role of technology depth and technology breadth, we also captured the number of those patents which fall in a given technology class or subject area. The Measures Section explains more fully how these numbers were used to build measures of technology depth and technology breadth.

**Measures**

Dependent Variable: Financial Capital was measured as an upfront payment in million dollars US by the pharma partner (financier) to the biotech partner (provider of technology).

Independent Variables: Following Zhang, Baden-Fuller and Mangematin (2007), we measured “technological depth” in two steps. First, the “Revealed Technological Advantage” (RTA) of each firm is computed as in equation (1), where \( P_{it} \) is the number of patents held by firm \( i \) in technology class \( t \).

\[
RTA_{it} = \frac{P_{it}}{\sum_t P_{it}} \tag{1}
\]

Equation (1) is the ratio of the share of firm \( i \) patents in technology class \( t \), to the share of all patents falling in that technology class. Then, we calculated depth as the coefficient of variation for all the firm’s RTA measures, as in equation (2).

\[
\text{depth} = \frac{\sigma_{\text{RTA}}}{\mu_{\text{RTA}}} \tag{2}
\]

“Technological breadth” is simply the total number of technology classes in which the firm was granted patents in the 2 year period prior to the alliance formation and the first year of the alliance.
“Stage of development of technology” was coded as integers ranging from 1 to 9 representing a categorical variable. 1: Formulation, 2: Discovery, 3: Lead molecule, 4: Preclinical trials, 5: Phase I, 6: Phase II, 7: Phase III, 8: BLA/NDA filed, 9: Approved.

“Equity-structure” was coded as a binary variable, with a value of 1 when the alliance involved the pharma partner purchasing equities in the biotech company, and 0 otherwise.

Control Variables: We controlled for other variables that influence the amount of financial capital a biotech firm receives from the pharma partner. The three control variables included the following: 1) The biotech firm’s size: measured by the total assets of the biotech firm at the time of alliance formation. 2) The biotech firm’s prior alliance experience: measured as the number of alliances that the biotech firm had entered into during the past five years leading to the alliance in question, and 3) The biotech firm’s slack resources: measured as the ratio of the firm’s current assets to current liabilities.

Analysis and Results

Table 1 presents the descriptive statistics and correlations between study variables. We observed a negative and significant correlation between the main two explanatory variables, i.e. depth and breadth. In order to assure that multicollinearity was not an issue, we computed the Value Inflation Factor (VIF) for this pair. Since the VIF value did not reach 3, we feel confident there is little threat of multicollinearity in the data. The strong negative correlation between technological depth and breadth reinforces a central assertion of this paper that most alliance-seeking biotech firms cannot simultaneously increase the depth and expand the breadth of their knowledge-based resources\(^1\). If they are so resource-rich to enjoy both a diversified and a

---

\(^1\) As George et. al (2008) put it, our concentration-based depth measure “penalizes firms for dispersion across patent classes”, i.e. a broader firm gets lower depth values. While we recognize this, we still keep the measure this way because it compares the concentration of a firm’s knowledge base with the concentration of other firms’
specialized knowledge-base, they are probably so large and so established that do no need alliances to gain financial capital, and hence they would not appear in our study sample.

Other correlation results also prove the earlier expectations of this study: The strong negative correlation between ‘alliance experience’ and ‘depth’ suggests that less-experienced and younger firms, well aware of their limited-resource, choose to invest in the depth rather than in the breadth dimension of knowledge-based resources. This notion is further reinforced by the positive correlation between ‘alliance experience’ and ‘breadth’. In a nutshell, it seems that for biotech managers, investment in technological focus comes before technological diversification. Consistent with this finding is that ‘slack’ is negatively correlated with ‘breadth’: Those biotech firms that had sufficient slack resources chose to (or could afford to) significantly diversify their knowledge portfolios.

There is a significant positive correlation between ‘alliance experience’ and ‘stage of development of technology upon entering the alliance’. This is consistent with the findings of past research that as firms accrue more alliance experience, they are better able to protect and develop their technologies by themselves until later stages of development where they have the leverage to obtain better partnership terms from big pharma partners (e.g. Lerner and Merges, 1998). In the same line is the positive and significant correlation between ‘alliance experience’ and ‘firm size’.

knowledge bases, regardless of how the size of those knowledge bases compare. This relates to how we conceptualized depth: The relative focus that gives the focal firm more leverage than another firm lacking that focus but perhaps having more resources. Moreover, George et. al (2008) find a correlation of r=0.80, p<0.001 between their own depth measure and the concentration-based measure which is similar to ours.
Table 2 presents the results of the hierarchical linear regressions. Since the dependent variable, financial capital, is a continuous variable, we used linear regression, with a hierarchical mode of entering independent variables: Starting with control variables in a base model and entering the research variables in the next step. We insert all the interaction terms together in a subsequent model \((Depth \times Stage, \ Breadth \times Stage, \ Depth \times EquityStructure, \ Breadth \times EquityStructure)\); because an interaction effect only exists if the interaction term gives a significant contribution over and above the direct effects of the independent variables.

When the two companies are negotiating the terms of the partnership, both the amount of financial capital and the governance structure (equity-based or not) are specified and agreed upon at the time of signing the contract.

Two of the control variables, namely ‘firm size’ and ‘firm’s slack resources’, have a positive and significant coefficient in the regression models. This seems to indicate that the smaller the firm’s size or the size of its slack resources, the less money it is able to collect from big pharma partners, consistent with earlier research (e.g. Gopalakrishnan, Scillioote and Santoro, 2008; Lerner and Merges, 1998).

Results of model 2 indicate a significant positive association between depth and financial capital \((\beta = 0.425, \ p < 0.05)\). This lends support for hypothesis 1: A biotech firm’s technological depth is positively related to the amount of financial capital it acquires from the big pharma partner upon alliance.

The coefficient corresponding to technological breadth is negative and significant \((\beta = -0.376, \ p < 0.01)\), and remains significant in model 3 as well. This supports hypothesis 2, meaning that we find proof that a firm’s technological breadth is negatively related to the amount of financial capital it collects in an alliance. Also, the stage of development of technology has a significant and positive coefficient in model 2, as expected. The same goes
for Equity type of alliance governance, which exhibits a significant and positive relationship with the dependent variable.

Model 3 included stage of technology development upon entering the alliance, as well as the binary variable for equity type of governance structure (value being 1 if equity-based, 0 otherwise). The interaction term \( \text{Depth} \times \text{Stage} \) has a positive and statistically significant coefficient, suggesting that later stage technology combined with technological depth tends to be associated with receiving more money in alliance. Hence, hypothesis 3a is supported. As to hypothesis 3b, it is also supported because the interaction term \( \text{Breadth} \times \text{Stage} \) has a very significant and positive coefficient \( (\beta = 0.077, p < 0.001) \). Interestingly, although technological breadth is associated to less money in alliances, those ‘broad’ firms which bring a well-developed technology to the alliance move towards collecting more money.

Finally, hypotheses 4a and 4b are not supported. Technological depth in an equity alliance does not seem to have a stronger relationship with acquired financial capital than a non-equity alliance. More interestingly, we find, with marginal statistical significance, the opposite of what we expected in hypothesis 4b: The negative relationship between technological breadth and acquired financial capital is even stronger when the alliance is equity-based. We’ll discuss these findings in the next section.

-----------------------------------------------

Insert table 2 around here

-----------------------------------------------
Technology Alliances: Disentangling Knowledge Resources to Target Financial Capital

**Discussion and Conclusions**

Past research has found that technical capital, denoted by its knowledge base or technical competence, may be a biotechnology firm’s major source of leverage when forming an alliance with a resource-rich pharmaceutical company (e.g. Ahuja, 2000). This study therefore sheds light on the less investigated relationship between knowledge depth and breadth on the one hand and ability to raise financial capital in an alliance, on the other hand. We show that knowledge plays a role and depth and breadth work in opposing ways in attracting financial capital.

Consistent with the first hypothesis, our findings confirm that the deeper a biotech firm’s technological knowledge base, the more money it will receive from the pharma partner. This is particularly important as the small partner’s depth of knowledge within a technology domain is the main resource that the biotech company has to leverage its position in the formation of the alliance (Coombs and Deeds, 2000). In accordance with the general view of biotechnology firms as specialized science-based organizations, our results suggest that the ‘deep knowledge’ of the smaller biotechnology partner is particularly sought after and is deemed as valuable by the typically broad-based and large pharma company.

The findings on the role of ‘technological breadth’ completed our understanding of the opposing impacts of depth versus breadth on the amount of financial capital raised in the alliance. Technological-breadth is found to have an opposite effect than depth, and moves the firm towards acquiring less financial capital. Not only being a ‘focused’ biotech firm is proven to be attractive for the big pharma, but also being ‘diversified’ (regardless of focus) has a negative effect on how much financial capital the big pharma partner is willing to invest upfront.

Our finding regarding the moderating role of the stage of development of technology said that later stage technologies contributed to a firm’s ability to raise funds, and the magnitude of this contribution was greater in the case of technological broad than depth. This could mean that if
Technology Alliances: Disentangling Knowledge Resources to Target Financial Capital

the firm is technologically-deep enough, even with an early-stage technology the pharma firm would trust its ability to undertake rigorous and productive R&D and hence would be willing to invest money in it. Whereas, if the firm is particularly broad, it needs to prove its expertise by bringing a concrete and tangible late-stage technology that is not so far from a final product. Only then, the big pharma is willing to finance the rest of this broad firm’s endeavor.

As to the structure of alliance governance, our results suggest that regardless of any exchange of equity, technological depth has an independent relationship with the acquired financial capital in the alliance. More surprisingly, when the alliance is governed by an equity relationship, technological breadth is even more punishing for a biotechnology firm as it shows an even stronger negative relationship with the amount of financial capital acquired. This could mean that for pharma companies the technological breadth of a biotechnology firm is an indicator of a risky or a less attractive investment opportunity.

Contributions to the literature

Extant research has investigated how technological resources of a biotech firm related to firm and alliance-level success. We build up upon and add to this research by suggesting that the depth and the breadth dimension of these technological resources can have differing impact in the alliance relationship. More specifically, we managed to explain some inconsistent findings of past research that had only considered the total stock of technological resources, rather than their depth and breadth, when investigating how technological knowledge drives a biotech firm’s ability to acquire financial capital in downstream alliances. Moreover, this study revealed how stage of development of technology comes into play to affect a firm’s ability to raise funds in alliance. While past research has consistently found a positive role, we add that such an effect is primarily crucial for technologically-broad firms, and the deeper counterparts still managed to tap deep pockets no matter how developed their technology is.
Limitations and Future Lines of Research

Despite its contributions, our study has a number of limitations which offer avenues for further research: Because we wanted to focus on the biotech firm’s core competencies, our independent variables captured several characteristics of the same. However, the pharma partner’s attributes are equally important, and recent research has shown a tendency towards dyad-level variables. While conceptually we manage to view the biotech firm from the big pharma’s lens, further research could incorporate empirical data from the larger firm as well. Specifically, future studies can investigate if there would be any relationship between knowledge relatedness of the two partners, their respective knowledge depth and breadth, and alliance-level outcomes.

Finally, we only considered those alliances for which: alliance financial data were disclosed, and firm’s financial data were publicly available (i.e. the firm was publicly traded). This could mean that our results are not generalizable to very young and small start-ups. An interesting path for further research would be to obtain longitudinal data on such small firms and investigate whether the findings of our study can be further validated. For example, do entrepreneurial biotech firm’s first focus on gaining specialized knowledge and postpone diversifying until a later moment in time?

Implications for Practice

Managers of new biotech firms need to recognize the differing potential roles of knowledge depth and breadth when adopting their knowledge strategy (Mooorthy and Polley, 2010). With limited resources, managers of small technology-based firms need to invest only in the right type and right dimension of technological knowledge: the one that brings them highest returns and most benefits in their inter-firm linkages. The empirical results of this study confirm that knowledge depth and breadth would yield different results for the firm in the alliance, and hence
Technology Alliances: Disentangling Knowledge Resources to Target Financial Capital

managers should be aware of and take into account these dimensions in addition to more well-known factors such as the stage of development of technology and the possibilities for equity investment.
References


https://doi.org/10.2307/3094190


Clarivate Analytics, 2018, Annual Deals & Portfolio Review, available online at: http://discover.clarivate.com/JPMDealsReview


George, G., Zahra, S. A., Wheatley, K. K., & Khan, R. (2001). The effects of alliance portfolio characteristics and absorptive capacity on performance: A study of


Technology Alliances: Disentangling Knowledge Resources to Target Financial Capital

**Tabel 1: Descriptive Statistics and Correlations**

<table>
<thead>
<tr>
<th></th>
<th>Mean</th>
<th>SD</th>
<th>Depth</th>
<th>Breadth</th>
<th>Firm Size</th>
<th>Alliance Experience</th>
<th>Slack</th>
<th>Stage</th>
<th>Equity St</th>
<th>Financial Capital</th>
</tr>
</thead>
<tbody>
<tr>
<td>Depth</td>
<td>0.008</td>
<td>0.123</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Breadth</td>
<td>9.357</td>
<td>32.537</td>
<td>-0.559**</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Firm Size</td>
<td>6.065</td>
<td>2.678</td>
<td>-0.427**</td>
<td>0.699**</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Alliance Experience</td>
<td>1.933</td>
<td>0.979</td>
<td>-0.169**</td>
<td>0.422**</td>
<td>0.319**</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Slack</td>
<td>3.614</td>
<td>1.966</td>
<td>0.045</td>
<td>-0.230**</td>
<td>-0.285**</td>
<td>-0.224**</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Stage</td>
<td>4.310</td>
<td>3.429</td>
<td>-0.084</td>
<td>0.087</td>
<td>0.08</td>
<td>0.197**</td>
<td>-0.084</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Equity St</td>
<td>0.29</td>
<td>0.43</td>
<td>0.04</td>
<td>-0.14*</td>
<td>-0.27*</td>
<td>-0.28**</td>
<td>0.081</td>
<td>0.06</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Financial Capital</td>
<td>4.570</td>
<td>1.945</td>
<td>0.043</td>
<td>-0.117*</td>
<td>0.03</td>
<td>-0.014</td>
<td>0.11</td>
<td>0.104</td>
<td>0.312</td>
<td>1</td>
</tr>
</tbody>
</table>
Table 2: Hierarchical Linear Regressions

<table>
<thead>
<tr>
<th>Dependent Variable</th>
<th>Model 1</th>
<th>Model 2</th>
<th>Model 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Constant</td>
<td>3,933***</td>
<td>4,974***</td>
<td>4,536***</td>
</tr>
</tbody>
</table>

**Control variables**

<table>
<thead>
<tr>
<th>Variable</th>
<th>Model 1</th>
<th>Model 2</th>
<th>Model 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>ALLIANCE EXPERIENCE</td>
<td>-0.008</td>
<td>0.017</td>
<td>-0.069</td>
</tr>
<tr>
<td>SLACK</td>
<td>0.152**</td>
<td>0.117*</td>
<td>0.127*</td>
</tr>
<tr>
<td>FIRM SIZE</td>
<td>0.033*</td>
<td>0.132**</td>
<td>0.142**</td>
</tr>
</tbody>
</table>

**Independent Variables**

<table>
<thead>
<tr>
<th>Variable</th>
<th>Model 1</th>
<th>Model 2</th>
<th>Model 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>DEPTH</td>
<td>0.425*</td>
<td></td>
<td>-0.182</td>
</tr>
<tr>
<td>BREADTH</td>
<td>-0.376**</td>
<td></td>
<td>-0.781***</td>
</tr>
<tr>
<td>STAGE</td>
<td>0.061*</td>
<td></td>
<td>0.161 +</td>
</tr>
<tr>
<td>EquitySt</td>
<td>0.687*</td>
<td></td>
<td>1.364</td>
</tr>
</tbody>
</table>

**Interactions**

<table>
<thead>
<tr>
<th>Interaction</th>
<th>Model 1</th>
<th>Model 2</th>
<th>Model 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>DEPTH x STAGE</td>
<td>0.108*</td>
<td></td>
<td></td>
</tr>
<tr>
<td>BREADTH x STAGE</td>
<td></td>
<td></td>
<td>0.077***</td>
</tr>
<tr>
<td>DEPTH x EquityStructure</td>
<td>0.316</td>
<td></td>
<td></td>
</tr>
<tr>
<td>BREADTH x EquityStructure</td>
<td></td>
<td></td>
<td>-0.936 +</td>
</tr>
</tbody>
</table>

+ p<0.1, * p<0.05, ** p<0.01, *** p<0.001. N=330 alliances