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STRATEGIC ALLIANCES AND PRODUCT DEVELOPMENT IN NEW TECHNOLOGY FIRMS: THE MODERATING EFFECT OF TECHNOLOGICAL CAPABILITIES

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ABSTRACT

We develop a model of product development based on the alliance portfolio of high technology firms. We draw on the capabilities perspective and argue that the impact of upstream, horizontal, and downstream alliances on the new firms’ rate of product development depends on the degree of specialization of the firm’s technological capabilities. Using a unique survey dataset of new technology firms in the German and UK biotechnology industries, the findings provide support for our model and demonstrate that technological capabilities are an important factor that mitigates the benefits and risks of alliances for the product development process of new technology firms. We discuss implications for the alliance literature.

INTRODUCTION

A capabilities perspective of alliance formation emphasizes that firms enter into alliances to access capabilities that they can not cost-efficiently build up internally (Teece, 1986). Most young technology firms have only limited internal capabilities although their product development processes are complex, time consuming, and extremely costly (DiMasi, Hansen, & Grabowski, 2003). Alliances are an important means for new firms to access the capabilities they need externally in order to enhance their patenting rate (George, Zahra, & Wood, 2002), rate of product development (Rothaermel & Deeds, 2004), and growth (Baum, Calabrese, & Silverman, 2000). Besides benefiting from alliances, however, existing literature has demonstrated that new firms also face a potential “dark side” of alliance formation. Entering into an alliance always bears the risks of expropriation of the firms’ own knowledge by the partner (Teece, 1986). Protection from expropriation by thorough selection of the alliance partner and appropriate contracting can be costly, and new firms may not have sufficient resources and competencies to achieve this effectively (Lerner & Merges, 1998).

Since firms are “bundles” of capabilities and these capabilities need to combined effectively to achieve high organizational performance (Teece, Pisano, & Shuen, 1997), it appears that achieving a fit between internal capabilities and the external capabilities possessed by the alliance partner is crucial for new technology firms to maximize benefits and minimize risks associated with alliance formation. We argue that the composition of internal technological capabilities is a particularly important precedent of benefits and risks. We suggest that the degree of specialization of a firm’s technological capabilities determines, in part, the contribution a new alliance makes to a new technology firm’s product development process. Our model distinguishes between vertical upstream, horizontal, and vertical downstream alliances (Baum et al., 2000), and assesses the interdependencies between internal technological capability specialization and the contribution alliances of either type can make to a new firm’s rate of product development. The understanding of these effects is important for new firms because unsuccessful alliances can have a daunting
effect on new firm performance and survival (Alvarez & Barney, 2001). We test our model with a sample of 199 biotechnology firms located in Germany and the UK.

THEORY AND HYPOTHESES

A central element of the effectiveness of alliances is the absorptive capacity of a firm, i.e., the capability to accumulate and mobilize external capabilities and thus benefit from entering alliances (Cohen & Levinthal, 1990). The development of absorptive capacity is a cumulative, path-dependent process involving investments to build up capabilities (Powell, Koput, & Smith-Doerr, 1996). While most studies assume that expenditures on R&D directly translate into absorptive capacity (Arora & Gambardella, 1990), we put forward that the level of specialization of a firm’s technological capabilities determines how much a firm profits from alliances. Technological capabilities denote the specific subset of capabilities that facilitates firms to develop a product according to the requirements of the market with respect to functionality, quality, costs, and schedule and include scientific methodologies, technological competencies, and expertise related to the particular area where the firm has a competitive advantage (Mayer & Nickerson, 2005).

Vertical upstream alliances and technological capabilities

Vertical upstream alliances refer to alliances that new firms form with organizations upstream of their own activities on the value chain. Alliances with universities and research institutions can provide access to valuable scientific and technological knowledge (George et al., 2002; Powell et al., 1996; Rothaermel & Deeds, 2006), which is essential to develop complex new technological products. For example, universities are a major source of scientific knowledge on molecular biology for young biotechnology firms, and university alliances provide a means to access membership in the scientific community and profit from knowledge spillovers (Owen-Smith & Powell, 2004). Empirical research has confirmed that entering into learning alliances with universities positively affects the product development rate of new technology firms (Zucker, Darby, & Armstrong, 2002).

While these studies support the notion that acquiring knowledge through vertical upstream alliances can facilitate for the product development processes of new technology firms, there are also risks associated with these alliances. Cultures of universities and businesses are often incompatible, for example with respect to secrecy and free exchange of knowledge (Bower, 1992). Whereas firm scientists try to keep new knowledge secret and not disseminate it to competitors, university scientists aim to publish new knowledge in scientific journals to enhance their scientific reputation. Further, university and firm scientists may consider different types of knowledge relevant – university scientists likely put first priority on generating publishable knowledge, whereas firm scientists will put emphasis on knowledge related to the development of new products. These different cultures and interests can cause tension and be detrimental to the knowledge transfer process (Bower, 1992). Because of these difficulties, university alliances may require considerable coordination and administration efforts as well as management and control systems, which can substantially increase the costs of the R&D process (George et al., 2002). These increased costs may slow down the firm’s rate of product development because fewer resources can be allocated directly to the development process (e.g., paying R&D personnel or buying new devices).

It appears that with more specialized internal technological capabilities new firms can maximize the benefits and minimize the costs associated with upstream alliances. Technological capabilities can be interpreted as an indicator for the absorptive capacity of a new firm – for its
ability to value and apply knowledge, which is crucial for the firm’s ability to learn from external sources (Cohen & Levinthal, 1990). Absorptive capacity, however, “is largely a function of the firm’s level of prior related knowledge” (Cohen & Levinthal, 1990: 128). That is, knowledge acquisition from the alliance partner is easier and more effective when the knowledge bases of both organizations are similar (Lane & Lubatkin, 1998). The more the technological capabilities of a new firm (and knowledge related to these capabilities) will match the knowledge base of the alliance partner, the better a new firm will be able to transfer knowledge from that partner.

Developing high levels of absorptive capacity in the knowledge domain of an alliance partner, however, requires that the new firm focuses its sparse resources on establishing internal technological capabilities that are specialized on that domain. The more specialized the technological capabilities on a knowledge domain, the higher the absorptive capacity of a new firm in that domain. When a new technology firm forms an alliance with a university lab to get access to knowledge present in this lab, it can better incorporate the knowledge into its own operations when it has specialized internal technological capabilities related to this knowledge – when it is itself an expert in the respective scientific field. For example, a biotechnology firm that is a DNA specialist and has built up expertise and strong technological capabilities with respect to DNA technology will be better able to acquire knowledge from university labs working with DNA technologies than a firm that is less specialized on DNA but also develops other technological capabilities. This latter firm has less in-depth knowledge related to DNA technology, which will limit its ability to incorporate and exploit DNA-related knowledge from the university partner. Therefore, the product development process of firms with more specialized internal technological capabilities and more in-depth knowledge related to these capabilities will benefit more from alliance formation with universities than the product development of firms with less specialized technological capabilities.

Second, the costs of vertical upstream alliances appear to be higher for firms with less specialized technological capabilities. In this case, firms’ scientists are no specialists in the scientific field of the university scientists, and likely have only a limited understanding of the research practices and results generated by their alliance partners. This makes it easier for university scientists to follow their self-interests, for example by focusing on research that is better suited for scientific journal publication than for commercialization purposes. Because of their limited methodological understanding, firm scientists will have difficulties in controlling and monitoring the research activities of the university partner. Moreover, due to the firm scientists’ limited understanding and missing in-depth knowledge of the university group’s research, communication and exchange of knowledge will be more difficult, and there a higher risk that the firm will not acquire enough knowledge to justify the costs associated with the alliance. In contrast, if the firm has more specialized technological capabilities and its scientists are experts in the scientific field of the university alliance partner, these scientists are better able to understand the scientific methodologies used and results generated by the alliance partner, which will make communication and monitoring easier, and lower the costs required for coordination, management and control systems. Thus,

H1: The relationship between the number of vertical upstream alliances and product development of a new technology firm is more positive when the internal technological capabilities of the firm are more specialized than when they are less specialized.
Horizontal alliances and technological capabilities

Horizontal alliances are formed when firms collaborate with other organizations at the same level of the value chain (Perry, Sengupta, & Krappel, 2004). Specific to new technology firms, horizontal alliances are often joint efforts with other firms to develop new products or services. One major benefit for new firms is that horizontal alliances provide access to knowledge in design, prototyping, testing, development, and new product introductions (George, Zahra, Wheatley, & Khan, 2001). Through common exploration activities the alliance partners generate new knowledge and ideas that are transformed into new product candidates (Rothaermel & Deeds, 2004).

Horizontal alliances have been described in the literature to be often problematic and entail a high failure risk with negative consequences for the alliance partners. For example, Park and Russo (1996) found that horizontal alliances in the electronics industries often fail due to potentially arising competition between the partners. Other authors have also highlighted that the tension between cooperation and competition of partners is difficult to manage in horizontal alliances (Mowery, Oxley, & Silverman, 1996). Since young technology firms face a hypercompetitive environment and a quickly changing competitive landscape, it is difficult to predict how the competitive relationship between the partners will develop in a horizontal alliance. Moreover, in high technology industries horizontal R&D alliances bear considerable problems of risk sharing, contract enforcement, and moral hazard (Deeds & Hill, 1998). The outcome of the exploration activities that are the basis of such alliances are uncertain and distant in time, which makes it difficult to develop efficient contracts that fully cover the potential outcomes and their appropriation by the alliance partners. Therefore, the risk of opportunistic partner behaviour is particularly high in horizontal R&D alliances (Deeds & Hill, 1998). Protection from these high risks can be costly, and may require lengthy and thorough partner evaluation, extensive monitoring, and frequent renegotiation of alliance contracts, which diminishes the resources the firm can allocate directly to its product development efforts.

Similar to vertical upstream alliances, however, it appears that more specialized internal technological capabilities facilitate new firms to better mitigate the risks and maximize the benefits of horizontal for the firm’s product development efforts. Following our argumentation above, efficient learning in horizontal alliances is only possible when firms possess sufficient absorptive capacity and therefore abilities to value, assimilate, and apply the new knowledge developed by the common R&D efforts (Cohen & Levinthal, 1990). That is, firms will profit the more from horizontal alliances the more they have the specialized technological capabilities suited to absorb the knowledge of the alliance partner. To continue with the example above, Alnylam is a world leading specialist for RNAi technologies, and has built up substantial experience and expertise with the systemic delivery of RNAi-based therapeutics in animal models. This related prior knowledge facilitated the application of INEX’s liposome technology as one so far unexplored way of systemic RNAi delivery, and contributed to the rapid and successful progress of the collaboration. If Alnylam had developed less specialized technological capabilities and had not been a dedicated RNAi specialist, it would not have had built up this level of expertise on systemic delivery of RNAi therapeutics. Thus, the firm would not have been that aware of specific problems and challenges associated with systemic delivery, and application of INEX’s lipid-based technology to RNAi delivery may have caused more and perhaps so far unknown problems. This would have made it more difficult to achieve the desired alliance outcome.

With respect to risks, scholars have described that the potential competition between partners may result in mutual opportunistic partner behavior that can turn the horizontal alliance into a
“learning race” (Grindley & Mowery, 1994). That is, as a reaction to the partner’s learning efforts, a firm may be motivated to increase its own learning and acquire knowledge from the partner, which in turn enhances the partner’s learning motivation, and so on. As a result, alliance partners use the alliance only to learn quickly and expropriate as much knowledge as possible from the partner without committing to the original purpose of the alliance. Successfully participating in a learning race, however, requires that the firm has specialized technological capabilities and sufficient absorptive capacity to quickly acquire the partner’s knowledge (see above). When a firm has less specialized internal technological capabilities and a limited absorptive capacity with respect to the partner’s knowledge, it is likely to lose this race and thus the alliance will entail high costs of expropriated knowledge while rendering little or no benefits for the firm’s product development efforts. The financial and human resources invested into the learning race may be lacking for other tasks of the firm’s product development process, thereby slowing down its rate of product development. Thus,

\[ H2: \text{The relationship between the number of horizontal alliances and product development of a new technology firm is more positive when the internal technological capabilities of the firm are more specialized than when they are less specialized.} \]

**Vertical downstream alliances and technological capabilities**

Vertical downstream alliances denote partnerships between new technology firms and organizations that operate downstream of the new firms’ value chains. Typically, downstream alliance partners are large incumbents, for example pharmaceutical firms for new biotechnology firms (Rothaermel & Deeds, 2004). With respect to the product development process of new technology firms, the primary motive to enter into downstream alliances is not to acquire knowledge capabilities from the partner, but to access complementary capabilities required to finalize the development of product candidates and introduce them to the market (Rothaermel & Deeds, 2004). These capabilities are often very costly and exceed the resource endowments of new firms. Finally, through downstream alliances firms also gain access to the incumbent’s legal and regulatory competence, manufacturing, distribution, and marketing capabilities (Rothaermel & Deeds, 2004).

The alliance literature also identified risks associated with the formation of downstream alliances, which can diminish the new firms’ product development processes. For example, Lerner and Merges (1998) found that biotechnology firms which are short of financial resources have little bargaining power when negotiating the alliance contract with an incumbent partner. These biotech firms are forced to enter into alliances to advance their product even if the majority of the control and product ownership rights are allocated to the incumbent. The same occurs when external financing is sparse during times of hostile equity markets (Lerner, Shane, & Tsai, 2003) – the biotechnology firm gives away much of its product ownership in exchange for cash it can not access via the capital market. Allocating the bulk of control rights and product ownership to the incumbent, however, is inefficient for product development since the research firm may not have enough incentives to contribute to the success of the alliance. Indeed, empirical research has shown that product development alliances negotiated in times of hostile equity markets and allocating too many control rights to the incumbent firm are significantly more likely to fail (Lerner et al., 2003). For new technology firms, these failed alliances do not only represent the loss of the partnered product, but also bind resources that can not be allocated to the development of other product candidates. This will slow down the firm’s product development rate.
In contrast to vertical upstream and horizontal alliances, we suggest that less rather than more specialized technological capabilities can enhance the benefits and counteract the risks associated with vertical downstream alliances for the product development process of new technology firms. Effectively accessing and exploiting the external capabilities of the downstream alliance partner depends on the ability of the new firm to transfer its own knowledge associated with the product candidate to that partner. For example, when a biotechnology firm seeks a downstream alliance with a pharmaceutical company to perform late stage clinical development of a new drug candidate, it needs to pass on all relevant information and knowledge about preclinical and early clinical trial results, so that the partner can continue the development process most effectively. Similarly, when the incumbent partner is to large-scale manufacture a biotherapeutic compound, the research firm must pass on both explicit information and tacit knowledge (e.g., by exchange of personnel) about the chemical and biological properties of the compound to facilitate the manufacturing process (see also Lerner et al., 2003).

Incumbent partners usually possess a broad knowledge base and are not specialized on a particular set of technology and products (Zhang, Charles, & Mangematin, 2007). Thus, the exchange of information and knowledge between the partners is likely more effective when the new technology firm itself has a broader knowledge base, that is, less specialized technological capabilities (Lane & Lubatkin, 1998). For example, large pharmaceutical companies sell a portfolio of drugs belonging to different compound classes (e.g., DNA, antibodies, small chemical entities) and targeting different types of diseases (e.g., cancer, cardiovascular and metabolic diseases). The scientists of the incumbent company are likely less specialized and no world-leading experts in a (emerging) scientific field (such as DNA technology), and they may have problems in assimilating the knowledge of the new firm if this firm has developed too specialized knowledge and technological capabilities. Problems may arise in communication and knowledge transfer between both partners and limit the effectiveness of the alliance process (see above). In contrast, new technology firms with less specialized internal technological capabilities and knowledge related to these capabilities will be better able to communicate with and transfer relevant knowledge to the incumbent partner, and thus speed up their product development by accessing external capabilities from that partner.

Concerning mitigation of downstream alliance risks, less specialized internal technological capabilities may provide new technology firms with more flexibility and bargaining power when entering into alliance negotiations and therefore partially escape over-control by the incumbent partner. The bargaining power of the new firm increases with the development stage of the product candidate (Aghion & Tirole, 1994), and advancing the product candidate along the value chain requires a more diverse set of technological capabilities. For instance, the development of advanced biopharmaceutical product candidates demands competencies in several disciplines including molecular biology, immunology, genetics, physiology, crystallography, and chemistry (Zhang et al., 2007). Similarly, the development of semiconductor prototypes draws on diverse competencies regarding both the components and the architecture of the product, before the prototype can be commercialized through downstream alliances with incumbents (Henderson, 1993). When the technology firm has highly specialized technological capabilities, it will only be able to cover a few and initial steps of the product’s value chain. This firm will have to form downstream alliances in early stages of the development process to advance the product, and it will enter into negotiation with little bargaining power leading to an allocation of control rights inefficient for the joint product development process (Aghion & Tirole, 1994; Lerner et al., 2003). Therefore, it appears that less specialized internal technological capabilities will be better suited to enhance the new firm’s bargaining power and counteract the risk of over-control in downstream alliances than highly specialized capabilities. Thus,
H3: The relationship between the number of vertical downstream alliances and product development of a new technology firm is more positive when the internal technological capabilities of the firm are less specialized than when they are more specialized.

RESEARCH METHOD

Data and Sample

We administered a survey among British and German biotechnology firms in 2006. The survey population is composed of all firms active in the bio-pharmaceutical sector according to the OECD definition. Firms that are not founded in the two countries or firms that are subsidiaries of foreign firms as well as firms solely offering services or supplying products without conducting R&D were excluded from our sample. Our sample was identified from several industry (e.g., Biocom, Dechema, Bio Commerce, and regional databases like Erbi, Bio-M) and internet searches. Identified firms were validated against our selection criteria with the help of biologists and biotechnologists. The final population consisted of 343 British and 346 German biotech firms.

Each firm received a personalized letter, addressed to the head of management and inviting them to participate in the survey. Prior to the field stage, we interviewed industry experts from biotechnology associations and firms which helped us to design the survey instrument. In addition, 12 pre-test interviews had been conducted to test the questionnaire, which led to some revisions, mainly in reformulating questions. We decided to perform face-to-face interviews since biotech firm managers said that they were reluctant to participate in mail and on-line surveys but were open to face-to-face interviews. Interviews were successful carried out with 118 British and 162 German firms providing us with an unusually comprehensive sample. Because this study focuses on product development, only firms active in the development of products were included, that is firms developing therapeutics, vaccines or diagnostics. Our final sample frame is 82 British and 117 German firms that match our criteria and for which we have all data to test our hypotheses.

Variables

The dependent variable in this study is a firm’s new product development. We build on previous research that has taken into account the extraordinarily long development time for biotechnological products, and the newness of the biotech industry with only a few products having reached the market (e.g. Deeds & Hill, 1996). According to these studies, an appropriate measure of the innovative output of biotechnology companies should consider products that are in regulatory trials and will hopefully reach the market at some future date. That is, we do not solely focus on products on the market but also consider products currently under development. The variable is operationalized as the logarithmic form of the sum of all internally developed products (i.e., therapeutics, vaccines, diagnostics) in a firm’s pipeline that have successfully entered preclinical and/or clinical stage as well as products that have already entered the market.

Three variables are included for the alliance portfolio of companies. Upstream vertical alliances is a count variable of a firm’s alliances with universities or publicly financed research organizations, that is, organizations focusing on upstream activities of the value chain. Horizontal alliances is a count variable of a firm’s alliances with other biotechnology firms. Accordingly, the downstream vertical alliances is a count variable of a firm’s alliances with pharmaceutical firms. In the survey questionnaire we defined an alliance as active participation in joint projects. Hereby, pure commissioning is explicitly excluded. The interviewees have been asked to provide the number of formal and informal co-operative projects. Hence, we did not restrict the analysis to
formal alliances, because to date we do not have knowledge about the extent to which formal alliances are more or less productive as compared to informal ones. Finally, technological capabilities indicate the technical specialization of firms. We operationalized the variable as a count variable representing the number of biotechnological techniques a firm is able to use in the development of its products. Hereby we differentiate between DNA/RNA based techniques, proteins and molecules, cell tissue culture and engineering as well as sub cell techniques, process techniques, bioinformatics and nanobiotechnology – the main areas of biotechnological techniques practised according to the OECD.

We included the following variables as controls because they are known or expected to influence the product development process. First, we controlled for firm age since older firms are likely to have more products in development and on the market than younger firms (Deeds & Hill, 1996). Age is measured by the log of the days from a firm’s inception to December 31, 2005. Second, we included the dummy variable VCfinanced to indicate whether a firm is venture capital financed. Venture capital financed firms might have more products in the pipeline and on the market as compared to non-venture capital financed firms since they are likely to profit from services provided by the investor and tend to have more money to spend on R&D. Third, we controlled for the effect of R&D intensity on product development by measuring the number of R&D employees since a higher R&D intensity may lead to a higher product development rate. Fourth, we controlled for the sector in which firms operate by including the dummy variable therapeutics. Firms developing therapeutics likely have fewer products in development or on the market than firms developing diagnostics. Finally, we controlled for firm location by using a dummy variable German firm that indicates whether the firm is located in Germany or in the United Kingdom.

RESULTS

Since the correlation coefficients indicated some correlation between independent variables (e.g., between vertical downstream and horizontal alliances) we tested for multicollinearity by calculating variance inflation factors (VIFs). The maximum VIF was 2.80 for horizontal alliances, which is below the acceptable threshold for multivariate analysis. Table 1 displays the results of the robust OLS regression analysis. We first entered the control variables (Model 1). This base model is statistically significant (pseudo $R^2 = 0.07$, $p < 0.07$). In the next step, we added the independent variables, resulting in a statistically significant model (Model 2) with a slight increase in explained variance as compared to the base model (pseudo $R^2 = 0.09$, $p < 0.06$). Finally, we entered the interaction variables describing our research hypotheses (Model 3). The resulting model is highly significant ($p < 0.001$). Moreover, we find a considerable increase in explained variance as compared to the base and main-effect only models (pseudo $R^2 = 0.17$).

With respect to our research hypotheses, we find statistically significant interactions between technological capabilities and (i) vertical upstream alliances, (ii) horizontal alliances, and (iii) vertical downstream alliances. In order to better understand these significant interactions we plot them on a x-axis of independent variables (upstream, horizontal, and downstream alliances) and on a y-axis of product development and plots representing specialized and diverse technological capabilities (one standard deviation above and below the mean, Figure 1).

Figure 1A shows that the relationship between the number of vertical upstream alliances a technology firm enters and the firm’s product development is more positive when the firm has more specialized technological capabilities than when the firm has less specialized technological capabilities. The nature of this significant interaction supports Hypothesis 1. Figure 1B shows that
the positive relationship between the number of horizontal alliances a technology firm enters and the firm’s product development is more positive when the firm has more specialized technological capabilities than when the firm has less specialized technological capabilities. The nature of this significant interaction supports Hypothesis 2. Finally, Figure 1C shows that the relationship between the number of horizontal alliances a technology firm enters and the firm’s product development is more positive when the firm has less specialized technological capabilities than when the firm has more specialized technological capabilities. The nature of this significant interaction provides support for Hypothesis 3. It is interesting to note that while, in relative terms, we find support for our hypotheses, in absolute terms the relationship between alliance formation and product development is positive if the firm’s degree of specialization of internal technological capabilities match with the capabilities of the (type of) alliance partner, but negative otherwise. That is, adding a new alliance either facilitates or diminishes the new firm’s product development.

**DISCUSSION**

Our paper adds the internal technological capabilities to the list of organizational factors mitigating the benefits and risks of entering into strategic alliances for new firms. So far studies have shown that alliance success is contingent on a firm’s general alliance experience (Hoang & Rothaermel, 2005), and the munificence of the financing environment (Lerner et al., 2003). Moreover, Rothaermel and Deeds (2006) demonstrated that entrepreneurial biotechnology ventures with higher levels of alliance experience gain more benefits from entering into an additional alliance (up to a certain point) than firms with less alliance experience. Our work focuses on the internal technological endowment of a new technology firm and shows that this technological endowment impacts the contribution of alliances to product development.

While we find (as expected) that this impact is more positive if the internal technological capabilities of the new firm match the type of the alliance partner, Figure 1 demonstrates that new alliances can indeed be detrimental for the new firm’s product development if the internal technological capabilities do not fit with the type of the alliance partner. Our study thus sheds more light on the dark side of new alliance formation, specifically at the organizational level. Much of this stream of literature has focused on individual alliances as the level of analysis (Deeds & Hill, 1998). However, these studies have neglected the effect alliance failure has on organizational performance. At the organizational level, many existing studies have argued that the more alliances the better for new firms (e.g. Shan, Walker, & Kogut, 1994), and only few researchers have focused on the potential dark side of adding a new alliance. These scholars found curvilinear relationships between either the total number of alliances (Deeds & Hill, 1996) or the number of upstream, horizontal, and vertical alliances (Rothaermel & Deeds, 2006) and new firm product development. The argument built is that new firms may not possess sufficient financial and managerial resources to deal with the complexity of an extended alliance portfolio, thus yielding diminishing and finally negative returns from new alliances. Although we tested for curvilinear relationships as well, we found only very limited support (only for horizontal alliances we found weak support, however, the significance of this effect disappeared after interaction effects were considered).

Instead, our data are more consistent with linear relationships between the number of upstream, horizontal, and downstream alliances and product development. These relationships, however, are only significant when interactions with technological capabilities are considered (please note that the significance of the interactions in Model 3 makes the non-significance of the linear terms for upstream, horizontal, and downstream alliances meaningless), and the firms’ technological capabilities determine, in part, whether a new alliance of either type is detrimental or beneficial to
product development. It thus appears that, in addition to diminishing and negative returns from entering into too many alliances (Deeds & Hill, 1996; Rothaermel & Deeds, 2006), negative returns from alliances can also arise for firms with low numbers of alliances when the type of the alliance entered does not match the technological capability base of the firm.

When we consider the interaction effects of internal technological capabilities with individual types of alliances, our results may help to understand previous research in the biotechnology industry. First, with respect to upstream alliances, George, Zahra and Wood (2002) found that new biotechnology firms that have links with universities do not develop more products than firms without these linkages. This mirrors our finding that there is no significant main effect of the number of upstream alliances on product development. However, our study also suggests one reason for this unexpected result – the effect of university linkages on product development can be either positive or negative, depending on the technological capabilities of the firm. Only when internal technological capabilities are specialized and the firm has a deep understanding of the university lab’s research, it appears to have enough absorptive capacity to capitalize on the scientific knowledge created by the alliance partner. Otherwise, the firm may be unable to integrate this knowledge and effectively monitor the partner’s research activities leaving it prone to the risk of opportunistic behaviour (Bower, 1992).

Second, with respect to horizontal alliances, our study indicates that they may not necessarily be as hazardous as often assumed. For example, Baum, Calabrese and Silverman (2000) found a negative effect of horizontal alliances on biotechnology firms’ patenting activities, and revenue and R&D spending growth, and other studies have also highlighted the danger of these alliances because of potential competition between alliance partners (Mowery et al., 1996; Park & Russo, 1996). Consistent with these arguments, we find a negative (although not significant) main effect of the number of horizontal alliances on product development (Model 2). However, the picture changes if we take into account interactions. Specifically, results suggest that a negative relationship is true for firms with less specialized technological capabilities, but that a more specialized capability base mitigates the risks and/or enhances the upside potential of horizontal alliances in a way that, on average, horizontal alliances are beneficial for product development. It is striking, however, that the line for positive returns (more specialized capabilities) is less positive and the line for negative returns (less specialized capabilities) more negative than for upstream and downstream alliances, respectively (compare Figure 1B with Figures 1A and 1C). This again highlights that entering into horizontal alliances is a dangerous endeavour for new firms and managers are well advised to consider whether the capabilities base of their firm matches the prerequisites to face the risks and challenges.

Third, regarding vertical downstream alliances, most scholars have emphasized the beneficial effect these alliances have on new firm product development, with only few researchers assessing their specific risks. One exception is the work by Lerner and colleagues (Lerner and Merges, 1998; Lerner, Shane and Tsai, 2003), who identified cash constraints and hostile financing environments as potentially leading biotechnology firms to enter into downstream alliances under unfavourable conditions and therefore give away much of their product’s future. In a recent study, Gulati and Higgins (2003) found no relationship between downstream alliances and IPO success of new biotech firms. The latter result may partially be explained by our findings. Since the valuation of biotech firms and IPO success is to a large extent dependent on the firm’s products under development (Deeds, DeCarolis and Coombs, 1997; Remer, Ang and Baden-Fuller, 2001), it is consistent with Gulati and Higgins that we do not find a main effect of downstream alliances on product development. However, we find a significant interaction which suggests that only a subset of biotechnology firms (those with less specialized technological capabilities) profit from
this type of alliance in terms of product development and, perhaps, subsequent IPO valuation. For another subset of firms (those more with specialized technological capabilities), however, product development (and perhaps IPO valuation) is diminished, yielding a non-significant main effect.

Our findings have implications for practice. First, managers should analyze and consider the technological capabilities endowment of their firm before looking for an alliance partner of a particular type because a firm’s composition of internal capabilities appears to influence the subsequent potential of the firm to acquire or access additional capabilities from external sources. Further, this study calls into question public policy efforts that blindly push firms to enter into alliance activities. We show that there is heterogeneity in the extent to which a firm gains from forming alliances, and pushing firms into allying too much or with the wrong partners can be detrimental to their product development efforts. For example, firms with less specialized technological capabilities might profit from entering downstream alliances with an incumbent, while this types of alliance appears less beneficial or even detrimental for firms with more specialized technological capabilities.

As all studies, this one has limitations which may be addressed by going forward scholars. First, our findings indicate that firms have to match partnering strategy with the composition of technical capabilities for profiting from alliances. Addressing the issue of technological specialization points to the discussion of breadth versus depth. Here, we do not distinguish between breadth and depth of technological capabilities, but only take into account their degree of specialization. We suggest that future research may analyze whether breadth and depth exclude each other. Moreover, we address the issue of generalizability. Caution must always be exercised when transferring results from a single industry to others. We hope that future research will verify our findings in settings other than the biotech industry.

In conclusion, we introduce the internal technological capabilities of a new technology firm as a factor mitigating the benefits and risks of new alliances for the product development process. We find differential effects for upstream, horizontal, and downstream alliances. For alliances where the acquisition and generation of knowledge is a primary goal for the new firms (upstream and horizontal), specialized technological capabilities appear a prerequisite for enough absorptive capacity to incorporate this knowledge. In contrast, when access to capabilities downstream of the new firm’s value chain is the main driver of alliance formation, it appears that less specialized capabilities are necessary to benefit the firm’s product development efforts. For either type of alliance, a misfit with the technological capabilities endowment seems to produce negative returns for the firm’s product development. These results advance our understanding of what determines the upside and downside potential of alliances.

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REFERENCES


Table 1: Results of OLS regression

<table>
<thead>
<tr>
<th>Variables</th>
<th>Model 1</th>
<th>Model 2</th>
<th>Model 3</th>
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<tbody>
<tr>
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<tr>
<td>Vertical upstream alliances</td>
<td>0.011</td>
<td>0.092</td>
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<tr>
<td></td>
<td>(0.015)</td>
<td>(0.031)**</td>
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<tr>
<td>Horizontal alliances</td>
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<tr>
<td></td>
<td>(0.018)</td>
<td>(0.036)</td>
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<tr>
<td>Vertical downstream alliances</td>
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<tr>
<td></td>
<td>(0.029)</td>
<td>(0.040)*</td>
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<tr>
<td>Technological capabilities</td>
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<tr>
<td></td>
<td>(0.045)</td>
<td>(0.049)</td>
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<tr>
<td>Vertical upstream alliances x</td>
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<td>-0.024***</td>
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<tr>
<td>Technological capabilities</td>
<td></td>
<td></td>
<td>(0.008)***</td>
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<tr>
<td>Technological capabilities</td>
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<td></td>
<td>(0.011)</td>
</tr>
<tr>
<td>Vertical downstream alliances x</td>
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<td></td>
<td>0.030**</td>
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<tr>
<td>Technological capabilities</td>
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<td>log Age</td>
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<td>(0.131)</td>
<td>(0.133)**</td>
<td>(0.132)</td>
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<td>(0.078)</td>
<td>(0.094)</td>
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<tr>
<td>Therapeutics Firm</td>
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<tr>
<td></td>
<td>(0.139)*</td>
<td>(0.135)**</td>
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<td>German Firm</td>
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<td>F-test (df)</td>
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<td>3.86(12)</td>
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Robust standard errors in parentheses
* significant at 10%; ** significant at 5%; *** significant at 1%
Figure 1: Interaction effects between the firm’s technological capabilities and (A) the number of vertical upstream alliances, (B) the number of horizontal alliances, and (C) the number of vertical downstream alliances.