The value of interfirm cooperation : an event study of new partnership announcements in the pharmaceutical industry*

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Abstract

We investigate share price responses to the formation of 237 partnerships in the biotechnology/pharmaceutical industry spanning 1995-2000. The average stock price response is positive, more so than in previous empirical works, which could be interpreted as evidence that interfirm collaboration is particularly valuable in high-technology industries. We find no evidence of wealth transfers. While all sorts of alliances can be associated to significantly positive returns, more value accrues to the partnership when it involves the creation or the transfer of technological knowledge. Looking at the firm characteristics, we conclude that being the smaller partner in a technological alliance generates higher abnormal returns (while no correlation is found in non-technological partnerships). Finally, the stock market value associated to the partnership increases with the profitability of the member firm.

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1 Introduction

This paper empirically examines the excess stock market value associated to the formation of interfirm partnerships in the pharmaceutical industry. The economic importance of alliances has increased greatly over the past 15 years. According to the National Science Board (1996)[1], the number of alliances involving an American firm has grown from 97 in 1980 to 420 in 1994. Most empirical studies also reveal that this growth has been particular spectacular in the high–technology industries (Hagedoorn, 1993; Hagedoorn et al., 2000). Nowhere is this trend sharper than in the biotechnology industry, where partnerships with pharmaceutical firms have sprang from 30 in 1981 to 171 in 1995 (Lerner and Merges, 1998). According to Shane (1994), the payments incurred through these biotechnology alliances have also increased : while actual payments through alliances during year 1981 were evaluated at only $9 millions of 1995, they reached an all–time peak in 1993, culminating around $800 millions.

Accordingly, inter-firm partnerships are now seen to be a distinguishing and widespread feature of the biotechnology/pharmaceutical complex. The advantages that they serve to embody are indeed clear enough. Young firms with novel technologies or compounds often lack the internal financial resources as well as the clinical, manufacturing and sales experience needed to turn them into successful new medicines. Due to informational asymmetries, the raising of equity or debt may be too difficult on the early stages of technology development. Likewise, research outcomes and research efforts are difficult to specify in an enforceable contract. Finally, organizational inefficiencies as well as the great uncertainty surrounding the research activity deter large firms from proceeding to more integrative strategies. Therefore, flexible partnerships appear as a convenient organizational scheme, designed as an intermediary practice

[1] Cited by Lerner and Merges (1998).

between market contracts and acquisitive strategies (Teece, 1986; Williamson, 1989).

The benefits stemming from these alliances may, however, be limited by specific costs due to agency problems, dilution of competitive advantage or asymmetric bargaining position. Still, an empirical assessment of whether collaborative ventures are effective organizational schemes presents several obstacles. An analysis of alliance outcomes is hard to provide because the failures of such schemes are rarely announced, contrary to partnership formation which is heavily advertised through press releases or regulatory filings. It is also often the case that partnership outcomes are not expected before several years, so that tracing them may require long time-series, for which data are seldom available[2]. Given these difficulties, the event study methodology, which this paper applies to partnership announcements in the biotech/pharmaceutical industry, appears as a very convenient tool of analysis : assuming an efficient capital market, investors ought to recognize the cash flow consequences of interfirm alliances when they are publicly announced. If partnerships lead to additional profits, the stock price reaction to their announcements should be favorable. Accordingly, several attempts have been made at evaluating the stock market effect of interfirm partnerships, but little work has been done on the evaluation of biotechnology partnerships despite their economic importance to the industry[3]. The event study methodology appears as very appropriate to this sector, since most biotechnology firms need to tap the financial market for funds. Therefore, the investment community is a key stakeholder that both directly and indirectly influences managers' decision making.

[2]For instance, it frequently takes a decade or more for a therapeutic product to move from animal studies and/or patent applications to approval by the Federal Food and Drug Administration. This process is filled with several stages, any of which may be considered a relevant success (or failure). Therefore, it could either be premature or unjust to consider whether an alliance has failed or succeeded in a given time span.

[3]See Hubler and Meschli (1999) for a brief survey of some of these works.

Thus, the objective of this paper is to examine the circumstances under which inter-firm partnerships in the biotechnology industry create value for the shareholders of the partnering firms. In addition, we investigate the importance of differences in the characteristics of firms and alliances in explaining the valuation variations across firms and types of partnerships. Previous empirical work has mainly focused on whether and with whom firms enter into alliances – see Kogut (1988) for an early example, Hagendoorn and al. (2000) for a survey and Shane (1994) and Majewski (1997) for two recent works devoted to biotechnology alliances. Another body of the literature has examined the structure of technology alliances including license payments (Parkhe, 1993), the form of the partnership (Pisano, 1989; Oxley, 1999) and the the allocation of property rights between the member firms (Lerner and Merges, 1998).

In contrast with most of the previous event–studies, we obtain unambiguous results regarding the impact on stock market returns of a partnership announcement. On average, firms that enter a collaborative venture experience a 3.91 % gain of the day of announcement, amounting to a gain in value of approximately $ 150 million. Chan and al. (1997) have suggested that alliances are more valuable in high–technology industries, a conclusion that seems to be borne out by this very significant estimation.

Below, we argue that the excess stock market value that results from these partnerships differs along three main dimensions. First, the value will depend upon the nature of the strategic alliance – whether it is a technical or non–technical partnership. Developing new technical knowledge is an uncertain and complex task, which cannot be easily captured through explicit, market based, transactions. Similarly, exchanges of technical information are subjected to several market imperfections (information asymmetry, lack of appropriability, tacitness) which may require non-contractual, flexible, arrangements. The strategic advantages associated to interfirm partnerships are plausibly higher when they involve some technological transfer.

Second, the value of a collaboration will depend upon the financial constraints imposed upon each partner. Start-up biotechnology firms look forward to alliances as a remedy for their lack of capital to bring their new products to the market. As their need for capital increases, so does their willingness to abandon most of the value associated to the partnership to their partner. In accordance with this intuition, we do find that less profitable firms experience lower abnormal returns when announcing a partnership.

Third, the value of a partnership to a firm will depend upon which of the partner retains the most crucial asset in the alliance. While our data do not allow us to describe the structure of control rights within each alliance, we hypothesize that if technological assets are more crucial that financing assets (usually provided by a pharmaceutical firm), R&D (i.e., smaller) firms should experience larger gains than (larger) firms that do not provide technical knowledge to the collaborative venture. A complement to this intuition relates the technological assets to the stage where the alliance is signed. Because technological compounds are specific assets which cannot be easily reallocated, we expect that the advantage of detaining technological knowledge decreases as R&D costs are sunk. Our data tend to confirm both assumptions. Smaller firms in the partnership do appropriate most of the gains associated to a new partnership and this advantage is higher when the alliance is signed in the development stage than in the production/marketing stage.

The paper is organized as follows. Section 2 discusses the theoretical framework and the related empirical literature. Section 3 describes the construction of the sample and the empirical methodology used upon it. Finally, section 4 presents the estimation results.

2 Theoretical framework and related empirical literature

Strategic alliances present organizational and strategic advantages and drawbacks. We begin by reviewing these in turn (2.1) and consider to what extent they may be particularly relevant to the biotechnology industry. In discussing the determinants of the stock market value associated to partnership formation, we choose to focus on three distinct elements : the nature of the partnership (2.2), the profitability of the partners (2.3) and the distribution of the bargaining power (2.4).

2.1 The value of interfirm partnerships

Interfirm alliances are often viewed as a mechanism for reducing the organizational inefficiencies associated to market transactions and hierarchical relationships (Williamson, 1989). While these "hybrid organizational forms" or "network organizations" do involve a mutual commitment not found in arms–length market transactions, they also have less impact on the partnering firms' operations than mergers and acquisition. Indeed, each partner can easily withdraw its resources from a joint venture or bring the partnership to a halt. On the contrary, managers are often reluctant to release the resources under their control (Jensen, 1993). Inter-firm partnerships also allow a better alignment between the entity that possesses the knowledge and the persons responsible for making decisions (Jensen and Meckling, 1991), thereby reducing the organizational costs associated with hierarchical relations.

In another strand of the literature, strategic alliances are seen as learning device (Mody, 1993). Incorporating new knowledge into existing organizations can be both time and money consuming, while acquiring it through market based transaction is very often uneffective because the degree of tacitness embedded in these transactions requires some form of cooperation between the seller and the buyer of the knowledge (Chesbrough and Teece, 1996). The ability to experiment as well as the opportunity to form multiple partnerships increases learning. Their flexibility may also be highly regarded in an environment characterized by rapid rates of product changes and significant risks of failure in product development.

Still, there can be significant costs associated to interfirm partnerships. These inefficiencies most frequently arise out of the potential for opportunism by the partner firms (Kranton, 1996). The mechanisms used to deter opportunistic behavior may also reduce the value associated to the partnership itself (Parkhe 1993). For instance, firms may prefer to commit non–recoverable assets (such as limited purpose technology, specialized physical assets with limited value outside the alliance and know-how that is of specific value to the partnership) as a pledge against defection, thereby reducing the costs associated to opportunism. In this process, however, the value associated to the collaborative venture is also reduced as each firm intends to preserve its own competitive advantage. Generally speaking, each party seeks to reduce the consequences of opportunism by precisely defining the control rights of the alliances and by lining out all contingencies. Thus, the negotiation of alliances is often a very long and uncertain process as the prerogatives of the parties in every stage of the project (from the allocation of research dollars to decisions about patent litigation and marketing strategy) are painstakingly negotiated (Lerner and Merges, 1998).

Beside these contractual inefficiencies, the partnership may also be undervalued because of agency problems between the manager and the shareholders. For instance, a manager may prefer a collaborative setting to an acquisition because the latter choice may imply its own sacking (Das and al., 1998). Asymmetry in the distribution of the bargaining power can also compel one firm to make more concessions than another, thereby reducing its expected profit in the alliance while increasing the partner's, a point we explore in more detail below. Finally, sharing competences with potential competitors could turn to the rival's advantage if he better succeeds in the race for learning that characterizes collaborative projects (Hamel and al., 1989).

These considerations may explain that the stock market return associated to partnership formation is often undetermined. With the exception of Hubler and Meschli (1999), however, most articles point out to a non–significant (Finnerty and al., 1986; Das and al., 1998) or positive (Chan and al., 1997) abnormal return on the days surrounding the announcement of the alliance. Joint ventures are almost systematically associated to positive stock market reactions (McConnell et Nantell, 1985; Woolridge and Snow, 1990; Koh and Venkataraman, 1991), but little work has been done on extending this line of inquiry to the formation of contractual strategic alliances. Yet, the type of the alliance can affect its valuation by the stock market, as shown by Koh and Venkatraman (1991).

Interfirm alliances can also exhibit considerable heterogeneity as to their industrial setting. Because we focus on a high-tech industry (i.e., biotechnology), we also expect our estimations to exceed those obtained by the previous literature. Indeed, the biotechnology industry is characterized by rapid technological change, tacit knowledge and competence, high R&D costs and great risks of technological failures, all of which should make alliances a privileged organizational form. In the biotechnology industry in particular, projects are highly complex and uncertain in their early stages, making it difficult to specify the features of the product to be developed : drafting enforceable contracts that could specify the contributions of each firm is a daunting task and this could lead firms into concluding more flexible agreements, i.e. alliances. Because of rapidly evolving technological and high failure risk, firms should also seek to make reversible commitments. On the other hand, however, the lack of enforcement could motive opportunistic behavior[4], thereby reducing the total value of the partnership[5].

2.2 Technical versus non technical alliances

Two types of collaborative organizational form are considered in the sample, *contractual alliances* and *joint ventures.* Contractual alliances involve less commitment because the partners do not form a new corporate entity separate from the parent organizations (as they do in a joint venture). The type of the alliance may determine how much value is associated to the partnership. For instance, Koh and Venkatraman (1991) examined the market value impact of partnerships formation in the information technology sector and showed that joint ventures had a greater impact than other forms of alliances.

While we do measure the abnormal returns associated to each of the organizational form separately, our main focus is on technological alliances (which involve cooperation in upstream value chain activities (R&D, engineering)) *versus* non technological alliances (involving cooperation in downstream activities such as production, sales, promotion, distribution and customer services).

The advantages of hybrid organizational forms are particularly salient when the creation or the transfer of knowledge is involved. Indeed, alliances are particularly needed when the transaction is highly complex or when there are huge development costs to be shared (Teece, 1986). In a market transaction, investments and outputs in R&D are subjected to severe moral hazard and adverse

[4] As pointed out by Lerner and Merges (1998), partnering firms often have other ongoing projects either on their own or with a competitor of their partner. In the case of a dispute, it may be very difficult for the financing firm to prove that the R&D firm has employed alliance resources to advance projects that were not part of the alliance.

[5] Madhavan and Prescott (1995) also find evidence that joint ventures will be more appreciated by the investor community when the information processing load associated with analyzing events in the relevant industry is either very low or very high.

selection problems because of the inability of the parties to observe actions and accurately assess the value of the output (Balakrishnan and Koza, 1993). Difficulties in transferring the knowledge across organizational boundaries further compounds the problem (Gulati, 1995). In contrast, non–technological alliances are typically formed when the R&D stage is over and when products need to be brought to the consumers. Therefore, uncertainty is lower, contracts are more easily written and enforced and, as a result, alliances may be less valuable.

> *Hypothesis 1. The abnormal returns associated to a technology partnership are higher than those associated to a marketing alliance.*

Because alliances are particularly frequent in high technology industries (Harrigan, 1985; Pisano, 1989; Mody, 1993), that a greater value should be associated to technological partnerships should come as no surprise (as found in Koh and Venkatraman , 1991, and Das and al., 1998). Yet, Chan and al. (1997) cannot differentiate between alliances involving R&D projects and those involving existing know/how, technologies or products – although they do find that alliances in high tech industries are more valuable (abnormal return : 1.12%, significant at the 1% level of significance) than those in low tech industries (abnormal return : 0.10 %, insignificant at conventional statistical thresholds). In a multivariate analysis, they also conclude, somewhat ambiguously that alliances involving the transfer or the pooling of a technology are better valued when the partners are in the same industry (than a non-technical alliance). It is the opposite for those alliances linking partners of a different industry.

2.3 Profitability of the firm and the value of the partnership

In the biotechnology industry, most alliances involve a biotechnology firm providing compounds and/or research expertise to a large pharmaceutical firm responsible for the financing of the project and/or the clinical trials. Such cooperative schemes are a prime source of financing for biotechnology firms, accounting for several billion dollars of funds annually (Lerner and Merges, 1998).

We expect more profitable firms to experience larger gains as they announce a partnership. Not only have they proved their ability to be effective, they also rely on available cash reserves to increase their bargaining power. Therefore, they should be in a better position to appropriate a larger share of the surplus generated through the partnership.

> *Hypothesis 2. There is a positive relation between profitability and the value of the partnership.*

While the reasoning above is intuitively appealing, it has seldom been put to test and the results that could be linked to this discussion are ambiguous at best. For instance, Lerner and Merges (1998) do find that the greater the financial resources of the technological partner, the fewer the control rights allocated to the financing firm (and plausibly, the lower the value of the partnership to this firm). However, Das and al. (1998) observe that the profitability of firms entering strategic alliances is negatively correlated with abnormal returns attributable to alliance announcements, especially so for non-technical alliances. A plausible interpretation is that cash–stretched firms are in a greater need of inter-firm collaboration. In that case, the rebound in value mainly translates the relief felt by the shareholders[6].

[6] Indeed, Mohanram and Nanda (1996) do find that joint ventures are often announced

2.4 Technological asset, firm size and the value of a partnership

The above discussion may have suggested that collaborative ventures should be less beneficial to smaller firms because they lack the financial base needed to increase their bargaining power within the alliance. Yet, small biotechnology firms are often sought out as alliance partners because of their access to proprietary technological know–how and specific research abilities. The smaller partner may thus have a greater bargaining power, which enables him to capture a larger share of the benefits generated by the alliance. All in all, the share of the cooperative surplus and, thus, the value associated to a partnership should depend on which element (financial capital or technological experience) is most crucial in the achievement of the project. Depending on the availability of alternative resources and the criticality of the resource for market success, one firm may be more dependent on the alliance than the other. ssuming that smaller firms need a technological advantage to attract their larger partner, we may thus write :

> *Hypothesis 3a. There is a negative relationship between relative size and the value of the partnership.*

In spite of its technological advantage, the smaller firms needs to confront two dangers. First, their technical knowledge may leak out to the partner : attenuation of intellectual property rights should decrease the (private) value of its technological competence and the share of the surplus it is able to appropriate. On the other hand, the tacitness of knowledge should reduce this risk. Second, the resources devoted to developing a particular compound are sunk and may not be easily transferable to another project. When the development

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when the parent firms' performance is deteriorating. On the other hand, Chan and al. (1997) report that firms forming strategic alliances exhibit better than average financial performance.

stage is over, the larger firm may be in a position to hold up the smaller partner, or more simply, to exclude the sunk R&D costs from bargaining. This leads up to the last of our hypothesis :

Hypothesis 3b. The negative correlation between relative size and the value of the partnership is stronger for alliances concluded in upstream stages.

It has often been found that smaller partners in the alliance experience a higher abnormal return than the larger partner (although the dollar value of their gains are approximately equal). For instance, Chan and al (1997) find that smaller partners experience a significative positive announcement day return of 2.22 (significant at the 1 % threshold) with a corresponding average increase in wealth of $8.9 million per firm. For larger firms, the corresponding figures are (respectively) 0.19 % (not significant at conventional statistical thresholds) and $8.1 million[7]. As pointed out by Das and al. (1998), this discrepancy is significant for technological alliances but not for marketing collaborations.

3 Data and methodology

3.1 Sample description

The construction of our dataset entailed two distinct stages. In a first step, we collected the daily cotations of a representative sample of pharmaceutical firms over the years 1994–2000. Our sample comprises 18 pharmaceutical firms and 47 biotechnology firms. These firms were all listed either on the New York Stock Exchange or on the Nasdaq at the time of the study. These stock markets are very convenient for the event study methodology because

[7] Also see McConnell and Nantell, 1985, for roughly similar results.

of their important liquidity (thus reducing the risk of asynchronism in the reactions of the investors) and because they list the majority of firms that are active in the industry.

In a second stage, we obtained dates and descriptions of the partnerships formed for the sampled firms from the *Reuters* daily news reports for the years 1995-2000. To avoid too much noise in the data as well as possible dependence between the abnormal returns, we screened the announcements to make sure that no two events occurred during the announcement period (a 3-day period centered on the event date). This led to a significantly reduced sample of event dates for large pharmaceutical firms because their size and the scope of their activities entailed a very high number of announcements each day. At the end of the procedure, 237 events (44 *joint-ventures* and 193 *contractual alliances*) remained in the sample . As expected, more than half of the partnerships involve asymmetric partners. A third of the sample is composed of alliances between small biotechnology firms. For the three–fourths of this sample (175 alliances), the cotation of only one of the two partners was available. For the remaining announcements, the stock market normal and abnormal returns were estimated for both firms. Finally, of the 237 partnerships in the sample, 66 are non-technological agreements and 124 are R&D agreements, leaving 47 "ambiguous" partnerships (such as R&D partnerships planning for a future commercial collaboration).

3.2 The event study methodology

The standard event study methodology was used here to measure the strength of investor response to joint venture announcements. It has been widely used both in financial and industrial economics and we only summarize the method[8].

[8]A detailed exposition can be found in Dodd and Warner (1983), Armitage (1995) or in McKinlay (1997). Note that the model assumes a semi–strong market efficiency so that the price of a stock reflects all the available information and is a function of the market risk

Abnormal performance for each event date is estimated using the market model[9] and daily stock returns obtained from *Datastream*. For pharmaceutical firms, the market index used in our estimation of the normal return is the *Datastream* pharmaceutical index, which comprises 80 % of the total US capitalisation of the pharmaceutical industry. For biotechnology firms, we use the Nasdaq biotech index, which is based on the daily cotations of the 193 biotechnology firms listed on the Nasdaq. Defining the announcement date as day 0, the estimation period for the market model estimates begins on day -210 and ends on day -11. Prediction errors from the market model are the abnormal stock returns. Abnormal returns are calculated for the event days -10 to +10[10] and are averaged across events and firms for each of the 21 event days.

Three distinct significance tests are used in this study. A standard t-statistics is used to determine whether the mean abnormal return is significantly different from 0[11]. Because the abnormal returns may fail to respect a standard normal distribution, we also use two non-parametric tests described in McKinlay (1997)[12]. The *sign test* is based on the sign of the abnormal return : assuming cross–stock independent abnormal returns and that the expected proportion of positive abnormal returns under H_0 is 0.5 (non–significant

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and of the firm–specific risk. Thus, it has some limitations, especially regarding departures from the capital market efficiency assumption (i.e., overreaction to events) and size effects (Bromiley and al. , 1989).

[9] To reduce the risk of data asynchronism, a market model based on Dimson's (1979) lag structure was also used. Results were left unchanged, which is not so surprising as the high liquidity of the NYSE and of the Nasdaq make data asynchronism very unlikely.

[10] The choice of the event period has been extensively discussed (Bromiley et al., 1989). Taking a conservative approach that accounts for possible information leakage before, during and after the formal announcement of the event date as well as allowing delays in processing information, we examined the market response over several time frames (i.e., 21, 11 and 3-day event windows) without incurring any significant change in the results.

[11] See the above references for a detailed description of this test.

[12] Note that these tests do not control for the possible dependence of the mean abnormal returns. Therefore, they should be used jointly with standard parametric tests.

abnormal returns), the statistic Z_{sign} writes as :

$$Z_{sign} = \left[\frac{N^+}{N} - 0.5\right]\frac{\sqrt{N}}{0.5} \sim N(0,1) \qquad (1)$$

where N^+ is the number of strictly positive abnormal returns.

Similarly, Corrado (1989) has proposed a *rank test*, which requires to rank the abnormal returns over the event window $[T_1+1, T_2]$ in ascending order. Thus, each abnormal return gets a ranking denoted $K_{i\tau}$. The stronger the impact, the higher the probability that the abnormal return on the event date gets a ranking of 1. Assuming these rankings are independent from one event to the other, the expected rank K_{H0} of the abnormal return at the event date under the assumption H_0 is :

$$K_{H0} = \frac{L_2+1}{2}$$

where L_2 is the length of the event window ($L_2 = T_2 - T_1$).

The statistic of the rank test over the event window $[T_1+1, T_2]$ writes as :

$$Z_{rank} = \frac{\frac{1}{N}\sum_{i=1}^{N}\left(K_{i0} - \frac{L_2+1}{2}\right)}{\sqrt{\frac{1}{L_2}\sum_{\tau=T_1+1}^{T_2}\left[\frac{1}{N}\sum_{i=1}^{N}\left(K_{i\tau} - \frac{L_2+1}{2}\right)\right]^2}} \sim N(0,1) \qquad (2)$$

Finally, a similar methodology is used to analyse the volumes of transactions V_{it}, defined as the transactions payments over market value (rotation rate).

$$V_{it} = \frac{log(1+TR_{it})}{log(1+MV_{it})} \qquad (3)$$

where V_{it} is the transaction volume of stock i at date t, TR_{it} is the transaction payments made over stock i at date t and MV_{it} is the market value of firm i at date t.

The expected volume of transaction in the absence of a partnership ($V_{i\tau}$) is estimated over a 200–day period preceding the event window[13] using the constant mean volume model as recommended by Mai et Tchemeni (1996). Thus, let us note $\overline{V}_i$ the mean transaction volume of stock i calculated over an estimation period of length L_1 ($L_1 = T_1 - T_0$) :

$$\overline{V}_i = \frac{1}{L_1} \sum_{t=T_0+1}^{T_1} V_{it} \tag{4}$$

Hence, the "normal" transaction volume for stock i at date t writes as :

$$V_{it} = \overline{V}_i + \xi_{it} \tag{5}$$

where :

$$E(\xi_{it}) = 0 \quad var(\xi_{it}) = \sigma^2_{\xi_i} \tag{6}$$

V_{it} refers to the transaction volume of stock i at date t and ξ_{it} is the corresponding residual term of zero mean and constant variance equal to $\sigma^2_{\xi_i}$.

4 Empirical results

We now turn to the results that were obtained when applying this methodology to the announcements of new partnerships. We find that the abnormal returns are unsensitive to the model used to estimate the normal returns. They also remain constant over different event windows. Therefore, we mainly focus on the results obtained on the basis of the market model and of a 21-day event window. We begin the discussion of empirical results by presenting the

[13]The length of the event window is of 11 and 21 days. A 3–day event window turned to be too short to assess the impact of a given event.

abnormal returns calculated for our sample of events (4.1). We next investigate whether the announcement period abnormal returns follow the main hypothesis outlined in paragraphs 2.2, 2.4 and 2.3 (4.2).

4.1 The abnormal returns associated to interfim partnerships

Table 1 presents the abnormal returns for the subsamples of joint ventures and contractual alliances. The 3-day mean cumulated abnormal return for contractual alliances is a highly statistically significant 3.91 % corresponding to an average increase in wealth of $152 million. The corresponding figures for joint venture formation are a statistically significant 4.09 % corresponding to gain in wealth of $150 million. This evidence suggests that establishing strategic relationships creates significant value for the shareholders of the partnering firms and that there are no significant differences between contractual alliances and joint ventures. Also note that most of the price adjustment occured on the announcement day, which should not come as a surprise since our sample of dates come from wire services (as opposed to the Wall Street Journal). More importantly, there does not seem to be any information leakage before the formal announcement of partnership creation[14].

Table 1 also reports a cumulated increase of 13.2 % in the volumes of transaction. The corresponding figure for joint ventures is slightly lower (9.7 %). The financial markets react more promptly to a joint venture announcement : in that case, abnormal transaction volumes only last for 2 days (instead of 7 days in the case of partnerships). One tentative explanation is that the evaluation of a contractual partnership requires more information about how intellectual property rights are distributed between both partners[15].

[14]Detailed results for each of the 21 event window days are available on request.

[15]The creation of a joint venture generally stipulates the structure of ownership. On

These abnormal returns are well above the estimations found in the previous literature. For instance, McConnell and Nantell (1985) obtained a significant two-day average of 0.74% for 104 US joint ventures. Similarly, Koh and Venkatraman (1991) concluded to a significant 0.87 abnormal return for 175 US joint-ventures. Using a dataset of 345 contractual agreements, Chan and al. (1997) estimate a significant 0.64 % abnormal return. On the contrary, Das and al. (1998) indicate that their sample of 119 contractual arrangements could only be associated to a marginally significant 0.05 % abnormal return. As discussed before, part of the difference could be attributed to the high-technology industry we are focusing on[16]. The rapid pace of technological change as well as the profound changes the industry has gone through are likely to render partnerships more desirable and valuable. Also, the formation of a partnership may be a unique opportunity for cash-constrained firms to bring one of their compounds to pharmaceutical form and, further, to commercialisation. Finally, a collaboration project could carry a strong signal towards the financial community regarding the viability of the technological path followed by the firm.

To examine whether the observed wealth effect is due to value creation or value appropriation (wealth transfers between the partners in the alliance), we compare the wealth changes experienced by pairs of partner firms. These exhibit a very clear pattern, in the sense that the *Reuters* description of each partnership led us to identify a (smaller) technology-buying and a (larger) technology-selling firm. As indicated earlier, there are 62 alliances for which price data are available for both partners. As seen from table 1, technology-

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the contrary, interfirm agreements do not systematically clarify the terms of the contract (duration, license fees, etc.), at least not publicly.

[16] Although this discrepancy could also be related to the relatively small size of our sampled firms, it should noted that even the estimated dollar changes in wealth are higher in our sample than in the previous empirical literature. For instance, Chan and al. (1997) conclude to a combined wealth change of "only" $17 million.

selling firms experience a significant positive announcement period abnormal return of 7.09%, while technology buying firms experience a (non-significant) 3-day abnormal return of 0.30%. Corresponding gains in wealth amount to $66 and $57 million, respectively. In other words, though the abnormal returns are significantly different between groups, the dollar value of their gains are approximately equal. We conclude that value is created by the formation of the partnership and that there is no evidence of wealth transfers between technology-selling and technology-buying partners.

This result is clearly in accordance with those obtained by McConnell and Nantell (1985), Koh and Venkatraman (1991), Chan and al. (1997) and Das and al. (1998) among others : shareholders of the smaller partners (technology-selling firms in our sample) earn significantly positive returns while those of larger partners (technology buying firms in our sample) earn insignificant returns. The large difference in our estimations should be attributed to the extreme distribution of sample firms : the average size of technology selling firms is less than 50 times that of technology buying firms.

Let us conclude on this point by looking at the abnormal rotation rates. These tend to corroborate the preceding results : for technology selling firms, we identify a strong increase in the number of shares exchanged (+20.7 % over seven trading days). We also report a slight but significant increase in the volume of trade for technology buying firms (1.6 %).

The conclusion that smaller (technology-selling firms) gain more (or at least as much) from interfirm partnerships as their larger partners tends to corroborate hypothesis 3a. It therefore appears that owning technological capital is highly rewarded by the financial markets. This assumption is further explored in the next section.

INSERT TABLE 1 HERE

Before that, we begin to explore whether technological alliances add more value to the partnering firms than non-technological alliances. To this end, we divide the sampled partnerships in technological and non-technological groups. The former group comprises 124 alliances, the latter one 66 (47 partnerships were ambiguous in their nature and were dropped out). Technological alliances lead to highly significant 3-day mean abnormal return of 4.2 %, whereas non-technological alliances result in a significantly lower 3-day mean abnormal return of 2.6 % (table 2). These results support our argument in section 2.2 that flexibility and ability to experiment are particularly valuable in complex transactions associated to a high risk of failures. They are also in accordance with most of the past literature, which stressed that technological partnerships generate greater value (Koh and Venkatraman, 1991; Das and al., 1998). This finding is further supported by the analysis of volume trading : the increase in the number of traded shares is of 15.2 % when the firm announces a technology partnership, to be compared to 5,8 % when it announces a commercial agreement. Finally, note that the non-technological partnerships is still associated to a significant 3-day abnormal return, a result which contrasts with previous estimations (where non-technical partnerships very rarely yield significant returns). Again, we believe this discrepancy should be attributed to specificities of the industry under consideration (namely, its high tech nature) and to the small average size of our sample firms.

It should be stressed however that the wealth gains associated to each partnership type are not significantly different from each other (table 2). Again, this very probably stems from the fact that larger (resp., smaller) firms announce more (resp., less) commercial partnerships that smaller (resp. larger) firms, so that the excess value associated to these agreements is naturally greater than that related to technology alliances (where smaller firms are more frequent). To control for the impact of firm size and deepen the hypothesis testing, the next section presents a regression analysis of the 3-day event period abnormal returns.

INSERT TABLE 2 HERE

4.2 Hypothesis testing

Section 2.2, 2.3 and 2.4 delineated three hypothesis on how investors may react to the formation of a partnership. These hypothesis hinged on :

- the type of the agreement
- the profitability of the firm
- the relative size of the firm

In dividing the initial sample into subsamples of firms or agreements, the previous subsection provided some statistical evidence that the first and the last of these intuitions. Their empirical relevance is now assessed through a regression analysis. Following MacKinlay (1997), the 3-day cumulated abnormal return serves as a dependent variable in all the regressions. The t statistics are computed following the White/Huber method and are robust to heteroskedasticity. There is a very low risk of multicolinearity as the crossed correlation coefficients never exceed 0.4 in any of the regressions. Moreover, the variance inflation factor is always inferior to 3, i.e., well below the conventional thresholds. Finally, we do not observe any correlation between the residuals and the independent variables For all regressions, model 1 presents the results of an ordinary least square estimation, while model 2 adds 10 (11-1) categorical variables designed to capture therapeutic class effects[17]

[17]With the help of doctors, pharmacists and scientists from various organisms (firms as well as universities and government–sponsors organisms), 11 therapeutic classes were designed and each announcement was related to a single category.

4.2.1 R&D agreements *versus* marketing agreements

In the previous section, we observed that technological agreements yielded a higher abnormal return than non–technical agreements. Part of this result was attenuated by firm size, however : smaller firms tend to announce more technological agreements, so that we cannot distinguish the empirical significance of the agreement type (relative to firm size). We therefore proceed to the following regression :

$$CAR_{i,(-1,+1)} = \gamma_0 + \gamma_1 MV_i + \gamma_2 ADEV_i + \varepsilon_i \tag{7}$$

where $CAR_{i,(-1,+1)}$ is the cumulated abnormal return of stock i over a 3-day period centered on the event date, MV_i is the market value (in logarithm) 2 days before the partnership was announced and $ADEV_i$ is a dummy variable equal to 1 (resp. 0) if the firm is engaged in a technological (resp. non-technological) partnership (ε_i is the residual term of zero mean).

INSERT TABLE 3 HERE

The coefficients and the associated t-statisitics are presented in table 3. Although the size coefficient is negative and highly significant (as expected), it stills remains that technological partnerships generate higher cumulated abnormal returns (relative to commercial partnerships), thus confirming our earlier results. The use of a fixed effect model to account for specific effets related to the therapeutic classes included in our sample does not alter this conclusion.

4.2.2 Firm profitability

In section 2.3, we argued that more profitable firms should experience higher mean abnormal returns because their capital base and strong performance should guarantee them a stronger bargaining position. We thus proceed to the following regression :

$$CAR_{i,(-1,+1)} = \beta_0 + \beta_1 MV_i + \beta_2 PROF_i + \varepsilon_i \qquad (8)$$

where $PROF_i$ is profit/turnover ratio (the year preceding the partnership) collected through the *Datastream* server. Like the stock-market capitalisation, it is expressed in logarithm. Consistently with our expectations, the variable $PROF_i$ is positive and significant at a 5 % level (table 4). Again, controlling for the specific effects related to different therapeutic classes does not modify the results.

INSERT TABLE 4 HERE

4.2.3 Firm size

Finally, section 2.4 posited that technological advantage gives smaller firms the upper hand in the negotiation of alliances. Thus, they should experience higher abnormal returns when announcing a partnership. We also argued that this advantage should gradually recede as R&D costs are sunk so that this intuition should be valid for technological alliances only. Assuming the smaller firm in the alliance detains the technological asset, we proceed to the following regressions :

$$CAR_{i,(-1,+1)} = \lambda_0 + \lambda_1 MV_i + \lambda_2 LEAD_i + \varepsilon_i \qquad (9)$$

$$CAR_{i,(-1,+1)} = \theta_0 + \theta_1 MV_i + \theta_2 ADEV_i + \theta_3 LEAD_i + \varepsilon_i \qquad (10)$$

$$CAR_{i,(-1,+1)} = \delta_0 + \delta_1 MV_i + \delta_2 PROF_i + \delta_3 LEAD_i + \varepsilon_i \qquad (11)$$

where $LEAD_i$ is a dummy variable equal to 1 if firm i's market value exceeds that of its partner, and 0 otherwise.

INSERT TABLE 5 HERE

The regression results displayed in table 5 all validate hypothesis 3a. The Fisher test comparing the abnormal returns for the small and large firms is systematically significant at the 1 % level.

We relate the greater abnormal returns experienced by the smaller firms to their technological position. Indeed, biotechnology alliances often involve the larger partner acquiring the technology of its smaller counterpart. The estimations conducted over pairs of partner firms have demonstrated that technology selling firms appropriate most of the value generated by the partnership. Below, we find evidence that this result should not be solely attributed to smaller partner size. More specifically, we proceed to the following regressions :

$$CAR_{i,(-1,+1)} = \omega_0 + \omega_1 MV_i + \omega_2 MONT_i + \varepsilon_i \tag{12}$$

where $MONT_i$ is the financial payments entailed by the partnership. They are positive if the firm under consideration is a net receiver, and negative or nil otherwise. They are expressed in logarithm. As indicated by table 6, those firms that receive financial payments enjoy significantly greater rewards than those who grant these payments.

INSERT TABLE 6 HERE

Finally, to test the validity of hypothesis 3b, we proceed to the following regression :

$$CAR_{i,(-1,+1)} = \mu_0 + \mu_1 MV_i + \mu_2 DEVL_i + \mu_3 DEVNL_i + \mu_4 NDEVL_i + \varepsilon_i \tag{13}$$

where $DEVL_i$ is a dummy variable equal to 1 when the firm is engaged in a R&D collaboration and is of a greater size than its partner (0 otherwise), $DEVNL_i$ is a dummy variable equal to 1 if firm i participates in an R&D collaboration and has a lower market capitalisation than its partner (0 otherwise), $NDEVL_i$ is a dummy variable equal to 1 if firm i is engaged in a commercial partnership and displays a greater market value than her partner (0 otherwise). Therefore, firms that participate in commercial partnership and are of smaller size (than their partner) are used as the reference. Hypothesis 3b stipulates that firms of smaller size should experience greater abnormal returns when they form a technological partnership with a larger firm (so that μ_3 should be significant and positive).

Consistently with this intuition, table 7 indicates that large firms do not reap smaller (or higher) rewards than their smaller partners when the agreement is a non-technological alliances ($\mu_0 \simeq (\mu_0 + \mu_4)$). On the other hand, smaller firms are the main beneficiaries of partnership formation when the agreement is of a technological type ($\mu_3 > \mu_2$). Thus, these results support hypothesis 3b. They also confirm the results obtained by Das, Sen et Sengupta (1998).

INSERT TABLE 7 HERE

5 Conclusion

We provide evidence concerning the impact of strategic alliances on the wealth of the partnering firms' shareholders. On average, we find significant positive wealth effects from the formation of such alliances and no evidence of wealth transfers between the members. These result support the conjecture made in the industrial literature that the gains associated to strategic alliance exceed their organizational and strategic costs. Our estimations are also significantly superior to those obtained by previous event-studies of partnership formation, a feature which we relate to the high–tech nature of the biotechnology/pharmaceutical industry.

Indeed, while we cannot identify any difference between contractual alliances and joint ventures, we do find that technological alliances yields greater returns than non-technological partnerships. Still, contrary to the past literature, non-technological alliances also yield a significant positive abnormal return, a result which contrasts with past evidence and which should be linked to the specificities of the high-tech industries.

Finally, relating the abnormal returns to several firm-level characteristics, our regression results confirm the negative correlation found between size and the abnormal return associated to a partnership. The smaller partner also appropriates most of the surplus generated through partnership formation, especially so when the it sells a technology to the larger partner. On the other hand, we also find that the abnormal return are positively related to the rate of profit. These results suggest that alliances with pharmaceutical firms are a profitable strategy for small biotechnology start-ups, despite their organizational and strategic costs.

Table 1: Excess market value

	Contractual agreements			Joint-ventures
	All firms involved ($N = 299$)	Technology selling firms ($N = 62$)	Technology-buying firms ($N = 62$)	All firms involved ($N = 44$)
$CMAR_{-1,+1}$ (in %)	3.91***	7.09***	.32	3.92***
Z_{sign}	5.14	4.06	.85	3.40
Z_{rank}	3.56	3.19	1.04	3.10
Mean market value (in mil. $)	12952.49	1258.08	53640.61	5920.65
Excess market value (in mil. $)	151.63	66.00	57.72	149.92
Excess volumes (in %)	13.19***	20.67***	1.61**	9.74***
Z_{sign}	8.74	5.46	1.41	3.80
Z_{rank}	3.51	3.02	.40	2.64
Number of days with significant excess volumes	7	7	2	2

*, ** and *** indicate the 10, 5 and 1 % levels of significance (parametric, i.e., Student, tests.

Table 2: Excess market value associated to partnership formation

	Technology agreements ($N = 162$)	Commercial agreements ($N = 81$)
$CMAR_{-1,+1}$ (en %)	4.20***	2.64***
Z_{sign}	4.95	1.91
Z_{rank}	3.38	1.94
Mean market value (in mil. $)	16084.04	23648.08
Excess market value (in mil. $)	71.77	67.30
Excess volumes (in %)	15.19***	5.84***
Z_{sign}	8.09	3.46
Z_{rank}	3.42	2.63
Number of days with significant excess volumes	7	4

*, ** and *** indicate the 10, 5 and 1 % levels of significance (parametric, i.e., Student, tests).

Table 3: Abnormal returns and the type of the partnership

$CAR_{i,(-1,+1)}$	(1)	(2)
MV_i	-.049***	-.055***
	(-5.790)	(-4.829)
$ADEV_i$	.016**	.017**
	(2.345)	(2.036)
Const.	.024***	.029***
	(4.650)	(4.725)
N	243	243
F	17.89	11.99
Prob.>F	.000	.000
Adjusted R^2 (%)	5.67	8.57

(1) OLS regression
(2) Fixed effect over therapeutic classes
*, ** and *** denote, respectively the 10 %, 5 % and 1 % thresholds of significance
Heteroskedastic-consistent t-statistics in parenthesis.

Table 4: Abnormal returns and profitability

$CAR_{i,(-1,+1)}$	(1)	(2)
MV_i	-.046***	-.054***
	(-4.545)	(-4.121)
$PROF_i$	.009**	.008**
	(2.295)	(2.309)
Const.	.044***	.052***
	(5.832)	(5.539)
N	243	243
F	14.64	12.13
Prob.>F	.000	.000
Adjusted R^2 (%)	9.73	12.74

(1) OLS regression
(2) Fixed effect model over therapeutic classes
*, ** and *** denote, respectively the 10 %, 5 % and 1 % levels of significance
Heteroskedastic-consistent t-statistics in parenthesis.

Table 5: Abnormal returns and relative firm size

	Regression 9		Regression 10		Regression 11	
$CAR_{i,(-1,+1)}$	(1)	(2)	(1)	(2)	(1)	(2)
MV_i	-.027***	-.032***	-.022***	-.029***	-.020**	-.029*
	(-3.778)	(-2.628)	(-3.124)	(-2.505)	(-2.581)	(-1.967)
$LEAD_i$	-.043***	-.040***	-.044***	-.040***	-.051***	-.047***
	(-4.162)	(-3.270)	(-4.166)	(-3.291)	(-3.781)	(-2.671)
$ADEV_i$			.017**	0.017**		
			(2.367)	(2.074)		
$PROF_i$					.005**	.007*
					(2.016)	(2.056)
Const.	.060***	.063***	.046***	.050***	.070***	.077***
	(6.497)	(5.954)	(5.521)	(5.218)	(5.544)	(4.903)
N	243	243	243	243	243	243
F	25.30	15.37	17.72	10.69	13.76	9.57
Prob.>F	.000	.000	.000	.000	.000	.000
Adjusted R^2 (%)	12.81	13.70	13.75	14.20	18.65	18.18
F $[\lambda_0 > (\lambda_0 + \lambda_2)]$	17.32	10.70	17.35	10.83	14.29	7.14
Prob.>F	.000	.001	.000	.001	.000	.009

(1) OLS regression
(2) Fixed effect model over therapeutic classes
*, ** and *** denote, respectively the 10 %, 5 % and 1 % thresholds of significance
Heteroskedastic-consistent t-statistics in parenthesis.

Table 6: Abnormal returns and financial payments

$CAR_{i,(-1,+1)}$	(1)	(2)
MV_i	-.054**	-.051**
	(-2.368)	(-2.260)
$MONT_i$	.012**	.012***
	(2.537)	(3.317)
Const.	.051***	.052***
	(5.746)	(5.039)
N	139	139
F	13.66	9.59
Prob.>F	.000	.000
Adjusted R^2 (%)	18.28	16.76

(1) OLS regression
(2) Fixed effect model over therapeutic classes
*, ** and *** denote, respectively the 10 %, 5 % and 1 % thresholds of significance
Heteroskedastic-consistent t-statistics in parenthesis.

Table 7: Abnormal returns, type of the partnership and firm size

$CAR_{i,(-1,+1)}$	(1)	(2)
MV_i	-.026***	-.035***
	(-3.704)	(-2.913)
$DEVL_i$	-.008	-.004
	(-.770)	(-.326)
$DEVNL_i$	.044***	.046**
	(3.082)	(2.542)
$NDEVL_i$	-.008	-.007
	-.765	-.494
Const.	.024***	.028***
	(2.752)	(2.669)
N	243	243
F	13.04	8.02
Prob.>F	.000	.000
Adjusted R^2 (%)	15.27	15.16
F [$\mu_0 > (\mu_0 + \mu_4)$]	.59	.24
Prob.>F	.445	.622
F [$\mu_3 > \mu_2$]	17.53	10.98
Prob.>F	.000	.001

(1) OLS regression
(2) Fixed effect model over therapeutic classes
*, ** and *** denote, respectively the 10 %, 5 % and 1 % thresholds of significance
Heteroskedastic-consistent t-statistics in parenthesis.

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