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ABSTRACT

For young technology firms, acquiring resources can often be costly due to the information asymmetry and uncertainty that exist surrounding the new technology. We contend that managers of technology companies use signals strategically as a potent tool for mobilizing necessary resources. We specifically examine a financing phenomenon known as private equity, or private placements. Our empirical analyses focus on the degree to which private equity placements are effective signals about firm quality. We examine whether these signals enable technology to mobilize three kinds of resources: capital, research partners, and commercial partners. Overall, the empirical analyses demonstrated consistent and cogent effects of the signaling properties of private equity placements on the ability to attract financial and complementary resources.

Keywords: *signaling, proprietary technology, private equity, information asymmetry, resource acquisition*

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The development and commercialization of a new technology often requires access to complementary resources, such as financial capital, human capital, and expertise in research, marketing or distribution, that are only available from sources outside the firm. For young, unproven firms, acquiring such complementary resources can often be costly due to the information asymmetry and uncertainty that surround their technology. In order to attract the attention of external resource providers, these firms must demonstrate not only that they are worthy recipients of new resources, but that they have sufficient stability to commercialize their new ideas. Young firms find this to be a challenge with proven technologies and codified knowledge; it is even more difficult when the firm's most valuable resources are intangible, tacit, complex, non-codifiable, causally ambiguous, or socially embedded (Lippman and Rumelt, 1982; Dierickx and Cool, 1989; Barney, 1991; Kogut and Zander, 1992). These characteristics limit a firm's ability to convey information about its stock of knowledge. Even if managers could transmit this knowledge, a desire to keep it proprietary limits their inclination to reveal such information to external resource providers (Liebeskind, 1997). Thus, when there are no bases for evaluation, even high "quality" firms face considerable challenges in acquiring financial and complementary resources necessary for growth.

Firm managers able to *signal* financial or alliance partners the value of their knowledge will be positioned better than rivals to attract resources. Like Heil and Robertson (1991), we adopt the view that managers purposefully signal external constituents and that signaling is a beneficial strategic tool. Rather than focusing on competitive signaling, however, we contend that managers of technology companies use signals strategically as a potent tool for mobilizing necessary resources.[1] Furthermore, we expect that the strength of the signal will influence the extent to which resources can be obtained by the firm.

The signal on which we focus relates to the firm's choice of financing. While capital is a commodity, we believe that how it is acquired has strategic implications for how and whether firms acquire other complementary resources. We specifically examine a financing phenomenon known as private equity, or private placements. While private equity transactions may be viewed as a form of governance that is optimal for dealing with information asymmetry (Williamson, 1988), we contend that it is also a mechanism by which managers signal firm value to outsiders.

Private placements represent the fastest growing segment of the capital markets (Fenn, Liang and Prowse, 1997), outstripping the growth of almost every class of financial product. It is estimated that the pool of private equity funds grew from $5 billion in 1980 to over $175 billion in 1999 (Lerner, 2000), with significant contributions made in the areas of biotechnology, pharmaceuticals, and software. Private placements account for a large fraction of equity raised by firms. In 1994, for instance, private placements of equity accounted for $25 billion out of total of $85 billion of all new stock issues in the U.S (The Federal Reserve Bulletin, 1996). The issue process in private placements differs fundamentally from that in public offerings. For example, firms issuing equity privately do not have to file a registration statement with the SEC. The shares they sell privately may be either registered or unregistered, but they should be placed with "sophisticated" investors since there are no formal disclosure requirements.[2] For reasons to be described in the next section, it is the explicit preference that existing public firms have for private equity placements over seasoned public offerings that signal a firm's undervaluation.

Our empirical analyses examines how the ability of public biotechnology firms to attract financial and strategic partners is affected by the signaling properties of private equity placements. One way to measure the effectiveness of a firm's signal is to use an event study, where the signal's impact, or "abnormal return", is measured using changes in the firm's stock price over a relatively short period of time. We complement our event study by using hazard rate modeling to examine how the private placement signal affects firms' speed and ability to attract crucial resources for growth: capital, research partners, and commercial partners.

INFORMATION ASYMMETRY, ADVERSE SELECTION, AND SIGNALING

When there is a regime of rapid technological development, research breakthroughs are so broadly distributed that no single firm has all the internal resources and capabilities necessary for success (Powell, Koput and SmithDoerr, 1996). Technology firms commonly need to form strategic alliances, vertically (both upstream and downstream), laterally, and sometimes horizontally in order to develop and commercialize new technologies. Furthermore, in the early stages, these firms do not have a steady stream of internally generated cash with which to fund new opportunities. Organizations, particularly R&D intensive entrepreneurial firms, can find themselves lacking resources to efficiently develop new technologies. Thus, attracting resources is a key challenge for young technology companies.

The dilemma for young technology firms is that resource providers have obvious problems in evaluating the focal firm's prospects for new products and processes. When unable to reliably evaluate the firm, the cost of exchange increases (Williamson, 1985).

One challenge in valuation may be tied to market or technological uncertainty. However, resource providers may also find it difficult to evaluate firms because of information asymmetry - they cannot obtain freely (or at all) information available to managers within the firm. Several factors may prevent managers of young technology firms from conveying full information about growth opportunities: a desire to keep technology proprietary and an inability to specify the "quality" of the firm's capabilities.

Most firms face the problem that at least some of their valuable knowledge can be appropriated (Cheung, 1982). For young technology companies, innovation and technology are the key competitive resources. Only knowledge that is asymmetrically distributed among firms for sustained periods of time can earn rents. The highly specialized nature of young technology companies and the absence of good property protection create strategic risks. The more details about their research they communicate, the more they risk the expropriation of their proprietary knowledge. Some firms go to great lengths to protect their technology from diffusing to other organizations. However, strategies to keep technology proprietary are both difficult to develop and costly to monitor (Liebeskind, 1997).[3]

Some technology cannot be fully appropriated by rival firms. A rival's use of a firm's knowledge may be limited by a lack of complementary assets (Teece, 1986) or absorptive capacity (Cohen and Levinthal, 1990), or because the firm's knowledge is complex (Winter, 1987). Similarly, it may be very difficult for one firm to replicate perfectly the valuable activities or technology of another firm because of causal ambiguity (Lippman and Rumelt, 1982) or because the knowledge is not codified.

Whether a technology firm intentionally or unintentionally keeps secrets from rivals, it is common for resource acquisition to proceed under conditions of ignorance. Accordingly, at least until reputations become established, exchange is likely to be exposed to hazards (Teece, 1996).[4] When firm managers have information that outsiders lack, problems of adverse selection erupt - managers of low quality firms have incentives to misrepresent the value of their firms.[5] The costs of exchange escalate when buyers cannot verify the quality of the product they are offered (Akerlof, 1970). Potential financial and alliance partners face a risk of not being able to differentiate between high and low quality firms. While both high and low quality firms risk not receiving the necessary resources, it is the high quality firms that "lose out" because the price offered does not reflect their true ability and therefore is judged unattractive. Problems of adverse selection and moral hazard are particularly poignant for young technology firms (Amit, Brander and Zott, 1998).Thus, acquiring resources is not only vital to capitalize on growth opportunities, but it represents a key competitive challenge for managers of high quality technology companies. We are interested in how managers of high quality technology firms overcome problems of adverse selection so that they can acquire financial and complementary resources at terms consistent with their value.

The transactional hazards aroused by information asymmetry and the potential for adverse selection disappear if managers can convey value to financial and alliance partners (Teece, 1996) without divulging the bases for their competitive advantage. Two such ways to convey value are signaling and reputation (Rasmusen, 1995). Firm reputations are based *directly* on an ability that is *observable* over time. Reputations develop by repeatedly accomplishing observable goals. Until reputations become established, technology firms must rely on signaling to resolve the threat of adverse selection. Signaling requires neither repetition nor the direct observation of high ability. Instead, the signaling action is useful because it is *related* to high ability (even though it need not be directly related). For example, individuals may signal job aptitude through education (Spence, 1974). Prospective employers cannot directly observe an individual's skill level, but they reason that more highly educated workers possess greater skill. For the education signal, or any other signal to be effective, it must be more costly for low ability firms to signal than for high ability firms. Outside observers can thus "separate" high quality firms from low quality ones.

We feel the distinction between reputation and signaling is one with important implications for strategy researchers and general managers. Firm reputation has been lauded as a key resource, and for good reason. However, if reputation is merely the product of a series of past successes or abilities, then it may most accurately be described as an aggregate measure, or stock, of ability. Furthermore, the prospects for building a reputation are quite time consuming and not strategic in the short-term. On the other hand, signals can be initiated quickly and purposefully. They can have short-term consequences, in terms of re-aligning valuations to acquire the necessary resources. Signals can also have long-term consequences, in terms of fueling growth or providing a buffer to withstand poor performance and liquidity problems without having to exit the business (Levinthal, 1991). In one sense, signals allow firms to adjust their reputation as perceived by potential resource providers to a level consistent with what managers believe it ought to be.

What mechanisms exist through which technology firms can signal the value of their company, while at the same time retaining a level of confidentiality about the processes and research methods being used for their new products? Deeds, DeCarolis, and Coombs (1997) argued that biotechnology firms do so in a number of ways. In support of their claims, they found that location decisions, the number of products under development, and citations by firm scientists influence the amount of capital raised in initial public offerings (IPOs).[6] While these variables may appear outwardly similar to signals, the last two represent *direct* indicators of ability and therefore pertain to reputation, while location decisions are a static signal initiated at the founding of the firm. Stuart, Hoang, and Hybels (1999) found that prominence of alliance partners was related to the speed at which biotechnology firms undertook IPOs. Furthermore, the benefits to signaling through "endorsements" were enhanced with greater uncertainty about the firm. As with Deeds, DeCarolis and Coombs (1997), it is quite difficult to disentangle reputation effects from signaling effects. We feel this distinction is important to fully diagnose the effects and the usefulness of strategic signaling on the ability to attract resources.

We explicitly focus attention on the signaling event. In particular, we examine the effects of signal timing and signal strength. Our work differs from Stuart, Hoang and Powell (1999) in other important respects. For example, we consider that firms need to signal post-IPO because their capabilities are constantly evolving and so too does information asymmetry. We also examine whether signals assist firms in attracting multiple types of resources, not just capital. Finally, the signal on which we focus relates to a financing event, specifically the preference for public firms to choose private equity financing over public equity financing.

Private Equity Placements as Signals

Public equity markets and private equity markets differ substantially in their capacity to deal with adverse selection. Myers and Majiluf (1984) were the first to identify the hazard of adverse selection leads to a fundamental paradox in public equity markets. Aware that managers of low quality firms may misrepresent the value of the firm's assets, market participants may be unwilling to provide capital to any firm at above average levels if they cannot effectively evaluate the value of that firm. In their model, managers and shareholders of high quality firms will forego public equity markets because they are unable to command a price consistent with the quality of their firms. This theory explains why firms experience negative abnormal returns of 3 percent, on average, at the announcement of seasoned public equity offerings.[7] The average negative abnormal return suggests that the market "adjusts" its valuation of the firm downward subsequent to learning of the intent to issue public equity.

The implication is not that weak firms issue public equity. Clearly, initial public offerings are an important stage in the life of a firm, and key investors such as venture capitalists wish to take public the companies as soon as they anticipate favorable valuations. In contrast to returns on seasoned equity issues, initial public offerings have very positive abnormal returns.[8] When other measures of firm performance are lacking, the rate at which firms can issue IPOs may be a reasonable substitute. However, when the firm is already public, it seems that the decision to issue further public equity does not have the same information content.[9] The implication of Myers and Majluf (1984) is that when resource providers to not have sufficient information about the public firm to reach an independent conclusion about its future prospects, a decision to issue public equity suggests that managers believe the firm is overvalued relative to the firm's true value.

In contrast to announcements on seasoned public offerings, firms with publicly-traded stock announcing private equity placements receive positive abnormal returns on average. Hertzel and Smith (1993) found that private equity placements are accompanied by positive abnormal returns of 1.72 percent, while Wruck (1989) found returns of 4.40 percent. There are two primary explanations for these positive returns around the event.[10] First, Hertzel and Smith (1993) argued that these positive returns reflect the fact that private equity placements credibly signal that the firm is undervalued due to information asymmetry. The second explanation for positive abnormal returns with private equity placements is that with the infusion of equity by a large investor, ownership concentration in the firm is increased, and owners are better motivated to monitor their investments (Wruck, 1989). We believe that the explanation provided by Hertzel and Smith (1993) is more aligned with our focus on young technology firms, where private placements reflect capital raising events rather than ownership restructuring events. Furthermore, management share ownership is already high in young technology firms, creating little need to realign manager's interests. Whether due to information asymmetry or ownership restructuring, private equity placements send a positive signal about the growth prospects of the firm.[11]

Relative to public offerings, several attributes of the private equity placement process make it an excellent mechanism for governing transactions with technology firms (Williamson, 1988). These same mechanisms, however, make issuing private equity a useful way for high quality firms to signal their value because the process reduces information asymmetry, making it costly and unreasonable for low quality firms to raise private equity. Such attributes include a) higher levels of short-term irreversibility, b) more knowledgeable investors conducting thorough analyses of the firm, and c) key monitoring provisions.

The private placement signal is made more credible by the level of irreversibility investors assume. If the shares firms sell privately are unregistered, then they are considered to be restricted by Rule 144, which imposes a two year resale restriction. There are also restrictions on the number of shares that may be resold. This two year time period is long enough to reveal useful information about the firm.

Because of the large risks inherent in making irreversible investments, private investors conduct a high level of rigorous information search before committing their funds (Varma and Szewczyk, 1993). Their "due diligence" process approaches the level offered in mergers in acquisition, a much higher standard than traditional public equity offerings, particularly seasoned offerings (Blackwell and Kidwell, 1988). For venture capital investors, such intensive due diligence is motivated by the desire to maintain a good reputation among the private equity investor community, a market characterized by a limited number of players who interact repeatedly over time. Due diligence review may last as long as six weeks and frequently include the following: a review of disclosure provided by the issuing firm; meetings with key employees, customers, suppliers, and creditors; and the retention of outside lawyers, accountants, and industry consultants. These investors refine their skills through volume and specialization - usually focusing on companies in specific industries or at specific stages of development. It is this active search for information prior to investment that reduces information asymmetry for the private investors. When market participants see that a well-informed party has chosen to invest, the signal is activated.

Finally, private investors structure agreements to provide ongoing monitoring of the firm to mitigate the moral hazard problem (Barry, Muscarella, Peavy and Vetsuypens, 1990; Lerner, 1995). Initial contracts usually contain covenants to inspect facilities, books and records, and receive timely financial reports and operating statements. Lerner (1994) reports that limited partnerships hold more than one-third of the seats on the boards of venture-backed biotechnology firms. Even if it lack voting control, it is usually the largest non-management shareholder, and in many cases controls opportunities for future funding, leaving the private equity investor with significant influence on strategic issues. Sahlman (1990) notes that staged investments, which create an option to abandon the project, is an important means for venture capital investors to minimize agency costs. Staged investment is also an important monitoring device (Gompers, 1995).

While previous studies have focused on abnormal returns for private and seasoned offerings across a broad array of industries, the expected effects should by most profound in a sample of young technology firms.

Hypothesis 1: Technology firms announcing seasoned public offerings will have negative abnormal returns.

Hypothesis 2: Technology firms announcing private equity placements will have positive abnormal returns.

Signaling as a Means to Attract Resources

Do young technology firms benefit from the private placement signal? Having signaled their high quality, are they better positioned to acquire resources necessary for growth? Clearly, these questions attend to an important issue: do managers intentionally signal by issuing private placements, or is the private equity event an impotent by-product of otherwise rational firm action? We believe that managers employ private placement signals not only to acquire subsequent equity, but also to attract research and commercial partners. Both potential capital partners and alliance partners share common concerns about identifying and evaluating promising partners.

Capital is always in short supply for technology firms. Managers of public firms that choose private equity over seasoned public offerings may do so to strategically signal the firm is undervalued so that, following a positive stock price adjustment, they can attract subsequent equity at a price more consistent with their value. Without revealing the specific content of a firm's capabilities to the marketplace, the signal effectively increases the market valuation so that both public and private equity markets are willing to provide capital at prices more acceptable to the firm's managers.

Firms able to credibly signal their growth opportunities may benefit not only through increased access to capital markets, but also through increased access to research and commercial partners. If there is a perceived association between private equity investors and evaluative ability, then third parties will interpret a connection to the private investor as an endorsement of the technology firm's growth opportunities. Because private investors are viewed as experts at the due diligence process (at least in the domain in which they have garnered recognition), the fact that one of them has determined that a new venture is of sufficient quality to merit transacting with is a valuable signal. This signal reduces search costs for potential alliance partners, by filtering out low quality firms unable to attract private equity.[12]

Hypothesis 3: Technology firms which successfully complete private equity placements will be better able to attract subsequent (a) financial capital, (b) research partners, and (c) commercial partners.

Moderating Effects of Signal Strength

To this point, we have argued that private placements provide a mechanism for separating the high quality firms from the low quality ones. Even among high quality firms, however, private equity signals should vary in their effectiveness. The benefits of signaling should hinge on the degree to which exchange partners do not have sufficient information about the firm to reach an independent conclusion about its future prospects. As a result, the signal should have a particularly strong effect on assessments of its value when there is considerable information asymmetry about the young company's quality, a point emphasized in the signaling literature (Spence, 1974). Consequently, signals are contingent: the less that is known about a focal organization, the greater the benefit from signaling. We highlight several factors that may represent the amount of information asymmetry surrounding a technology firm.

The longer it has been since the last signal, the more information asymmetry about firm value. There may be several explanations for this effect. First, a private placement investment suggests that an investor validates the quality of the firm through its evaluation process. Over time, changes in the firm and the environment cause firm valuation to deviate from previous levels. The more recent the private placement signal, the more reliable the positive evaluation of the technology firm's growth opportunities, and the more willing should be suppliers to provide resources. A related argument is that because technology firms need capital constantly, they have an incentive to issue private placements whenever their perceived value falls below the valuation that managers ascribe to the firm. A lack of a private placement over an extended period of time suggests that negative information about firm has developed (which may or may have revealed to outsiders). This negative information inhibits the firm's ability to raise subsequent resources.[13]

Hypothesis 4: Technology firms having more recently initiated a private placement will be better able to attract subsequent (a) financial capital, (b) research partners, and (c) commercial partners.

A firm's abnormal return on the most recent private equity placement should represent the degree to which there was information asymmetry prior to the private equity placement. After all, the abnormal return is a stock price adjustment simultaneous to the announcement of the private placement. Thus, firms with larger abnormal returns should have a greater marginal benefit from a private placement than firms with lower abnormal returns. We also expect that the effect of abnormal returns on the ability to attract subsequent resources to diminish over time. Private placements with larger abnormal returns and done more recently will be stronger signals about firm prospects.

Hypothesis 5: Technology firms having a larger abnormal return on the previous private placement will be better able to attract subsequent (a) financial capital, (b) research partners, and (c) commercial partners.

Hypothesis 6: Technology firms having initiated the last private placement more recently and having higher abnormal returns will be better able to attract subsequent (a) financial capital, (b) research partners, and (c) commercial partners.

Finally, we contend that firms have stronger signals when they have initiated more previous private placements, enabling them to attract subsequent resources more effectively. Several reasons may account for this. First, acquiring capital from private equity investors represents a valuable skill. With each private placement, firms learn how to recruit private investors and convey information more effectively through the due diligence process, reducing search time and costs for equity investors. Firms demonstrating a skill to repeatedly tap private markets are more desirable candidates for attaining subsequent resources, including both capital and complementary resources. Second, to the extent that private placements are made to existing investors having experience with the issuing firm, the signal may suggest added confidence in the firm. Such repeated investments are observable to outside resource providers, enhancing the credibility and strength of the signal. Finally, firms able to disseminate multiple signals during any given period of time (with or without the same investor), allow the receiving firms to cross-validate their intrepretation of firm valuation. Consistency checks often build the receiving firm's confidence in signal interpretation and reaction (Heil and Robertson, 1991).

Hypothesis 7: Technology firms with more prior private equity placements will be better able to attract subsequent (a) financial capital, (b) research partners, and (c) commercial partners.

METHOD

Sample and Data

We are interesting in the signaling properties of private equity placements. Two types of dependent variables are used. First, we compare abnormal returns for firms issuing private equity placements with firms issuing public equity. As such, the starting point for our data collection was gathering data on publicly traded biotechnology firms so that we could attain abnormal returns based on private placement announcements and announcements for seasoned public offerings. Our data describe 328 dedicated U.S. biotechnology firms that have undertaken an initial public offering between 1973 and 1998, and therefore, have stock that is publicly traded. The initial sample of private equity placements and public offerings was identified by searching for announcements in the BIOSCAN directory (published by Oryx Press) the Actions database (published by the North Carolina Biotechnology Center), and Standard & Poors NetAdvantage. To find announcement dates on these events and other equity financing events not revealed in those sources, we undertook an exhaustive quest using Lexis-Nexus and Dow Jones Interactive by searching news articles by company name and the following words: "equity", "placement", "offering", and "financing", all preceded by "public" or "private". This process revealed a total of 780 private equity placements and 346 public offerings that were completed subsequent to initial public offerings. We used CRSP tapes to gather stock returns on this sample of 1126 events. Due to stock delistings and insufficient stock returns, we were only able to calculate abnormal returns on 695 private placements and 293 public offerings.

The second set of dependent variables focuses on a firm's ability to attract resources. Even though having access to public equity markets by virtue of an initial public offering, young biotechnology firms face the constant challenge of attracting the financial and complementary resources necessary to carry out their research and development processes. Three crucial variables that measure a firm's ability to attract resources are: the speed at which they attract capital (the time from initial public offering to subsequent financing events), the speed at which they attract research partners (the time from initial public offering to research alliance events), and the speed at which they attract commercial partners (the time from initial public offering to commercial alliance events).

Assessing the second dependent variable - the rate at which biotechnology firms attract resources – required information on early life events for the firms in our sample. It is worth reiterating that while we only study post-IPO events, our independent variables are not constrained to post-IPO information. Rather, we have gathered data from a firm's inception to its exit from the industry by liquidation or acquisition. We relied on a number of sources to assemble the life histories of the firms in our sample. The primary source for the alliance data and the pre-IPO financing events was the Bioscan directory, but we also consulted the Actions Database. Patents and patent application dates were gathered from the U.S. Patent database. COMPUSTAT was used to gather annual firm-level data on cash, R&D expense, book-to-market ratios, assets, number of employees, sales, and long-term debt. COMPUSTAT did not have information on all our public biotechnology firms, therefore there is some attrition in models that include these firm-level data.

Modeling Abnormal Returns

To measure the information effects of private placement and public offering announcements we analyzed the significance of abnormal returns associated with the announcement. Abnormal returns are the difference between a firm's predicted and actual stock price for any given day, derived from regressions involving a market portfolio. By removing the portion of the return that is related to variation in the market's return, the variance of the abnormal return is reduced. This can lead to increased ability to detect event effects. In the absence of new, significant information about the firm, individual stock price changes should closely follow changes in the market portfolio. When the changes in the firm price diverges from the changes in the market portfolio it can be assumed that new information about the firm has been revealed.

Sometimes it is useful to add "factors" when trying to model the normal or "predicted" return. Factor models potentially provide the benefit of reducing the variance of the abnormal return by explaining more of the variation in the normal return. Typically, the factors are portfolios of traded securities. The market model identified above is an example of a one-factor model, but in a multi-factor model one might include industry indexes in addition to the market. Sharpe, Alexander and Bailey (1999) discuss index models with factors based on industry classification. In practice the gains from employing multi-factor models for event studies are limited (Campbell, Lo and MacKinlay, 1997). The reason for this is that the marginal explanatory power of additional factors beyond the market factor is small, and hence there is little reduction in the variance of abnormal returns. However, the variance reduction will typically be greatest in cases where the sample firms have a common characteristic, for example they are all members of a single industry. Since all our firms reside in the biotechnology industry, we introduce a second factor to our model – a biotechnology stock index. The details of the construction of the index can be found in (Lerner, 1994)

Using ordinary least squares regression over an estimation period of 221 days (250 days prior to 30 days prior the event), we calculated the two-factor model.

$$(1)\quad R_{jt} = \alpha_j + \beta_{j1} F_{1t} + \beta_{j2} F_{2t} + \varepsilon_{jt}\ ,$$

where R_{jt} is the rate of return of security j on day t, F_{1t} is the rate of return on a value-weighted market portfolio (the NASDAQ Composite Index) on day t, F_{2t} is the rate of return on a value-weighted biotechnology index on day t, and β_{j1} and β_{j2} are the sensitivities of security j to those two factors. α_j is the intercept term for security j and ε_{jt} is the error term of security j on day t.[14]

The abnormal performance of these firms relative to the date of first announcement of private placements or public offering is calculated using the two-factor model. Prediction errors for each firm j, PE_j, are calculated for each day t of interest around the date of announcement of the private placement event, where

$$(2)\quad PE_{jt} = R_{jt} - (\alpha_j + \beta_{j1} F_{1t} + \beta_{j2} F_{2t}).$$

An average prediction error for each day t is calculated as

$$(3)\quad \overline{PE_t} = \left(\frac{1}{N}\right)\sum_{1}^{N} PE_{jt}\ .$$

where N represents the number of private placement events (695) when calculating abnormal returns for private placement announcements, and N equals the number of public offering events (293) when calculating abnormal returns for public offering announcements. To determine whether the average prediction errors are significantly different from zero, the following test statistic is calculated:

$$(4)\quad t = \overline{PE_t} / \sigma_{PE}, \text{ where}$$

$$(5)\quad \sigma_{PE} = \left[\frac{1}{220} \sum_{-250}^{-30} (\overline{PE_T} - APE)^2 \right]^{\frac{1}{2}} \text{ with}$$

$$(6)\quad APE = \sum_{-250}^{-30} \overline{PE_T} / 220 .$$

We also aggregated the abnormal return observations across time in order to draw overall inferences for the event of interest. The cumulative abnormal return CAR(τ_1, τ_2) is defined as the cumulative abnormal return from period τ_1 to τ_2. To examine whether the CAR is significantly different from zero, a t-statistic is calculated, as

$$(7)\quad t = \overline{CAR}(\tau_1, \tau_2) / \overline{\sigma}(\tau_1, \tau_2), \text{ and}$$

$$(8)\quad \overline{\sigma}(\tau_1, \tau_2) = \left[\frac{1}{N^2} \sum_{1}^{N} \sigma_j^2(\tau_1, \tau_2) \right]^{\frac{1}{2}} .$$

Table 1 presents the daily average prediction errors and the cumulative average prediction errors of returns to stockholders of firms involved in either private equity placements or seasoned public offerings.

[Insert table 1 about here]

The results of the event study are consistent with expectations highlighted in Hypotheses 1 and 2. The evidence strongly supports the hypothesis that private and public equity announcements do indeed convey information useful for the valuation of firms. Focusing on the announcement day (day zero), the sample average abnormal return for firms issuing private placements using the two-factor model is 0.0164. Since the standard error of the one-day private placement average abnormal return is 0.0023, the t-statistic is 7.13 and the null hypothesis that the event has no impact is strongly rejected. The story is the same for firms issuing public equity. The event day sample abnormal return is –0.0192, with a standard error of 0.0028, leading to a t-statistic of -6.86 and again strong evidence against the null hypothesis. There is also some evidence of a positive announcement effect on days 1, -1, and –3 for firms announcing private placements. Firms issuing public equity have negative announcement effects, on average, for days other than day zero, including days 10, 8, 4, 1, -2, -5, -6, -7.

The cumulative abnormal returns presented in table 1 also provide strong support Hypotheses 1 and 2.[15] Figure 1 plots the CARs.[16] The CAR plot shows that market gradually learns about the forthcoming announcement. The average CAR of the private placement firms drifts up in days –8 to –1, and the average CAR of the public offering firms drifts down over this period. In the days after the announcement, the CAR for the private equity firms remains relatively stable, while the CAR for the public firms continues to trend down.

[Insert figure 1 about here]

<u>Modeling Time to Attract Subsequent Resources</u>

The three dependent variables pertaining to the ability to attract resources are modeled separately. The first dependent variable is the <u>rate of financing through private equity placements or (secondary) public offerings</u> subsequent to the firm's initial public offering, $\lambda_1(t)$. The second dependent variables is the <u>rate of research alliances</u> subsequent to the firm's initial public offering, $\lambda_2(t)$. The third dependent variable is the rate of commercial alliances subsequent to the firm's initial public offering, $\lambda_3(t)$. In each case, the rate is defined as

$$(9)\ \lambda(t) = lim[q(t, t+\Delta t)/\Delta t],\ \Delta t \rightarrow 0$$

where q is the discrete probability of the firm initiating subsequent financing between t and $(t+\Delta t)$, conditional on the history of the process up to time t. This rate summarizes the information on the intervals of time between successive events, with higher values of the rate corresponding to shorter times between events and vice versa.

The rate $\lambda(t)$ was specified as an exponential function of the independent variables and a set of parameters capturing the effects of the variables on the rate of subsequent financing such that:

$$(10)\ \lambda(t)=\exp(\alpha X_t)$$

The exponential distribution is suitable for modeling data with a constant hazard and when there is no *a priori* expectation as to the nature of the distribution. Parameters were estimated by the method of maximum likelihood using STATA.

One key assumption used for maximum likelihood estimates of α is that there is independence of event times – no correlation between event times. However, when firms have repeated financing or alliance events the assumption of independence of the events is highly questionable. The problem is that the covariance matrix does not take into account the additional correlation in the data, meaning the conventional estimate of variance is not appropriate (Lin, 1994). We use the "robust" option in STATA, and originally proposed by

Lin and Wei (1989), to adjust for this concern. We report the adjusted standard error for each coefficient.

RESULTS

The independent variables and control variables are described in table 2. They are time varying and updated monthly, except where otherwise noted. Descriptive statistics and correlations for the independent variables are listed in table 3. We present a synopsis of our hypotheses and results in table 4. Table 5 illustrates the results from the subsequent financing models, table 6 illustrates the results from the research alliance models, and table 7 illustrates the results from the commercial alliance models.

[Insert tables 2, 3, 4, and 5 about here]

Subsequent Financing

Table 5 reports two baseline models, including control variables for the industry and the firm, that estimate the rate of subsequent public or private financing. In running these models we test Hypothesis 3a-7a. The first baseline model (1) excludes variables gathered from Compustat sources. We present both baseline models since we could not gather Compustat data across all periods for all firm. Both baseline models present a significant improvement over an unreported constant rate (exponential) model. Due to the similarity between models 1 and 2, we interpret the coefficients for control variables from the model (2) including the more comprehensive set of control variables.

A number of industry and firm-level control variables are significant in model 2. First, we discuss the industry controls. Model 2 shows that a higher biotechnology index increases the speed at which firms are able to raise subsequent financing. Each additional point increase in the biotechnology index multiplies the rate of subsequent financing by a factor of 1.14 ($e^{[.1332 * 1]}$). The coefficient for the industry total number of commercial alliances in the most recent quarter is both significant and negative. The coefficient estimate on this variable implies that each additional ten commercial alliances multiplies the rate of subsequent financing by a factor of 0.94 ($e^{[-.0066 * 10]}$). The negative coefficient for the industry total number of patents in the most recent quarter suggests that each additional 10 patents multiplies the rate of subsequent financing by a factor of 0.97. The positive coefficient for "after 1990" suggests that subsequent financing is 1.64 times easier to raise after 1990.

Next, we discuss the firm control variables. The significant and positive coefficient for "therapeutic" suggests that operating in the therapeutic industry segment increases the speed at which capital is raised by a factor of 1.38. The negative and significant coefficient for age suggests that each additional year decreases the rate at which subsequent capital is raised drops, multiplying it by a factor of 0.96. A higher book-to-market ratio decreases the rate at which subsequent financing is attained. Firms with more assets attract capital at a slower rate, while firms with more employees attract capital at a faster rate. The coefficient for "patent clock" is positive, suggesting that the longer the duration since the last patent the better able are firms to attract subsequent financing. More specifically, each year since the last patent increases the rate of subsequent financing by a rate of 1.05. In contrast, the negative coefficient for "commercial alliance clock" suggests that the more recent the last commercial alliance, the quicker are firms to attract financing. Finally, firms with more commercial alliances attract funds more readily.

Models 3 and 4 (with Compustat variables) add the dummy variable for whether the firm has previously initiated a private placement in order to test Hypothesis 3a. Using a likelihood ratio test, we compared model 3 to baseline model 1. This test produced a chi-square statistic of 99.29, well above the critical value of 3.84 for 1 degree of freedom. The test suggests that the addition of the private placement variable enhances the explanatory power significantly ($p < 0.001$) more than the baseline model (1). A similar test comparing model 4 with model 2 also suggests that the private placement variable provides a significant improvement. Using model 4, we interpret the positive coefficient for the private placement dummy to suggest that firms having previously initiated private placements are able to attract subsequent financing at a rate 2.17 times those that have not initiated private placements. This result provides strong support for hypothesis 3a.

Models 5, 6, 7 and 8 in table 5 introduce the variables that are hypothesized to moderate the private placement effect on the rate of attracting subsequent equity. These models provide strong support for Hypotheses 4a, 5a, and 7a. Models 5 and 6 (with Compustat variables) introduce the private placement count and clock variables. Log-likelihood ratio tests was used to compare model 5 with model 1, and to compare model 6 with model 2. These tests produce chi-square statistics of 125.43 and 86.54, respectively. Both are well above the critical value for 2 degrees of freedom, suggesting that the addition of both variables significantly adds to the baseline model. Models 7 and 8 (with Compustat variables) incrementally introduce the variable associated with the abnormal return for the most recent private equity placement. This variable is introduced separately from the other two moderating variables because there are occasions when we do not observe the abnormal return for private equity placements due to missing CRSP data. As a result, the number of events drops significantly in models 7 and 8. We interpret the results of all three moderating variables with respect to model 8.

In Hypothesis 7a we argue that increases in the number of private placements will lead to an increased rate of subsequent financing. The positive coefficient provides support for Hypothesis 7a. Each additional private placement increases the rate of subsequent financing by a factor of 1.05. In Hypothesis 4a we argue that a shorter duration since the last private placement will increase the rate of subsequent financing. The negative coefficient implies that each additional year since the last private placement will multiply the rate of subsequent financing by a factor of 0.88, lending support to Hypothesis 4a. The final moderating effect pertains to the abnormal return of the most recent private placement. The positive coefficient implies that larger abnormal returns will increase the rate of subsequent financing. This finding supports Hypothesis 5a. While the main effects relating to private placement duration and abnormal returns were as expected, it is difficult to interpret main effects in the presence of significant interaction effects. One needs to look at both simultaneously.

Models 9 and 10 incrementally add the interaction between abnormal return and private placement duration specified in Hypothesis 6a, plus a dummy variable if the abnormal return does not correspond with the last private placement. These models provide strong support for the hypothesis. Log likelihood ratio tests generate a chi-square statistic of 9.51 when comparing model 9 with model 7, and a chi-square statistic of 10.22 when comparing model 10 with model 8. These tests indicate that the full models (9, 10) are a significant improvement ($p < 0.001$, 2 d.f.) over the others (7, 8). The negative coefficient suggests that higher abnormal returns coupled with a shorter duration since the last private placement should increase the likelihood of subsequent financing events. Figure 2 offers a systematic illustration of the joint effects of abnormal returns and private placement duration using coefficients from model 10. Figure 2 demonstrates the effect of private placement duration over the variable's range at three different levels of abnormal returns: the mean abnormal return, the mean abnormal return plus a standard deviation, and the mean minus a standard deviation. The vertical axis represents the multiplier of subsequent financing resulting from the combined effects of abnormal returns and private placement duration, while other variables are held constant. The figure demonstrates that higher abnormal returns had a much greater impact on the rate of subsequent financing when private placements were more recently initiated. This provides strong support for Hypothesis 6a, and also confirms the main effects suggested in Hypothesis 4a and 5a.

[Insert figure 2 and table 6 about here]

In examining the dependent variables relating to the rate of research alliances, $\lambda_2(t)$, and the rate of commercial alliances, $\lambda_3(t)$, we repeat the same steps as identified above.

Research Alliances

Table 6 reports both baseline models 1 and 2 (with Compustat), including control variables for the industry and the firm, that estimate the rate of attracting research partners. In running these models we test Hypothesis 3b-7b. Both baseline models present a significant improvement over an unreported constant rate (exponential) model. We interpret the coefficients for control variables from model 2. First, we discuss the industry controls. Model 2 shows that a higher biotechnology index increases the speed at which firms are able to attract research partners. Each additional point increase in the biotechnology index multiplies the rate of research alliances by a factor of 1.11. The coefficient for the total amount of private equity raised in the industry in the most recent quarter is negative, implying that each additional $100 million raised in private equity multiplies the rate of research alliances by a factor of 0.97. The coefficient for the total number of research alliances initiated in the most recent quarter is positive, and implies that if 10 additional research alliances are initiated at the industry level in the previous quarter the rate of research alliances increases by a factor of 1.11. The same positive relationship pertains to the total number of commercial alliances initiated in the most recent quarter, although the rate of increase is only 1.07. The negative coefficient for "after 1990" suggests that research alliances after 1990 are initiated at a rate of 0.77 times those prior to 1990.

Next, we discuss the firm control variables. The significant and positive coefficient for "therapeutic" suggests that operating in the therapeutic industry segment increases the speed at which research alliances are initiated by a factor of 1.35. Firms with a higher book-to-market ratio, a higher survival index, and more employees attract research alliance partners at a faster rate. Firms with more commercial alliances find it more difficult to attract research partners. In fact, every additional commercial alliance initiated by the firm multiplies the rate of research alliances by a factor of 0.98. In contrast, firms that have initiated more research alliances are able to attract research partners at a much higher rate. Each additional research alliance increases the rate of a research alliance being initiated by a factor of 1.06. The negative coefficient for the research alliance duration variable implies that the longer it has been since the last research alliance, the slower the rate of any subsequent research alliance. A delay of one year will reduce the hazard by a factor of

0.76. A similar result is attained for the coefficient pertaining to the duration since the last public offering. The longer since the last public offering reduces the hazard of a research alliance. Finally, firms that have initiated more public offerings have a decreased rate of research alliances. Each additional public offering decreases the rate of research alliances by a factor of 0.92.

Models 3 and 4 (with Compustat variables) in table 6 add the dummy variable for whether the firm has previously initiated a private placement in order to test Hypothesis 3b. Using likelihood ratio tests, we compared model 3 to baseline model 1, and model 4 to baseline model 2. This test produced chi-square statistics of 33.04 and 16.44, both well above the critical value of 3.84 for 1 degree of freedom. The test suggests that the addition of the private placement variable significantly enhances the ability to estimate research alliance events. Using model 4, we interpret the positive coefficient for the private placement dummy to suggest that firms having previously initiated private placements are able to attract research alliance partners at a rate 1.32 times those that have not initiated private placements. This result provides strong support for hypothesis 3b.

Models 5, 6, 7 and 8 in table 6 introduce the variables that are hypothesized to moderate the private placement effect. These models provide strong support for Hypotheses 4b and 5b. Models 5 and 6 (with Compustat variables) introduce the private placement count and clock variables. Likelihood ratio tests were used to compare model 5 with model 1, and to compare model 6 with model 2. These tests produce chi-square statistics of 21.4 and 10.44, respectively. Both exceed the critical value for 2 degrees of freedom, suggesting that the addition of both variables significantly adds to the baseline model. Models 7 and 8 (with Compustat variables) incrementally introduce the variable associated with the abnormal return for the most recent private equity placement. We interpret the results of all three moderating variables with respect to model 8.

In Hypothesis 7b we argue that increases in the number of private placements will lead to an increased rate of attracting research alliance partners. The coefficient for the number of previous private placements was not significant, so therefore we cannot support Hypothesis 7b. In Hypothesis 4b we argue that a shorter duration since the last private placement will increase the rate of attracting research partners. The negative coefficient implies that each additional year since the last private placement will multiply the rate of attracting research partners by a factor of 0.78, lending support to Hypothesis 4b. The final moderating effect pertains to the abnormal return of the most recent private placement. The positive coefficient implies that larger abnormal returns will increase the rate of research alliances. This finding supports Hypothesis 5b. For each an abnormal return 10 percent higher, the rate of attracting research partners increases by a factor of 1.09.

Models 9 and 10 incorporate the interaction between abnormal returns and private placement. Log-likelihood ratio tests indicated that the interaction effect did not significantly enhance the ability to explain the rate of research alliance formation. Therefore, Hypothesis 6b is not supported.

Commercial Alliances

Table 7 reports both baseline models 1 and 2 (with Compustat), including control variables for the industry and the firm, that estimate the rate of attracting commercial partners. In running these models we test Hypothesis 3c-7c. Both baseline models present a significant improvement over an unreported constant rate (exponential) model. We interpret the coefficients for control variables from model 2. First, we discuss the industry controls. Model 2 shows that the coefficients for the total number of research alliances and commercial alliances initiated in the most recent quarter are positive. Both coefficients imply that if 10 additional research alliances, or 10 additional commercial alliances, are initiated at the industry level in the previous quarter the rate of commercial alliances increases by a factor of 1.08. The coefficient for density is negative, implying that when the industry density is higher there is a decreased rate of attracting commercial alliance partners. The negative coefficient for "after 1990" suggests that commercial alliances after 1990 are initiated at a rate of 0.72 times those prior to 1990.

[Insert table 7 about here]

Next, we discuss the firm control variables. The significant and positive coefficient for "veterinary" suggests that operating in the veterinary industry segment multiplies the speed at which commercial alliances are initiated by a factor of 1.19. Firms operating in more industry segments are better able to attract commercial alliance partners. Firms with a higher survival index, more employees, and less long-term debt attract commercial alliance partners at a faster rate. Firms with more commercial alliances find it easier to attract commercial alliance partners. Every additional commercial alliance initiated by the firm multiplies the rate of commercial alliances by a factor of 1.04. Furthermore, the negative coefficient for commercial alliance duration suggest that the more recent the last commercial alliance the better able are firms to attract commercial partners. A delay of one year multiplies the hazard of commercial alliance by a factor of 0.63. Similarly, the negative coefficients for research alliances and public offerings suggest that a delay of one year multiplies the hazard of commercial alliances by a factor of 0.91 for both. Finally, more public offerings a firm has undertaken, the less likely it will initiate a commercial alliance. Each public offering multiplies the hazard of commercial alliances by 0.93.

Models 3 and 4 (with Compustat variables) in table 7 add the dummy variable for whether the firm has previously initiated a private placement in order to test Hypothesis 3c. Using likelihood ratio tests, we compared model 3 to baseline model 1, and model 4 to baseline model 2. This test produced chi-square statistics of 58.34 and 34.60, respectively. Both statistics are well above the critical value of 3.84 for 1 degree of freedom. The test suggests that the addition of the private placement variable significantly enhances the ability to estimate commercial alliance events. Using model 4, we interpret the positive coefficient for the private placement dummy to suggest that firms having previously initiated private placements are able to attract commercial alliance partners at a rate 1.42 times those that have not initiated private placements. This result provides strong support for hypothesis 3c.

Models 5, 6, 7 and 8 in table 7 introduce the variables that are hypothesized to moderate the private placement effect on the rate of initiating commercial alliances. These models provide strong support for Hypotheses 4c and 7c. Models 5 and 6 (with Compustat variables) introduce the private placement count and clock variables. Likelihood ratio tests were used to compare model 5 with model 1, and to compare model 6 with model 2. These tests produce chi-square statistics of 18.18 and 27.42, respectively. Both exceed the critical value for 2 degrees of freedom, suggesting that the addition of both variables significantly adds to the baseline model. Models 7 and 8 (with Compustat variables) incrementally introduce the variable associated with the abnormal return for the most recent private equity placement. However, when comparing these models to baseline models with the same set of data, the chi-square statistics of 0.12 and 0.08, respectively, fell below the critical value. Therefore, we do not support Hypothesis 5c pertaining to the moderating effect of the abnormal return, and we interpret the results of the other two moderating variables with respect to model 6. In Hypothesis 7c we argue that increases in the number of private placements will lead to an increased rate of attracting commercial alliance partners. The coefficient for the number of previous private placements was positive, supporting Hypothesis 7c. It suggests that with one additional private placement, firms can attract commercial alliance partners at a rate of 1.04 times faster. In Hypothesis 4c we argue that a shorter duration since the last private placement will increase the rate of attracting commercial partners. The negative coefficient implies that each additional year since the last private placement will multiply the rate of attracting commercial partners by a factor of 0.96, lending support to Hypothesis 4c.

Models 9 and 10 incorporate the interaction between abnormal returns and private placement. Log-likelihood ratio tests indicated that the interaction effect did not significantly enhance the ability to explain the rate of commercial alliance formation. Therefore, Hypothesis 6c is not supported.

DISCUSSION

In uncertain contexts, signals of firm quality become the bases for evaluations. Uncertainty pervades attempts to evaluate new and unproven companies having mostly intangible assets and/or a desire to keep proprietary specific information about firm capabilities. In such contexts, signaling is an important firm strategy to attract resources necessary to capitalize on growth opportunities. In this study we focused on the signaling qualities of private equity placements, arguing that the signal and the signal strength will influence the ability of young biotechnology companies to attract three types of resources - financial capital, research partners, and commercial partners. Overall, the empirical analyses demonstrated consistent and cogent effects of the signaling properties of private equity placements on the ability to attract financial and complementary resources. Moreover, the signaling effects held up in models that included a comprehensive set of control variables capturing firm differences and industry conditions. Building a new company is a highly competitive endeavor, and it is difficult to overstate the importance of being able to signal "high ability" when trying to attract resources necessary to capitalize on growth opportunities.

The results raise several points worth emphasizing about the impact of private placement events on the ability to raise subsequent resources. First, the analysis clearly demonstrates that private equity placements aid firms in attracting financial capital. Subsequent financing was easier to attract when firms had more prior private placements and had initiated a private placement more recently. The benefits to private placements appear to go beyond merely providing capital, because prior seasoned public offering events had no significant effect on the ability to raise capital. We believe that manager's decision to issue private equity over public equity is an intentional signal that the firm is undervalued. Consistent with this argument is the strong positive effect of prior private placement abnormal returns on the ability to raise capital, and the declining effect of abnormal returns as more time has elapsed since the private placement. We can think of no other explanation for these results than the signaling argument presented. Perhaps this point is most clearly demonstrated by the finding that private equity placement announcements had a strong positive effect on the firm's valuation. Compared to the negative abnormal returns for firms offering seasoned public equity, these results suggest that, on average, private placements send different information to capital markets than do seasoned public offerings.

The differences between the subsequent financing models and the models examining the rate of research and commercial alliances also merit emphasis. While the size and the recency of the abnormal returns played a very important role in the ability to raise subsequent financing, the effect of abnormal returns varied across partner types. In the research alliance model, the significant coefficient for abnormal returns suggests that research partners, much like participants in financial markets, weigh the strength of the signal when deciding whether to commit resources to a biotechnology firm. Curiously, however, the effect of the abnormal return did not dissipate over time, as it had in the subsequent capital model. This implies that when evaluating biotechnology firms research alliance partners are not concerned about temporary asymmetries in the market value of the firm, rather, they view the abnormal return as representative of a more enduring assessment of firm capabilities, valuation, and viability. We also suspect that research partners focus most extensively on the most recent private placement signal when evaluating candidates for partnership. While abnormal return and elapsed time for the most recent private placement had strong effects, the total number of prior private placements was not significant in models incorporating the abnormal return.

In contrast to research partners, commercial partners do not seem to focus on the size of the abnormal return on the last private placement. One explanation may be that commercial partnerships are generally formed in later stages of a project, when there is less uncertainty about the value of the growth opportunities of the projects. Furthermore, in order to develop a contract allowing for the licensing of a technology, the technology must be sufficiently codified so that both parties clearly understand property rights. The codification process, by definition, should reduce uncertainty about the nature of the underlying technology. With less uncertainty, the potency of a signal is reduced. Thus, it may be that the strong effects of the number of prior private placements and the recency of the last placement on the ability to attract commercial partners reflect their concerns about ongoing viability of the biotechnology firm due to capital infusion. However, because we had a comprehensive set of variables to control for firm liquidity, we are reluctant to concede that private placement signaling is unimportant to commercial partners.

This study raises two issues that are worth discussing. First is causality. Can we be sure that our effects are driven by the hypothesized signaling process rather than unobserved differences between firms that happen to correlate with the strength and recency of the private placement signal. To rule out this possibility, we made every effort to control for the presence and the timing of patents, research alliances, commercial alliances, and public offerings. We also controlled for "hot" and "cool" financing and alliances windows at the industry level. Furthermore, we restricted our sample to one industry to reduce the effect of differences in firm strategies. While one can never rule out unobserved heterogeneity, the abnormal return effects and the contingency in the abnormal return effects greatly enhance our confidence in the theory. Other than the hypothesized signaling explanation, it is difficult to construct a cogent explanation for the strong and consistent effect of abnormal returns on the rate of attracting subsequent capital (table 5) and research partners (table 6), and the interaction effect observed in Figure 2. The most compelling alternative explanation is that positive abnormal returns for private placements reflect the positive repercussions of attracting funds. However, since we control for the amount of cash by incorporating each firm's survival index, this alternative explanation does not seem satisfactory.[17]

The second issue is generalizability. While caution must always be exercised when generalizing from a single industry study, we believe that the signaling processes we have observed in the biotech industry do operate in other contexts. Ours is a study of how firms attract resources while having unproven performance, intangible assets, and a desire to keep technology proprietary. We believe that these attributes translate to other industry contexts, particularly those where there are high burn rates. Other industries that use private placements intensively include computer software and hardware, medical instruments, health services, telecommunications, and internet-based companies (Fenn *et al.*, 1997). There is some evidence (in the form of consistent abnormal returns) of private placement signaling across a broad array of industries represented in the NASDAQ Exchange (Hertzel and Smith, 1993), an exchange that features smaller, younger, and technologically-oriented firms. Unfortunately, as far as we know, ours is the first single-industry study on private equity placements. Our study differs in that we view the signal not as an unintentional byproduct of a decision, rather, as a potent tool for acquiring subsequent resources.

The results of this study open some avenues for future research. First, evaluations of new ventures are affected by other types of transactions than those we have scrutinized. For example, research partners considered the depth and timing of prior research experience. Commercial partners were easier to attract when firms had initiated more commercial alliances, and when they had initiated commercial and research alliances more recently. It may be that these effects highlight the importance of firm reputation or capabilities developed over time through visible technological advances or accomplishments. Alternatively, these relationships may suggest that commercial and research partnerships serve as signals, much like private placements. To further probe this proposition, it would be useful to know whether abnormal returns from these events have a significant effect on the ability to attract future resources.

Second, we have for the most part ignored the reputation effects of the private equity investors. A related line of research has shown that the reputation of a firm's partners significantly effects its valuation (Stuart *et al.*, 1999). It is almost certain that the reputation of private equity partners bears upon the strength of the signal. Future work might formally test whether private equity investor reputation bears upon the ability to attract subsequent resources. We would like to emphasize, however, that the presence of a reputation effect does not theoretically conflict with our viewpoint, nor does it alter the interpretation of a strong signaling effect. In fact, to the extent that investor reputation matters, its effect should be incorporated in the abnormal return, which is part of our model.

Third, the obvious implication of our findings is that young, technologically-oriented firms should strongly-consider private equity financing when they feel their firm is undervalued by potential resource providers. One interesting question pertains to the conditions under which firms will succeed at recruiting private equity investors. Is technological prowess the prime determinant of raising private funds, or is it determined more by the identity of organizational leaders, or embeddedness in a network, or membership of a technological cluster, or geographical proximity to venture capitalists? A second question pertains to a "pecking order" of signal types. In the presence of multiple ways to signal, how should firms choose among them? Are all signals equally effective, equally expensive to erect? Investigating questions such as these will enlighten the processes through which signals are created and the consequences of incorporating signaling as an active firm strategy for attracting resources to capitalize on growth opportunities.

ENDNOTES

[1] The research on competitive actions and multipoint competition are notable contributions to the literature on competitive signaling.

[2] Accredited investors as defined in Regulation D, include officers and directors of the firm, high net worth individuals, and institutions such as pension funds and banks.

[3] Leibeskind (1997) defined three ways in which firms may strategically inhibit the diffusion of knowledge: rules, compensation schemes, and structural isolation.

[4] It is a widely accepted proposition that markets for knowledge transfer will tend to fail (Arrow, 1996).

[5] These same conditions are ripe for moral hazard. The tenacity and veracity of the entrepreneur are difficult to calibrate, with consequences much more unfortunate for the investor than for the entrepreneur. Ascertaining whether the entrepreneur's optimism is honest, yet misplaced is perhaps even more difficult. There is much evidence that in the context of planning and action most people are prone to extreme optimism in their forecasts of outcomes, and often fail to appreciate the chances of an unfavorable outcome (Kahneman and Lovallo, 1994). Decision makers often take risks because they deny their existence or underestimate their extent (March and Shapira, 1987).

[6] Deeds *et al.* (1997) also argued that R&D expenditures and the number of patents would signal value, but found no significant relationship between these variables and the amount of capital raised..

[7] A "seasoned" public offering is any public offering issued by the firm after its IPO. See Smith (1986) for a summary of findings pertaining to short-term abnormal returns associated with public equity offerings. Brous (1992) and Jain (1992) found that the decision to issue public equity also conveys unfavorable information about long-term earnings.

[8] In a survey article, Ibbotson, Sindelar, and Ritter (1988) report an average initial return of 16.37 percent for 8,668 new issues between 1960 and 1987.

[9] Loughran and Ritter (1997) found that issuers of seasoned offerings are disproportionately high growth firms, but have much lower subsequent operating performance returns than non-issuers with the same growth rates.

[10] One might argue for a third explanation for positive returns with private placements - the addition of the private equity investor to the management expertise of the firm. Clearly, these investors are quite experienced and take an active role in management of their portfolio companies. However, for firms that are already public, the expertise argument is less valid. Private placements that occur after the firm has gone public are always represents the 2nd or 3rd stage of private funding. Firms should already have in place expert private investors that have taken lead investment roles with prior private placements.

[11] Clearly, private equity is not the only signaling mechanism available to managers. Other mechanisms include the percentage of equity retained by the entrepreneur (Leland and Pyle, 1977), the reduction of dividends, and the level of debt . However, debt is only of limited value in financing innovation, unless a firm has collateral or is under-leveraged. In examining a number of signaling mechanisms, Noe and Rebello (1996) found that private equity placements are an optimal mechanism to signal undervaluation when dividend reductions are not an alternative. In our sample of 328 public biotechnology firms, only three firms issued dividends.

[12] A related argument is that an infusion of (private) equity increases the perceived viability of young technology firms. In that case, increases in firm liquidity should be associated with an increased ability to raise subsequent resources. However, we believe that even after controlling for firm liquidity, private equity placements have important effects related to the signal.

[13] A final justification for the effect of the recency of the private placement on the ability to raise subsequent resources may reflect concerns about firm viability. Firms lacking cash may be less viable, or may be forced to slow down development of technology, making them less attractive to external resource providers. The time since previous funding is correlated with the amount of available cash.

[14] Event studies are subject to biases if there is thin trading on stocks. Certain biotechnology stocks may experience thin trading. The nontrading or nonsynchronous trading effect arises when prices are taken to be recorded at time intervals of one length a when in fact they are recorded at time intervals of other possibly irregular lengths. Scholes and Williams (1977) present a consistent estimator of beta in the presence of nontrading. Jain (1986) compares the distribution of abnormal returns estimated using the Scholes-Williams approach to the distribution of abnormal returns using the usual OLS betas and finds the differences are minimal. This suggests that in general the adjustment for thin trading is not important (Campbell *et al.*, 1997).

[15] While the (-10, 10) day window for private placement events is not significant at the $p < 0.05$ level, it is significant at $p < 0.10$.

[16] The magnitude of CARs on both private placements and seasoned offerings is consistent with previous studies mentioned earlier. A notable study that was previously unmentioned is (Krishnamurthy, Spindt, Subramaniam and Woidtke, 1999). They found a CAR(-3,0) of 1.83 for private equity placements across a broad range of firms whose stock is traded on NASDAQ.

[17] We also ran models where the survival index was dichotomized into two variables, cash and R&D expenditures. Those models had less explanatory power, and the dichotomization did not effect the robustness of our findings.

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Table 1: Abnormal Returns for Event Studies on Private Equity Placements and Seasoned Public Offerings

	Private Placement Announcements		Seasoned Public Offering Announcements	
Event time (t)	Abnormal Returns (Prediction Errors) (PE_t)	Standard Error of Prediction Error (σ)	Abnormal Return (Prediction Errors) (PE_t)	Standard Error of Prediction Error (σ)
-10	-0.0033	0.0023	-0.0007	0.0028
-9	0.0013	0.0023	-0.0032	0.0028
-8	-0.0009	0.0023	-0.0045	0.0028
-7	0.0016	0.0023	-0.0066 *	0.0028
-6	0.0027	0.0023	-0.0060 *	0.0028
-5	0.0015	0.0023	-0.0064 *	0.0028
-4	0.0025	0.0023	-0.0014	0.0028
-3	0.0044 *	0.0023	-0.0031	0.0028
-2	-0.0013	0.0023	-0.0082 **	0.0028
-1	0.0052 *	0.0023	-0.0027	0.0028
0	0.0164 ***	0.0023	-0.0192 ***	0.0028
1	0.0054 *	0.0023	-0.0058 *	0.0028
2	-0.0010	0.0023	-0.0023	0.0028
3	-0.0015	0.0023	0.0002	0.0028
4	-0.0050 *	0.0023	-0.0058 *	0.0028
5	-0.0012	0.0023	-0.0002	0.0028
6	-0.0014	0.0023	-0.0034	0.0028
7	0.0008	0.0023	-0.0009	0.0028
8	-0.0035	0.0023	-0.0067 **	0.0028
9	-0.0029	0.0023	-0.0037	0.0028
10	-0.0009	0.0023	-0.0054 *	0.0028
(-10, 10)	0.0198	0.0117	-0.0951 ***	0.0171
(-3, 3)	0.0281 ***	0.0071	-0.0398 ***	0.0075
(-2, 1)	0.0243 ***	0.0057	-0.0347 ***	0.0055
(-1, 1)	0.0265 ***	0.0054	-0.0269 ***	0.0051
(-1, 0)	0.0216 ***	0.0039	-0.0212 ***	0.0040

* $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$

Table 2: Variable Definitions

Variable Name	Variable Definition
Private Placement Dummy	Dummy equal to "1" if firm *j* initiated a prior private placement.
Private Placement Count	The cumulative count of all firm *j*'s prior private placements.
Private Placement Duration	The elapsed time since firm *j*'s last private equity placement, measured in days/365.25.
Private Placement Abnormal Return	The CAR(-2, 1) for firm *j*'s most recently observed private placement. This 3-day window was chosen because on average, most of the information is conveyed during this period.
Missing CAR dummy	Dummy equal to "1" if firm *j*'s most recent private placement has an unobserved abnormal return.
PP Duration x PP Abnormal Return	The interaction between Private Placement Abnormal Return and Private Placement Duration
Public Offering Count Research Alliance Count Comm. Alliance Count Patent Count	The cumulative count of al firm *j*'s prior public offerings, research alliances, commercial alliances, and patents, respectively.
Public Offering Clock Res. Alliance Clock Comm. Alliance Clock Patent Clock	The elapsed time since firm *j*'s last public offering, research alliance, commercial alliance, and patent, respectively. Measured in days/365.25.
LT Debt	Firm *j*'s prior year long-term Debt
Sales	Firm *j*'s prior year sales revenues
Employees	Square root of firm *j*'s prior year number of employees.
Assets	Square root of firm *j*'s prior year total assets.
Survival Ratio	Firm j's prior year (cash / (R&D expense + S,G, & A Expense)).
Book-to-Market	Firm j's prior year (equity / (stock price * shares outstanding)).
Firm Age	Number of days since firm *j*'s founding.
Scope	Number of biotechnology segments in which firm *j* is involved, where $0 \geq$ Scope ≤ 6. Segments include human therapeutics, human diagnostics. veterinary, agriculture, food, and other.
Therapeutic Dummy	Dummy equal to "1" if firm *j* is active in therapeutic segment.
Diagnostic Dummy	Dummy equal to "1" if firm *j* is active in diagnostic segment.
Veterinary Dummy	Dummy equal to "1" if firm *j* is active in veterinary segment.
> 1990	Dummy equal to "1" if observation occurs after 1990.
Density	Total number of biotechnology firms alive in the current year
Quarterly Res. Alliances Quarterly Com. Alliances Quarterly Patents	The total number of research alliances, commercial alliances, and patents, respectively, issued by firms in the sample in the 3 months prior to the current month.
Quarterly Priv. Placements Quarterly Public Offerings	The total amount of capital raised through private equity placements and public offerings, respectively, by firms in the sample in the 3 months prior to the current month. These measures control for "hot" and "cold" financing windows.
Nasdaq	Nasdaq Composite Index - monthly average
Biotechnology Index	Biotechnology Stock Index - monthly average.

Table 3: Descriptive Statistics and Pairwise Correlations (page 1 of 2)

	Variables	Mean	St. Dev.	Min	Max	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1	Biotechnology Index	3.589	0.981	1.680	5.862	1.000													
2	Nasdaq	693.450	381.730	7.810	1949.540	-0.038	1.000												
3	Quart. Pub. Offerings	401.684	388.846	0.000	1622.167	0.577	0.034	1.000											
4	Quart. Priv Placements	283.582	244.945	0.000	1293.999	0.430	0.063	0.325	1.000										
5	Quart. Com. Alliances	53.225	16.443	0.000	93.000	0.348	0.154	0.285	0.490	1.000									
6	Quart. Res. Alliances	44.095	17.673	0.000	91.000	0.410	0.095	0.386	0.663	0.814	1.000								
7	Quart. Patents	37.973	30.826	0.000	94.000	-0.032	0.108	-0.030	-0.204	0.130	0.083	1.000							
8	> 1990	0.759	0.428	0.000	1.000	0.533	0.212	0.541	0.489	0.511	0.666	0.333	1.000						
9	Density	503.934	45.259	117.000	540.000	0.241	0.181	0.343	0.392	0.654	0.650	0.415	0.655	1.000					
10	LT Debt	23.494	64.364	0.000	419.589	0.035	0.035	0.029	0.073	0.088	0.101	0.044	0.097	0.096	1.000				
11	Sales	65.623	213.850	0.000	2239.800	0.039	0.049	0.036	0.096	0.096	0.113	0.023	0.105	0.093	0.621	1.000			
12	Employees	0.492	0.402	0.000	2.727	0.025	0.050	0.025	0.089	0.119	0.128	0.068	0.115	0.123	0.744	0.741	1.000		
13	Assets	8.871	8.211	0.470	52.589	0.066	0.063	0.050	0.129	0.161	0.180	0.092	0.170	0.170	0.744	0.764	0.922	1.000	
14	Survival Ratio	0.053	1.124	-6.258	3.955	0.062	0.007	0.017	0.027	0.060	0.061	0.060	0.052	0.045	-0.002	-0.045	0.013	0.187	1.000
15	Book-to-market	0.314	0.335	-1.800	5.005	-0.006	-0.007	0.016	-0.023	-0.023	-0.021	0.027	0.007	0.013	-0.030	-0.026	-0.026	-0.033	0.093
16	Veterinary Dummy	0.324	0.468	0.000	1.000	-0.124	-0.059	-0.145	-0.166	-0.151	-0.195	-0.043	-0.252	-0.202	0.183	0.199	0.221	0.224	0.050
17	Diagnostic Dummy	0.536	0.499	0.000	1.000	-0.061	-0.024	-0.075	-0.091	-0.076	-0.094	0.008	-0.112	-0.096	0.156	0.136	0.184	0.152	-0.003
18	Therapeutic Dummy	0.817	0.386	0.000	1.000	0.013	0.009	0.001	0.018	0.001	0.005	-0.031	-0.004	-0.009	0.105	0.051	0.054	0.122	0.088
19	Scope	2.675	1.314	1.000	6.000	-0.108	-0.061	-0.136	-0.146	-0.138	-0.173	-0.037	-0.233	-0.181	0.320	0.228	0.339	0.324	0.064
20	Firm Age	3662.253	1209.849	0.000	8483.000	0.163	0.081	0.176	0.273	0.324	0.364	0.111	0.372	0.427	0.294	0.288	0.439	0.444	0.003
21	Patent Count	12.701	16.888	0.000	88.000	0.046	0.077	0.072	0.088	0.142	0.166	0.200	0.219	0.217	0.418	0.455	0.581	0.586	0.037
22	Patent Clock	0.972	1.568	0.000	11.696	0.160	0.019	0.135	0.275	0.203	0.245	-0.159	0.195	0.168	0.031	0.036	0.022	0.038	-0.051
23	Com. Alliance Count	14.850	13.197	0.000	63.000	0.017	0.017	0.028	0.074	0.134	0.124	0.104	0.093	0.183	0.550	0.475	0.658	0.721	0.059
24	Com. Alliance Clock	0.819	1.281	0.000	13.581	0.109	0.044	0.096	0.124	0.109	0.147	0.040	0.203	0.174	-0.052	-0.032	-0.041	-0.061	-0.087
25	Res. Alliance Count	9.844	8.119	0.000	40.000	0.050	0.019	0.040	0.121	0.166	0.165	0.068	0.124	0.193	0.454	0.412	0.569	0.638	0.087
26	Res. Alliance Clock	1.145	1.617	0.000	14.189	0.084	0.028	0.096	0.116	0.109	0.130	0.047	0.176	0.175	-0.055	-0.038	-0.051	-0.036	-0.009
27	Pub. Offering Count	2.307	1.401	0.000	11.000	0.152	0.065	0.145	0.219	0.253	0.286	0.068	0.290	0.289	0.360	0.232	0.477	0.535	0.147
28	Pub. Offering Clock	2.978	2.566	0.000	16.729	0.014	0.019	0.032	0.117	0.139	0.151	0.008	0.105	0.186	0.174	0.265	0.248	0.234	-0.060
29	Missing CAR Dummy	0.030	0.170	0.000	1.000	-0.022	0.023	-0.020	-0.034	-0.024	-0.033	0.005	-0.026	-0.033	-0.133	-0.098	-0.077	-0.118	0.051
30	Priv. Placement Dummy	1.000	0.000	1.000	1.000	0.090	0.068	0.092	0.155	0.192	0.212	0.066	0.208	0.241	0.126	0.115	0.249	0.272	0.162
31	Priv. Placement Count	3.647	2.457	1.000	21.000	0.113	0.034	0.106	0.194	0.190	0.230	-0.010	0.215	0.214	0.281	0.212	0.372	0.394	0.064
32	Priv. Placement Clock	1.691	1.707	0.003	12.197	0.015	0.056	0.011	0.068	0.124	0.122	0.090	0.115	0.150	0.134	0.265	0.334	0.357	0.073
33	Priv. Placement CAR	0.030	0.134	-0.371	1.539	-0.065	-0.037	-0.040	-0.010	0.006	-0.029	-0.019	-0.098	-0.009	0.024	-0.013	0.005	0.001	-0.068
34	PP Clock x PP CAR	0.069	0.364	-0.720	7.117	-0.002	-0.021	-0.007	-0.033	-0.016	-0.032	0.065	-0.003	0.024	0.046	0.011	0.035	0.025	-0.105

Table 3: Descriptive Statistics and Pairwise Correlations (page 2 of 2)

	Variables	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33
15	Book-to-market	1.000																		
16	Veterinary Dummy	-0.044	1.000																	
17	Diagnostic Dummy	-0.063	0.132	1.000																
18	Therapeutic Dummy	-0.078	0.133	-0.060	1.000															
19	Scope	-0.070	0.605	0.553	0.338	1.000														
20	Firm Age	-0.012	0.143	0.124	-0.019	0.164	1.000													
21	Patent Count	-0.038	0.164	0.070	0.032	0.196	0.513	1.000												
22	Patent Clock	-0.023	-0.031	0.017	-0.046	-0.037	0.411	0.041	1.000											
23	Com. Alliance Count	-0.051	0.384	0.115	0.154	0.434	0.537	0.563	0.121	1.000										
24	Com. Alliance Clock	0.003	-0.024	0.007	-0.017	-0.053	0.299	0.061	0.189	-0.078	1.000									
25	Res. Alliance Count	-0.037	0.301	0.123	0.153	0.374	0.502	0.511	0.111	0.846	-0.023	1.000								
26	Res. Alliance Clock	-0.022	0.043	0.102	-0.052	0.034	0.334	0.094	0.279	0.081	0.343	-0.033	1.000							
27	Pub. Offering Count	-0.061	0.070	0.094	0.061	0.146	0.601	0.491	0.231	0.517	0.097	0.538	0.127	1.000						
28	Pub. Offering Clock	-0.053	0.249	0.077	-0.030	0.184	0.510	0.227	0.218	0.350	0.221	0.229	0.256	0.132	1.000					
29	Missing CAR Dummy	0.082	-0.062	0.001	0.004	-0.047	-0.195	-0.113	-0.099	-0.193	0.031	-0.128	-0.031	-0.241	-0.197	1.000				
30	Priv. Placement Dummy	0.009	0.136	0.068	0.111	0.159	0.315	0.251	0.115	0.302	0.084	0.328	0.150	0.321	0.178	0.367	1.000			
31	Priv. Placement Count	-0.011	0.176	0.001	0.108	0.216	0.385	0.271	0.171	0.470	0.053	0.418	0.110	0.327	0.324	0.001	0.598	1.000		
32	Priv. Placement Clock	0.007	0.183	0.091	0.041	0.170	0.374	0.404	0.136	0.329	0.153	0.373	0.142	0.362	0.163	0.341	0.482	0.157	1.000	
33	Priv. Placement CAR	0.069	0.105	-0.012	0.109	0.098	0.028	-0.015	0.036	0.032	0.084	0.081	-0.022	0.018	0.013	0.038	.	-0.077	0.117	1.000
34	PP Clock x PP CAR	0.041	0.115	-0.030	0.093	0.118	0.093	0.004	0.108	0.073	0.105	0.107	-0.001	0.030	0.084	0.055	.	-0.097	0.307	0.739

Table 4: Hypotheses and Findings

Hypotheses	Expected Relationship	Findings: Financing	Findings: Research Alliances	Findings: Commercial Alliances
1 Technology firms announcing private equity placement will have abnormal returns	+			
2 Technology firms announcing seasoned public offerings will have abnormal returns	-			
3 Technology firms which successfully complete private equity will be better able to attract subsequent resources	+	+	+	+
4 Technology firms having more recently initiated a private placement will be better able to attract subsequent resources	-	-	-	-
5 Technology firms having a larger abnormal return on the previous private placement will be better able to attract subsequent resources.	+	+	+	0
6 Technology firms having initiated the last private placement more recently and having higher abnormal returns will be better able to attract subsequent resources.	-	-	0	0
7 Technology firms with more prior private placements will be better able to attract subsequent resources.	+	+	0	+

Table 5: Maximum Likelihood Estimates for the Hazard of Subsequent Private Equity and Public Offerings Together (page 1 of 2)

Variable Name	1	2	3	4	5	6	7	8	9	10
Biotechnology Index	0.1622 ***	0.1332 **	0.1657 ***	0.1380 **	0.1466 ***	0.1225 **	0.0614	0.0448	0.0612	0.0464
	(0.0421)	(0.0455)	(0.0409)	(0.0440)	(0.0404)	(0.0431)	(0.0498)	(0.0523)	(0.0498)	(0.0527)
Nasdaq	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)
Quarterly Public Offerings	0.0000	- 0.0001	0.0000	0.0000	0.0001	0.0000	0.0002	0.0001	0.0002	0.0001
	(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.0012)	(0.0001)	(0.0001)
Quarterly Private Placements	0.0001	0.0002	0.0001	0.0028 ***	0.0001	0.0002	0.0001	0.0002	0.0002	0.0003
	(0.0002)	(0.0002)	(0.0002)	(0.0002)	(0.0002)	(0.0002)	(0.0002)	(0.0002)	(0.0002)	(0.0002)
Quarterly Research Alliances	0.0035	0.0027	0.0022	0.0021	0.0036	0.0033	0.0013	0.0005	0.0011	- 0.0001
	(0.0035)	(0.0038)	(0.0034)	(0.0037)	(0.0035)	(0.0038)	(0.0044)	(0.0044)	(0.0043)	(0.0044)
Quarterly Com. Alliances	- 0.0065 *	- 0.0066 *	- 0.0064 *	- 0.0066 *	- 0.0064 *	- 0.0065 *	- 0.0074 *	- 0.0669 ***	- 0.0072 *	- 0.0064 *
	(0.0032)	(0.0033)	(0.0031)	(0.0033)	(0.0031)	(0.0033)	(0.0038)	(0.0039)	(0.0038)	(0.0039)
Quarterly Patents	- 0.0027 *	- 0.0027 *	- 0.0022 *	- 0.0018	- 0.0008	- 0.0003	- 0.0007	- 0.0007	- 0.0005	- 0.0004
	(0.0013)	(0.0014)	(0.0013)	(0.0013)	(0.0013)	(0.0014)	(0.0016)	(0.0017)	(0.0017)	(0.0018)
Density	0.0018	0.0017	0.0014	0.0014	0.0014	0.0011	- 0.0009	- 0.0004	- 0.0004	0.0003
	(0.0012)	(0.0014)	(0.0012)	(0.0014)	(0.0010)	(0.0013)	(0.0014)	(0.0015)	(0.0016)	(0.0018)
> 1990	0.3610 *	0.4946 **	0.2511	0.3553 *	0.2062	0.3098 *	0.4821 *	0.5943 **	0.4547 *	0.5488 *
	(0.1606)	(0.1751)	(0.1591)	(0.1730)	(0.1570)	(0.1746)	(0.2201)	(0.2332)	(0.2210)	(0.2364)
Therapeutic Dummy	0.1512	0.3244 **	0.1204	0.2870 **	0.1152	0.2614 **	0.0965	0.2159 *	0.0867	0.2136 *
	(0.1142)	(0.1241)	(0.1035)	(0.1126)	(0.0834)	(0.0919)	(0.0854)	(0.1015)	(0.0861)	(0.1027)
Diagnostic Dummy	- 0.0162	0.0325	- 0.0211	0.0359	0.0396	0.0746	- 0.0016	0.0100	0.0185	0.0242
	(0.1110)	(0.1218)	(0.0964)	(0.1070)	(0.0764)	(0.0851)	(0.0865)	(0.0920)	(0.0854)	(0.0910)
Veterinary Dummy	- 0.1055	- 0.1033	- 0.1822	- 0.1685	- 0.1038	- 0.1216	- 0.2780 *	- 0.2627 *	- 0.3053 **	- 0.2621 *
	(0.1518)	(0.1462)	(0.1393)	(0.1347)	(0.1048)	(0.1105)	(0.1237)	(0.1398)	(0.1235)	(0.1352)
Scope	0.0039	- 0.0847	- 0.0774	- 0.0904	- 0.0319	- 0.1143 *	- 0.0468	- 0.0914	- 0.0395	- 0.0878
	(0.0598)	(0.0657)	(0.0522)	(0.0602)	(0.0474)	(0.0550)	(0.0532)	(0.0654)	(0.0520)	(0.0631)
Firm Age	- 0.0001	- 0.0001 *	0.0000	- 0.0001 *	- 0.0001 *	- 0.0001 **	- 0.0001 *	- 0.0001 **	- 0.0001 *	- 0.0001 **
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)
Book-to-Market		- 0.1807 **		- 0.1680 *		- 0.1405 *		- 0.1973		- 0.1973
		(0.0765)		(0.0812)		(0.0641)		(0.1282)		(0.1262)
Survival Ratio		0.0208		0.0012		0.0195		0.0152		0.0171
		(0.0306)		(0.0263)		(0.0257)		(0.0326)		(0.0336)
Assets		- 0.1028 ***		- 0.1075 ***		- 0.0975 ***		- 0.0868 ***		- 0.0891 ***
		(0.0304)		(0.0280)		(0.0240)		(0.0248)		(0.0248)
Employees		1.6293 ***		1.4442 ***		1.3620 ***		1.9630 ***		2.0496 ***
		(0.4535)		(0.4062)		(0.3899)		(0.4223)		(0.4233)

* if p<0.05; ** if p<0.01; *** if p<0.001

Table 5: Maximum Likelihood Estimates for the Hazard of Subsequent Private Equity and Public Offerings Together (page 2 of 2)

Sales		- 0.0016 (0.0012)		- 0.0008 (0.0009)		- 0.0012 (0.0011)		- 0.0010 (0.0008)		- 0.0011 (0.0008)
LT Debt		0.0017 (0.0021)		0.0021 (0.0021)		0.0015 (0.0019)		- 0.0011 (0.0018)		- 0.0009 (0.0018)
Patent Count	- 0.0015 (0.0057)	0.0006 (0.0059)	- 0.0014 (0.0050)	0.0001 (0.0054)	0.0020 (0.0036)	0.0029 (0.0036)	- 0.0008 (0.0353)	- 0.0013 (0.0038)	- 0.0027 (0.0038)	- 0.0033 (0.0041)
Patent Clock	0.0522 * (0.0228)	0.0466 * (0.0255)	0.0416 * (0.0217)	0.0324 (0.0246)	0.0520 * (0.0230)	0.0480 * (0.0240)	0.0396 (0.0248)	0.0494 * (0.0273)	0.0449 * (0.0251)	0.0533 * (0.0274)
Com. Alliance Count	0.0124 (0.0090)	0.0217 ** (0.0091)	0.0132 (0.0085)	0.0227 ** (0.0085)	0.0025 (0.0049)	0.0149 ** (0.0064)	0.0090 (0.0056)	0.0188 ** (0.0074)	0.0107 * (0.0057)	0.0199 ** (0.0074)
Com. Alliance Clock	- 0.0913 ** (0.0313)	- 0.1025 ** (0.0350)	- 0.1008 *** (0.0298)	- 0.1100 *** (0.0333)	- 0.0938 ** (0.0299)	- 0.0999 ** (0.0322)	- 0.0957 * (0.0440)	- 0.0980 * (0.0501)	- 0.1007 * (0.0447)	- 0.0999 * (0.0508)
Res. Alliance Count	0.0029 (0.0112)	0.0048 (0.0125)	- 0.0069 (0.0105)	- 0.0029 (0.0118)	0.0035 (0.0084)	0.0044 (0.0094)	0.0045 (0.0088)	0.0013 (0.0095)	0.0027 (0.0085)	- 0.0006 (0.0091)
Res. Alliance Clock	- 0.0319 (0.0256)	- 0.0421 (0.0283)	- 0.0532 * (0.0255)	- 0.0601 * (0.0279)	- 0.0225 (0.0232)	- 0.0342 (0.0254)	- 0.0233 (0.0323)	- 0.0278 (0.0350)	- 0.0282 (0.0317)	- 0.0327 (0.0338)
Pub. Offering Count	- 0.0571 (0.0521)	- 0.0422 (0.0649)	- 0.0905 * (0.0541)	- 0.0607 (0.0642)	- 0.0641 (0.0499)	- 0.0376 (0.0608)	- 0.0269 (0.0586)	- 0.0318 (0.0649)	- 0.0167 (0.0580)	- 0.0212 (0.0641)
Pub. Offering Clock	- 0.5109 *** (0.0193)	- 0.0327 (0.0231)	- 0.0468 ** (0.0176)	- 0.0333 (0.0217)	- 0.0661 *** (0.0172)	- 0.0452 * 0.0206	- 0.0216 (0.0237)	- 0.0140 (0.0284)	- 0.0163 (0.0241)	- 0.0068 (0.0290)
Missing CAR Dummy									0.6287 ** (0.2105)	0.7387 ** (0.2440)
Priv. Placement Dummy			0.7796 *** (0.0859)	0.7758 *** (0.1004)						
Priv. Placement Count					0.1251 *** (0.0107)	0.1130 *** (0.0140)	0.0593 *** (0.0146)	0.0442 ** (0.0162)	0.0594 *** (0.0148)	0.0439 ** (0.0164)
Priv. Placement Clock					-0.0689 *** (0.0172)	-0.0473 ** (0.0174)	-0.1718 *** (0.0403)	-0.1245 *** (0.0388)	-0.1521 *** (0.0409)	-0.1087 ** (0.0384)
Priv. Placement Abnormal Return							0.1886 (0.1933)	0.2519 (0.2139)	0.7094 * (0.3378)	0.7842 * (0.3502)
PP Clock x PP Abnormal Return									- 0.2873 ** (0.1203)	- 0.2790 * (0.1216)
Constant	- 7.5849 *** (0.5362)	- 7.4071 *** (0.6200)	- 7.7615 *** (0.5181)	- 7.6044 *** (0.6001)	- 7.3559 *** (0.4683)	- 7.0880 *** (0.5539)	- 5.6289 *** (0.6409)	- 5.9142 *** (0.7002)	- 5.9034 *** (0.7756)	- 6.3116 *** (0.8484)
Log-Likelihood Ratio	-285.06 ***	-119.90 ***	-235.42 ***	-81.21 ***	-222.35 ***	-76.63 ***	256.15 ***	254.48 ***	260.91 ***	259.59 ***
# of Financing Events	1126	981	1126	981	1126	981	586	540	586	540

* if p<0.05; ** if p<0.01; *** if p<0.001

Table 6: Maximum Likelihood Estimates for the Hazard of Subsequent Research Alliances (page 1 of 2)

Variable Name	1	2	3	4	5	6	7	8	9	10
Biotechnology Index	0.1001 * (0.0452)	0.1000 * (0.0449)	0.1016 * (0.0444)	0.1021 * (0.0444)	0.0964 * (0.0450)	0.0978 * (0.0447)	0.0705 (0.0511)	0.1025 * (0.0531)	0.0700 (0.0510)	0.0938 * (0.0539)
Nasdaq	0.0000 (0.0000)	0.0000 (0.0000)	0.0000 (0.0000)	0.0000 (0.0000)	0.0000 (0.0000)	0.0000 (0.0000)	0.0000 (0.0000)	0.0000 (0.0000)	0.0000 (0.0000)	0.0000 (0.0000)
Quarterly Public Offerings	0.0000 (0.0001)	0.0000 (0.0001)	0.0000 (0.0001)	0.0000 (0.0001)	0.0000 (0.0001)	0.0000 (0.0001)	0.0001 (0.0001)	0.0001 (0.0001)	0.0001 (0.0001)	0.0001 (0.0001)
Quarterly Private Placements	- 0.0003 * (0.0002)	- 0.0003 * (0.0002)	- 0.0003 * (0.0002)	- 0.0003 * (0.0002)	- 0.0003 * (0.0002)	- 0.0003 * (0.0002)	- 0.0003 (0.0002)	- 0.0004 * (0.0002)	- 0.0003 (0.0002)	- 0.0004 (0.0002)
Quarterly Research Alliances	0.0102 *** (0.0031)	0.0101 ** (0.0032)	0.0098 (0.0331)	0.0097 ** (0.0032)	0.0103 *** (0.0031)	0.0102 ** (0.0032)	0.0073 (0.0046)	0.0083 * (0.0045)	0.0074 (0.0046)	0.0082 * (0.0045)
Quarterly Com. Alliances	0.0082 ** (0.0026)	0.0073 ** (0.0026)	0.0083 ** (0.0026)	0.0075 ** (0.0026)	0.0082 ** (0.0026)	0.0073 ** (0.0026)	0.0138 *** (0.0037)	0.0129 *** (0.0035)	0.0139 *** (0.0037)	0.0132 *** (0.0036)
Quarterly Patents	0.0018 (0.0013)	0.0004 (0.0013)	0.0004 (0.0013)	0.0006 (0.0013)	0.0008 (0.0013)	0.0008 (0.0013)	0.0005 (0.0017)	0.0019 (0.0016)	0.0003 (0.0017)	0.0015 (0.0017)
Density	- 0.0012 (0.0009)	- 0.0010 (0.0009)	- 0.0014 (0.0009)	- 0.0011 (0.0009)	- 0.0014 (0.0009)	- 0.0011 (0.0009)	- 0.0039 ** (0.0013)	- 0.0024 * (0.0014)	- 0.0039 ** (0.0013)	- 0.0022 (0.0014)
> 1990	- 0.1506 (0.1378)	- 0.2622 * (0.1362)	- 0.1969 (0.1352)	- 0.3096 * (0.1342)	- 0.1965 (0.1419)	- 0.2907 * (0.1405)	- 0.0278 (0.2057)	- 0.2922 (0.2072)	- 0.0431 (0.2060)	- 0.2882 (0.2081)
Therapeutic Dummy	0.1805 (0.1192)	0.3009 * (0.1330)	0.1613 (0.1141)	0.2795 * (0.1296)	0.1727 (0.1114)	0.2838 * (0.1324)	- 0.0106 (0.1332)	0.0465 (0.1506)	- 0.0060 (0.1349)	0.0357 (0.1537)
Diagnostic Dummy	- 0.0898 (0.0977)	- 0.0574 (0.0944)	- 0.0862 (0.0937)	- 0.0609 (0.0916)	0.0714 (0.0913)	- 0.0465 (0.0876)	0.0839 (0.1322)	0.0488 (0.1158)	0.0945 (0.1326)	0.0517 (0.1152)
Veterinary Dummy	0.1308 (0.1077)	0.0821 (0.1107)	0.0837 (0.1128)	0.0464 (0.1134)	0.1342 (0.1132)	0.1000 (0.1133)	0.4164 ** (0.1411)	0.3857 ** (0.1415)	0.4244 ** (0.1410)	0.4059 ** (0.1418)
Scope	0.1412 ** (0.0564)	0.0990 * (0.0534)	0.1333 ** (0.0557)	0.0991 * (0.0530)	0.1285 ** (0.0540)	0.0937 * (0.0526)	- 0.0429 (0.0747)	- 0.0508 (0.0713)	- 0.0500 (0.0748)	- 0.0517 (0.0705)
Firm Age	0.0000 (0.0000)	- 0.0001 * (0.0000)	0.0000 (0.0000)	- 0.0001 * (0.0000)	0.0000 (0.0000)	- 0.0001 * (0.0000)	0.0000 (0.0001)	0.0000 (0.0001)	0.0000 (0.0001)	0.0000 (0.0001)
Book-to-Market		0.0589 *** (0.0122)		0.0570 *** (0.0129)		0.0597 *** (0.0127)		0.2474 * (0.1234)		0.2552 * (0.1244)
Survival Ratio		0.0894 ** (0.0354)		0.0803 * (0.0348)		0.0892 ** (0.0352)		0.0758 * (0.0408)		0.0743 * (0.0413)
Assets		- 0.0001 (0.0157)		- 0.0022 (0.0156)		0.0045 (0.0155)		0.0118 (0.0180)		0.0124 (0.0181)
Employees		0.8373 ** (0.3139)		0.7470 ** (0.3024)		0.7900 ** (0.3216)		0.4379 (0.3749)		0.3899 (0.3777)

* if p<0.05; ** if p<0.01; *** if p<0.001

Table 6: Maximum Likelihood Estimates for the Hazard of Subsequent Research Alliances (page 2 of 2)

Sales		0.0000 (0.0003)		0.0001 (0.0003)		0.0001 (0.0003)		0.0010 ** (0.0003)		0.0010 ** (0.0004)
LT Debt		- 0.0007 (0.0011)		- 0.0003 (0.0012)		- 0.0011 (0.0011)		- 0.0009 (0.0010)		- 0.0009 (0.0010)
Patent Count	- 0.0039 (0.0065)	- 0.0080 (0.0054)	- 0.0034 (0.0663)	- 0.0082 (0.0053)	- 0.0032 (0.0061)	- 0.0071 (0.0049)	- 0.0013 (0.0048)	- 0.0087 * (0.0042)	- 0.0006 (0.0050)	- 0.0092 * (0.0046)
Patent Clock	- 0.0529 (0.0340)	- 0.0387 (0.0357)	- 0.0584 * (0.0344)	- 0.0445 (0.0360)	- 0.0486 (0.0343)	- 0.0340 (0.0360)	- 0.0809 * (0.0438)	- 0.0723 (0.0450)	0.0871 * (0.0434)	- 0.0806 * (0.0455)
Com. Alliance Count	- 0.0132 (0.0099)	- 0.0170 (0.0080)	- 0.0129 (0.0096)	- 0.0168 (0.0079)	- 0.0144 (0.0088)	- 0.0188 (0.0075)	0.0037 (0.0082)	- 0.0092 (0.0065)	0.0035 (0.0081)	- 0.0077 (0.0062)
Com. Alliance Clock	- 0.0956 * (0.0469)	- 0.1000 * (0.0561)	- 0.0989 * (0.0523)	- 0.1033 * (0.0605)	- 0.0927 * (0.0493)	- 0.0931 * (0.0563)	- 0.1400 * (0.0769)	- 0.1148 (0.0763)	- 0.1447 * (0.0779)	- 0.1233 (0.0795)
Res. Alliance Count	0.0678 *** (0.0099)	0.0603 *** (0.0089)	0.0640 *** (0.0105)	0.0578 *** (0.0093)	0.0668 *** (0.0097)	0.0618 *** (0.0084)	0.0462 *** (0.0115)	0.0433 *** (0.0097)	0.0462 *** (0.0115)	0.0411 *** (0.0093)
Res. Alliance Clock	- 0.2669 *** (0.0370)	- 0.2730 *** (0.0389)	- 0.2846 *** (0.0387)	- 0.2863 *** (0.0399)	- 0.2657 *** (0.0375)	- 0.2651 *** (0.0386)	- 0.3373 *** (0.0574)	- 0.2891 *** (0.0565)	- 0.3350 *** (0.0583)	- 0.2870 *** (0.0566)
Pub. Offering Count	- 0.0667 (0.0514)	- 0.0847 * (0.0381)	- 0.0814 (0.0521)	- 0.0881 * (0.0385)	- 0.0753 (0.0540)	- 0.0821 * (0.0373)	- 0.0381 (0.0720)	- 0.0516 (0.0447)	- 0.0372 (0.0729)	- 0.0471 (0.0443)
Pub. Offering Clock	- 0.1555 *** (0.0246)	- 0.1338 *** (0.0239)	- 0.1533 *** (0.0247)	- 0.1342 *** (0.0238)	- 0.1603 *** (0.0249)	- 0.1358 *** -0.0243	- 0.0861 *** (0.0257)	- 0.0982 *** (0.0245)	- 0.0864 *** (0.0259)	- 0.1011 *** (0.0251)
Missing CAR Dummy									- 0.0179 (0.3088)	0.2075 (0.2746)
Priv. Placement Dummy			0.3601 *** (0.1106)	0.2784 ** (0.1172)						
Priv. Placement Count					0.0516 ** (0.0201)	0.0263 (0.0193)	- 0.0026 (0.0233)	- 0.0081 (0.0210)	- 0.0029 (0.0234)	- 0.0095 (0.0214)
Priv. Placement Clock					- 0.0222 (0.0215)	- 0.0372 (0.0233)	- 0.1717 ** (0.0574)	- 0.2538 *** (0.0568)	- 0.1875 ** (0.0685)	- 0.2669 *** (0.0591)
Priv. Placement Abnormal Return							0.8560 ** (0.3149)	0.8743 ** (0.3049)	0.4949 (0.4260)	0.3671 (0.4427)
PP Clock x PP Abnormal Return									0.1633 (0.1507)	0.2573 (0.1681)
Constant	- 6.1738 *** (0.3717)	- 6.2940 *** (0.3675)	- 6.2351 *** (0.3592)	- 6.3629 *** (0.3642)	- 6.1035 *** (0.3730)	- 6.2422 *** (0.3744)	- 4.4081 *** (0.5682)	- 5.1858 *** (0.6087)	- 4.4047 *** (0.5655)	- 5.2055 *** (0.6188)
Log-Likelihood Ratio	166.65 ***	370.94 ***	183.17 ***	379.16 ***	177.35 ***	376.16 ***	653.88 ***	675.53 ***	654.69 ***	677.01 ***
# of Res. Alliances	1642	1476	1642	1476	1642	1476	744	707	744	707

* if p<0.05; ** if p<0.01; *** if p<0.001

Table 7: Maximum Likelihood Estimates for the Hazard of Subsequent Commercial Alliances (page 1 of 2)

Variable Name	1	2	3	4	5	6	7	8	9	10
Biotechnology Index	0.0414 (0.0386)	0.0185 (0.0396)	0.0420 (0.0375)	0.0193 (0.0388)	0.0404 (0.0379)	0.0192 (0.0393)	0.0369 (0.0441)	0.0416 (0.0457)	0.0389 (0.0443)	0.0407 (0.0459)
Nasdaq	0.0000 (0.0000)	0.0000 (0.0000)	0.0000 (0.0000)	0.0000 (0.0000)	0.0000 (0.0000)	0.0000 (0.0000)	0.0000 (0.0000)	0.0000 (0.0000)	0.0000 (0.0000)	0.0000 (0.0000)
Quarterly Public Offerings	0.0000 (0.0001)	0.0000 (0.0001)	0.0000 (0.0001)	0.0000 (0.0001)	0.0000 (0.0001)	0.0000 (0.0001)	0.0001 (0.0001)	0.0001 (0.0001)	0.0001 (0.0001)	0.0001 (0.0001)
Quarterly Private Placements	0.0001 (0.0001)	0.0001 (0.0002)	0.0001 (0.0001)	0.0002 (0.0002)	0.0001 (0.0002)	0.0001 (0.0002)	0.0013 *** (0.0002)	0.0001 (0.0002)	0.0001 (0.0019)	0.0001 (0.0002)
Quarterly Research Alliances	0.0067 * (0.0031)	0.0074 (0.0031)	0.0060 * (0.0030)	0.0070 * (0.0030)	0.0070 * (0.0031)	0.0777 *** (0.0032)	0.0098 ** (0.0039)	0.0102 ** (0.0039)	0.0099 ** (0.0039)	0.0103 ** (0.0039)
Quarterly Com. Alliances	0.0088 *** (0.0025)	0.0079 (0.0025)	0.0090 *** (0.0024)	0.0081 *** (0.0024)	0.0086 *** (0.0025)	0.0078 ** (0.0025)	0.0054 * (0.0032)	0.0050 (0.0032)	0.0054 * (0.0032)	0.0050 (0.0032)
Quarterly Patents	0.0012 (0.0012)	0.0007 (0.0012)	0.0013 (0.0013)	0.0096 *** (0.0012)	0.0018 (0.0013)	0.0012 (0.0013)	0.0035 * (0.0015)	0.0043 ** (0.0014)	0.0036 ** (0.0015)	0.0043 ** (0.0014)
Density	- 0.0019 ** (0.0007)	- 0.0018 (0.0008)	- 0.0021 *** (0.0007)	- 0.0020 ** (0.0007)	- 0.0020 ** (0.0007)	- 0.0020 ** (0.0007)	- 0.0033 ** (0.0012)	- 0.0023 * (0.0011)	- 0.0034 ** (0.0012)	- 0.0024 * (0.0011)
> 1990	- 0.3432 ** (0.1246)	- 0.3258 (0.1221)	0.3822 ** (0.1284)	- 0.3673 ** (0.1261)	- 0.3870 ** (0.1304)	- 0.3693 ** (0.1251)	- 0.4192 ** (0.1610)	- 0.6060 *** (0.1522)	- 0.4310 ** (0.1649)	- 0.6054 *** (0.1540)
Therapeutic Dummy	- 0.1118 (0.1005)	- 0.0186 (0.1096)	- 0.1469 (0.0980)	- 0.0509 (0.1083)	- 0.1160 (0.0958)	- 0.0352 (0.1041)	- 0.0598 (0.1205)	- 0.0420 (0.1260)	- 0.0472 (0.1216)	- 0.0389 (0.1271)
Diagnostic Dummy	- 0.0400 (0.0911)	0.0021 (0.0899)	- 0.0340 (0.0831)	0.0014 (0.0851)	0.0036 (0.0833)	0.0452 (0.0826)	- 0.0056 (0.1043)	- 0.0380 (0.0990)	- 0.0166 (0.1033)	- 0.0428 (0.1003)
Veterinary Dummy	0.2214 ** (0.0940)	0.1743 (0.0924)	0.1786 * (0.0995)	0.1409 (0.0983)	0.2489 ** (0.0979)	0.1987 * (0.0917)	0.2811 ** (0.1180)	0.2028 * (0.1145)	0.2820 ** (0.1180)	0.2025 * (0.1151)
Scope	0.1529 ** (0.0527)	0.1069 (0.0500)	0.1348 ** (0.0545)	0.0995 * (0.0524)	0.1288 ** (0.0535)	0.0915 * (0.0500)	0.0326 (0.0559)	0.0505 (0.0501)	0.0281 (0.0548)	0.0455 (0.0507)
Firm Age	0.0001 * (0.0000)	0.0000 (0.0000)	0.0001 * (0.0000)	0.0000 (0.0000)	0.0001 * (0.0000)	0.0000 (0.0000)	0.0001 ** (0.0001)	0.0001 ** (0.0000)	0.0001 ** (0.0001)	0.0001 ** (0.0000)
Book-to-Market		- 0.0572 (0.0584)		- 0.0548 (0.0535)		- 0.0457 (0.0462)		- 0.1519 (0.1050)		- 0.1589 (0.1062)
Survival Ratio		0.0662 (0.0276)		0.0595 (0.0287)		0.0680 ** (0.0280)		- 0.0016 (0.0387)		- 0.0001 (0.0395)
Assets		- 0.0152 (0.0141)		- 0.0187 (0.0147)		- 0.0113 (0.0140)		0.0151 (0.0149)		0.0162 (0.0149)
Employees		0.8449 (0.3287)		0.7270 (0.3135)		0.7061 * (0.3213)		0.0766 (0.3229)		0.0452 (0.3214)

* if p<0.05; ** if p<0.01; *** if p<0.001

Table 7: Maximum Likelihood Estimates for the Hazard of Subsequent Commercial Alliances (page 2 of 2)

Sales		- 0.0003 (0.0003)		- 0.0001 (0.0002)		- 0.0001 (0.0003)		0.0007 ** (0.0002)		0.0007 ** (0.0002)
LT Debt		- 0.0031 (0.0008)		- 0.0026 (0.0009)		- 0.0035 *** (0.0009)		- 0.0025 ** (0.0009)		- 0.0026 ** (0.0009)
Patent Count	- 0.0101 ** (0.0042)	- 0.0060 (0.0036)	- 0.0092 * (0.0045)	- 0.0059 (0.0038)	- 0.0083 * (0.0042)	- 0.0042 (0.0034)	- 0.0017 (0.0032)	- 0.0027 (0.0029)	- 0.0007 (0.0031)	- 0.0018 (0.0029)
Patent Clock	- 0.0323 (0.0272)	- 0.0194 (0.0272)	- 0.0412 (0.0268)	- 0.0311 (0.0270)	- 0.0263 (0.0260)	- 0.0148 (0.0265)	- 0.0543 * (0.0318)	- 0.0481 (0.0326)	- 0.0535 * (0.0314)	- 0.0512 (0.0314)
Com. Alliance Count	0.0349 *** (0.0064)	0.0345 (0.0067)	0.0353 *** (0.0062)	0.0358 *** (0.0067)	0.0300 *** (0.0068)	0.0306 *** (0.0070)	0.0299 *** (0.0061)	0.0232 (0.0669)	0.0290 *** (0.0062)	0.0232 *** (0.0068)
Com. Alliance Clock	- 0.4510 *** (0.0430)	- 0.4638 (0.0454)	- 0.4631 *** (0.0433)	- 0.4742 *** (0.0457)	- 0.4518 *** (0.0443)	- 0.4597 *** (0.0471)	- 0.5194 *** (0.0698)	- 0.4979 *** (0.0696)	- 0.5156 *** (0.0694)	- 0.4923 *** (0.0680)
Res. Alliance Count	- 0.0013 (0.0076)	- 0.0050 (0.0075)	- 0.0059 (0.0077)	- 0.0088 (0.0078)	0.0026 (0.0075)	- 0.0010 (0.0075)	- 0.0097 (0.0088)	- 0.0105 (0.0084)	- 0.0090 (0.0090)	- 0.0104 (0.0084)
Res. Alliance Clock	- 0.0624 ** (0.0233)	- 0.0926 (0.0275)	- 0.0769 *** (0.0229)	- 0.1057 *** (0.0269)	- 0.0581 ** (0.0245)	- 0.0862 ** (0.0278)	- 0.1064 ** (0.0335)	- 0.1067 ** (0.0350)	- 0.1031 ** (0.0332)	- 0.1059 ** (0.0346)
Pub. Offering Count	- 0.0791 * (0.0382)	- 0.0752 (0.0380)	- 0.0949 ** (0.0379)	- 0.0777 * (0.0388)	- 0.0813 * (0.0370)	- 0.0669 * (0.0372)	- 0.0861 * (0.0413)	- 0.0598 * (0.0354)	- 0.0884 * (0.0413)	- 0.0611 * (0.0352)
Pub. Offering Clock	- 0.1380 *** (0.0219)	- 0.0998 (0.0216)	- 0.1329 *** (0.0233)	- 0.0956 *** (0.0233)	- 0.1430 *** (0.0244)	- 0.1020 *** 0.0240	- 0.1209 *** (0.0221)	- 0.1069 *** (0.0206)	- 0.1216 *** (0.0219)	- 0.1102 *** (0.0206)
Missing CAR Dummy									- 0.4298 (0.2914)	- 0.4180 (0.3261)
Priv. Placement Dummy			0.4212 *** (0.1311)	0.3513 ** (0.1273)						
Priv. Placement Count					0.0517 ** (0.0191)	0.0427 ** (0.0166)	- 0.0049 (0.0190)	- 0.0079 (0.0197)	- 0.0045 (0.0188)	- 0.0081 (0.0194)
Priv. Placement Clock					-0.0350 (0.0213)	-0.0424 * (0.0209)	-0.1702 *** (0.0508)	-0.2081 *** (0.0502)	-0.1761 ** (0.0567)	-0.2192 *** (0.0477)
Priv. Placement Abnormal Return							- 0.0808 (0.3151)	- 0.0782 (0.3583)	- 0.1424 (0.4070)	- 0.4265 (0.4806)
PP Clock x PP Abnormal Return									0.0459 (0.1642)	0.2510 (0.2701)
Constant	- 5.3426 *** (0.3265)	- 5.2700 *** (0.3632)	- 5.3739 *** (0.2951)	- 5.3109 *** (0.3421)	- 5.2865 *** (0.3254)	- 5.2143 *** (0.3694)	- 3.9534 *** (0.5475)	- 4.4073 *** (0.5436)	- 3.8975 *** (0.5647)	- 4.3062 *** (0.5766)
Log-Likelihood Ratio	1269.07 ***	1396.49 ***	1298.24 ***	1413.79 ***	1286.98 ***	1410.20 ***	1396.46 ***	1347.97 ***	1398.23 ***	1349.76 ***
# of Com. Alliances	2185	1969	2185	1969	2185	1969	1083	1015	1083	1015

* if p<0.05; ** if p<0.01; *** if p<0.001

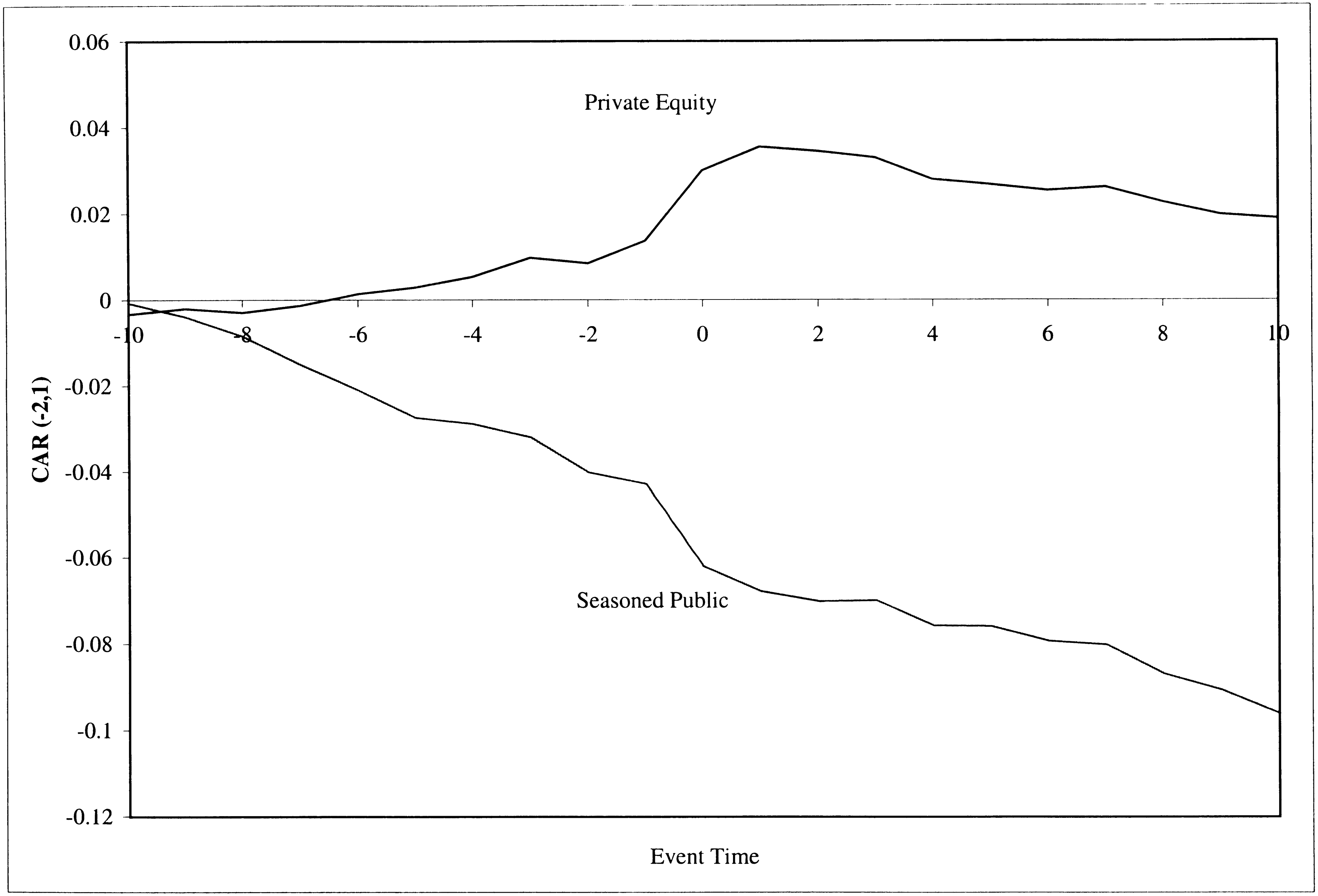

Figure 1: Plot of Cumulative Two-Factor Abnormal Returns for Private Equity Placement Announcements and Public Equity Offering Announcements

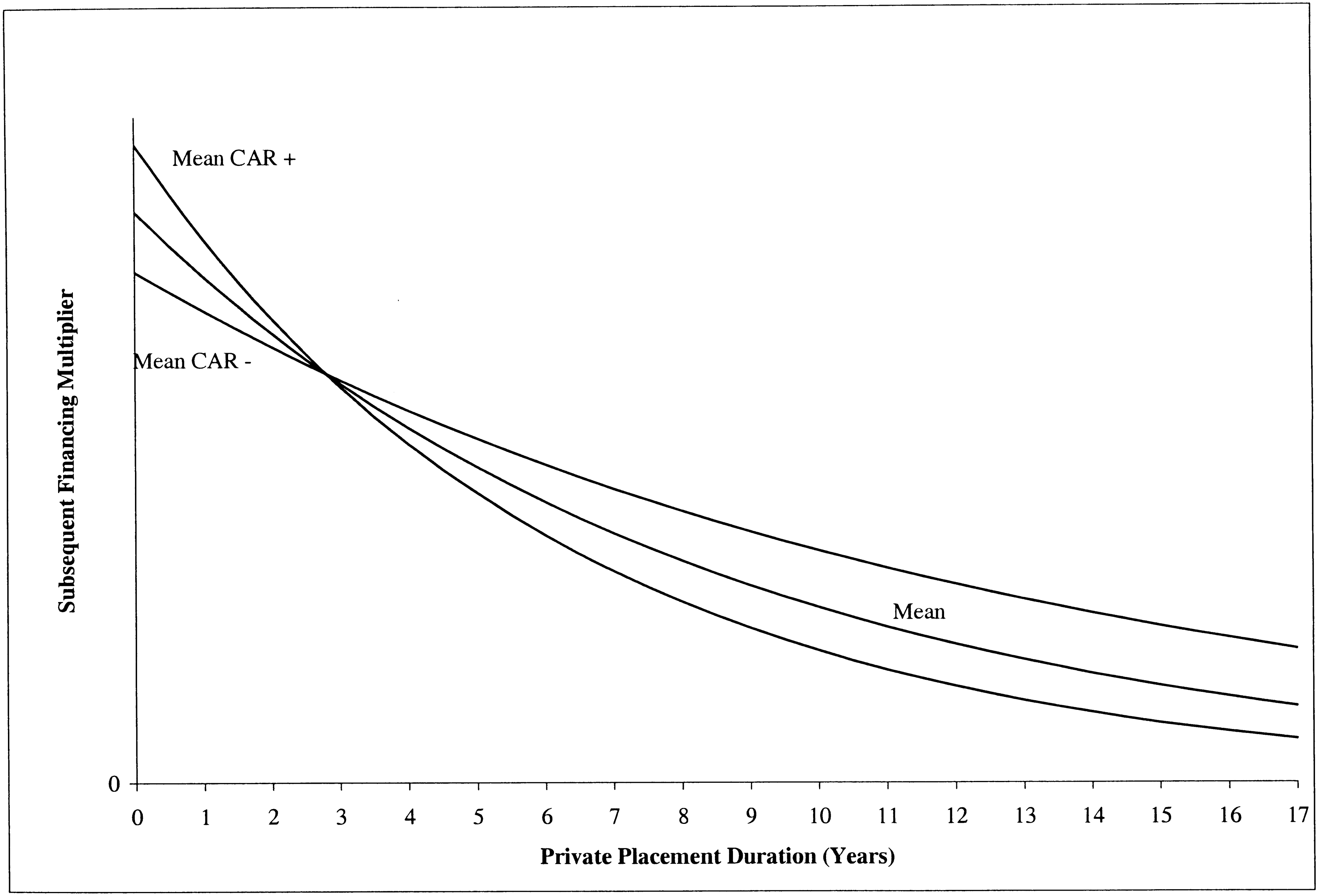

Figure 2: Effect of Private Placement Duration on Subsequent Financing at Different Levels of Abnormal Returns

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