Interorganizational Endorsements and the Performance of Entrepreneurial Ventures

Toby E. Stuart
University of Chicago
Ha Hoang
Case Western Reserve University
Ralph C. Hybels
Leadership in Medicine, Inc.

This paper investigates how the interorganizational networks of young companies affect their ability to acquire the resources necessary for survival and growth. We propose that, faced with great uncertainty about the quality of young companies, third parties rely on the prominence of the affiliates of those companies to make judgments about their quality and that young companies "endorsed" by prominent exchange partners will perform better than otherwise comparable ventures that lack prominent associates. Results of an empirical examination of the rate of initial public offering (IPO) and the market capitalization at IPO of the members of a large sample of venture-capital-backed biotechnology firms show that privately held biotech firms with prominent strategic alliance partners and organizational equity investors go to IPO faster and earn greater valuations at IPO than firms that lack such connections. We also empirically demonstrate that much of the benefit of having prominent affiliates stems from the transfer of status that is an inherent byproduct of interorganizational associations.•

Mobilizing resources to build a new organization is an undertaking laden with uncertainty and unforeseeable hazards (Stinchcombe, 1965; Aldrich and Auster, 1986; Freeman, 1997). It is also inherently a social process, because entrepreneurs must access financial and social capital and other types of resources via business relationships with parties outside of the boundaries of their organizations. Because the quality of a new venture is always a matter of some debate, however, the decision of external resource holders to invest their time, capital, or other resources in a new organization is one that must be made under considerable uncertainty about the embryonic enterprise's life chances and its financial prospects. This paper investigates how interorganizational relationships, by shaping potential investors' assessments of the quality of young companies, affect those firms' ability to obtain the resources to survive.

Interorganizational exchange relationships can act as endorsements that influence perceptions of the quality of young organizations when unambiguous measures of quality do not exist or cannot be observed. As a result, the valuations of young firms are at times attributions influenced by the characteristics of the affiliates of the companies under scrutiny. Because strong relationships with prominent organizations convey the fact that young companies have earned a positive evaluation from experienced and influential actors, associations with high-status organizations elevate the reputations of new ventures. This paper documents how the performance of young biotechnology firms is affected by such an interorganizational certification, or endorsement process, as it operates in the industry's strategic alliance and equity ownership networks, as well as through the connections between new ventures and the investment banks that underwrite their securities offerings. Our empirical analyses focus on the degree to which the prominence of the business partners of young biotechnology companies affect their ability to acquire a crucial resource: capital.

0001-8392/99/4402-0315/$1.00.

•
We thank Ron Burt, Rob Gertner, Steve Kaplan, Jesper Sorensen, and Olav Sorensen for many helpful suggestions. We also thank Satomi Degami and Mark Edwards of Recombinant Capital for supplying us with information on private biotechnology firms, and Joshua Lerner for providing us with the equity index used in our analysis and for his extensive comments on this paper. Seminar participants at the Sloan School of Management, Harvard Business School, Haas School of Business, and Columbia University offered many valuable suggestions for improving this paper. This research was generously supported by a grant (to Stuart) from the Kauffman Center for Entrepreneurial Leadership at the Ewing Marion Kauffman Foudation, Kansas City, MO. Please direct all correspondences to Toby Stuart, University of Chicago, Graduate School of Business, 1101 East 58th Street, Chicago, IL 60637.

INTERORGANIZATIONAL ENDORSEMENTS

Many obstacles confront young companies. New organizations often lack the commitment of their employees, knowledge of their environments, and working relationships with customers and suppliers (Stinchcombe, 1965). Similarly, unseasoned enterprises have little production experience, and so operate under the guidance of immature and unrefined routines (Sorensen and Stuart, 1999). Because young companies often are unable to produce outputs of consistent quality, they face a high probability of dissolution (Hannan and Freeman, 1984). Moreover, new organizations tend to be small organizations. In part because they do not have the financial and other resources to withstand a sustained period of poor performance, the rate of disbandment among small organizations is quite high (Aldrich and Auster, 1986; Levinthal, 1991). These perils have led organizational sociologists to argue that young (or small) organizations are highly vulnerable to environmental selection, a notion succinctly portrayed as a liability of newness (or smallness).

Because young and small companies encounter so many potential hazards and because they have short track records by which outsiders can evaluate their quality, there is considerable uncertainty about the value of new ventures. This uncertainty is compounded for certain types of organizations, such as those established to pursue commercial applications of new technologies (Aldrich and Fiol, 1993). Added to the usual hazards of inexperience, young technology companies often require substantial resources to fund early-stage and speculative development projects, while revenues cannot be expected until well into the future. Moreover, new technology is by its very nature highly uncertain: undeveloped markets follow unforeseen turns; hyped-up technologies disappear far more often than they engender promised technological shifts; technologies obsolesce extremely rapidly; and unanticipated kinks derail once-promising development projects (Tushman and Rosenkopf, 1992). For these reasons, new technology companies are extremely risky.

The case of Microcide Pharmaceutical illustrates the challenges in evaluating young companies. Founded in 1992 to develop novel antibiotics, Microcide is a genomics company. When the company filed for an initial public offering (IPO) in 1996, it had made progress in the development of a gene function-based technology platform to identify and commercialize new antibiotics. This technology enables the identification of the genes in a microorganism that cause pathogenicity in the body. The company had already filed for 30 patents, although all of them were still being reviewed by the Patent Office in 1996. On the heels of these potentially significant achievements, Microcide sought to raise $40 million for a 24-percent stake in the company in an IPO (Microcide Pharmaceuticals, SEC form S-1, 1996). At the time of the offering, however, Microcide had yet to commercialize a product, and it garnered no revenues other than milestone payments from its strategic alliance partners. In addition, the antibiotics market was hotly contested; many of the largest drug companies and a significant number of upstart biotech firms were competing in this domain. Because of the intense competition in this area and the scientific uncertainty associated with Microcide's research approach, it was difficult to predict whether any of Microcide's discoveries would lead to the development of a clinically viable therapeutic. In fact, the only certainty at the time of the Microcide IPO was that the company was many years away from generating a significant revenue stream from sales of internally developed products.

In this paper, we examine how perceptions of the value of early-stage companies such as Microcide are affected by the relationships that position those firms in interorganizational exchange networks. Because the quality of young companies often cannot be observed directly, evaluators must appraise the company based on observable attributes that are thought to covary with its underlying but unknown quality. Resource holders therefore assess value by estimating the conditional probability that a firm will succeed, given a set of observable characteristics of the organization.

There are two qualitatively distinct categories of information that influence perceptions of the probability that a young company will succeed. First, important constituencies such as potential investors and customers make quality judgments through careful consideration of the previous accomplishments of the organization. In addition to having intrinsic value, these attainments are often signals (Spence, 1974) of a young company's abilities. For example, one of the most important achievements of a new venture in a technology-intensive industry may be the number of patents that the organization has accrued. A proven ability to patent new technologies is important not only because patents are property rights to potentially revenue-generating inventions but also because this track record signals the depth of the firm's underlying technological capabilities: firms with many patents are likely to have high-quality scientific and engineering staffs. In industries in which innovation is one of the pivotal bases of competition, firms with many patents signal their ability to create future advances and to capitalize on external scientific developments that may be relevant to the firm's commercial interests (Cohen and Levinthal, 1990; Henderson and Cockburn, 1994; Kogut and Zander, 1996).

The second category of information evaluators can use to estimate the worth of a young company is the attributes of the exchange partners of a focal organization. Evaluators routinely take into account the characteristics of a young company's exchange partners when they estimate the likelihood that a new venture will succeed. Therefore, the identity of exchange partners becomes a primary consideration when potential investors, customers, employees, suppliers, and other exchange partners decide whether to commit their resources to a new enterprise. Because the prior accomplishments of an entrepreneurial venture are rarely sufficient to resolve the uncertainty about its quality, the social structure of business relationships can significantly affect perceptions of the quality (and hence value) of new ventures.

The general argument that the characteristics of affiliates serve as discernible guides for resolving uncertainty about the quality of a young or unknown entity follows directly from the notion that actors' reputations are constructed in part from the identities of their associates (Blau, 1964). Network theorists have long asserted that relationships implicitly transfer status between the parties in an association (while also serving as the channels of material and social exchanges). For example, a young scholar's professional prospects may be greatly enhanced when he or she has the backing of a prestigious researcher (Merton, 1973; Goode, 1978). Latour (1987) argued that professional evaluations of scientific work are influenced by the prestige of the scientist's affiliates, particularly in uncertain research areas where there is dissension over what constitutes an important contribution. In a study of the diffusion of a new drug through a community of physicians, Burt (1987) showed that doctors' perceptions of the therapy improved after prominent physicians chose to adopt it. Generalizing this idea to a corporate context, Podolny and Stuart (1995) demonstrated that inventions in uncertain technological areas were more likely to become widely important when they had been previously adopted by high-status organizations. In a related line of research, Baum and Oliver (1991, 1992) demonstrated that organization-to-institution ties signal conformance to institutional prescriptions and thereby facilitate young organizations in their attempts to acquire legitimacy and other resources (see also Aldrich and Auster, 1986; Singh, House, and Tucker, 1986; Rao, 1994).

The starting point of much of this work is the observation that social or industrial structures can be represented as a set of positions that are arranged hierarchically according to the prominence of their occupants. In addition, many of these scholars argue that when there is uncertainty about the quality of an individual, an organization, or a product, associations with the occupants of positions of prominence enhance the regard paid to the "connected" actor and its endeavors. There are three possible social mechanisms that may lead would-be investors, customers and other potential exchange partners to take into account the characteristics of a focal new venture's affiliates as they strive to assess its unobserved and uncertain quality: (1) relationships have reciprocal effects on the reputations of those involved, (2) the evaluative capabilities of well-known organizations are perceived to be strong, and (3) relationships with prominent organizations signal a new venture's reliability, and, thus, its high likelihood of survival.

Reciprocal relationships. The first of the three mechanisms assumes that relationships have reciprocal influences on the reputations of actors. Thus, even when an association is between a prominent organization and a young enterprise, the prominent organization's reputation may be damaged if the new venture is of very low quality. In general, as long as exchange relations create the possibility of a loss of status, those held in high regard will have a commensurately strong incentive to avoid low-quality exchange partners. Therefore, prominent organizations will be exclusive in their selection of associates: to do otherwise would be to risk dissipating the economic and social rents generated by a good reputation (Blau, 1964; Goode, 1978; White, 1985; Podolny, 1994; Podolny and Phillips, 1996). Through this dynamic, relationships with prominent actors may raise third parties' estimates of the quality of the affiliated enterprises.

Quality assessments. The second mechanism posits that resource holders are influenced by the evaluations of prominent actors because they trust the ability of prominent organizations to discern quality under conditions of uncertainty (Stuart, 1998). If there is a perceived association between prominence and evaluative ability, then third parties will interpret a connection to a prominent organization as an endorsement of the initiatives of a young venture. Because prominent organizations 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 it is, in and of itself, a valuable endorsement. Unlike the first mechanism, however, this process does not depend on the assumption that the reputational capital of prominent organizations is at stake in each of their associations. It is not necessary to assume that an occasional, low-quality exchange partner will meaningfully damage an organization's reputation.

Reliability. Organizational ecologists argue that organizations that are thought to be reliable, accountable, and trustworthy have higher chances of survival and better performance (Stinchcombe, 1965; Hannan and Freeman, 1984). Two assumptions are needed to conclude that new ventures with prominent partners will be perceived as reliable and accountable. First, we must assume that gaining a partnership with a prominent organization draws attention to a new venture. This premise is likely to hold because the initiates of prominent organizations are focal points that attract the attention of industry analysts and the business press, as well as potential employees, suppliers, and customers. Second, if we assume that organizations in general will eschew relations with firms that may be unreliable, then the mere fact that a young company was previously selected as a partner in a consequential exchange relation is, in and of itself, a signal of reliability. Based on these two assumptions, prominent associates augment the reputation of young companies more than do run-of-the-mill partners because the signal of reliability and trustworthiness implicit in exchange relations is most widely disseminated when a new venture's associates are particularly well known.

Together, these three social processes suggest that, for a new venture, gaining a prominent affiliate serves to enhance perceptions of its quality. When a young company obtains a prominent associate, it has earned a form of certification by virtue of the fact that it has withstood the due diligence process of a selective and highly capable evaluator. In much the same way as certain types of organizations can benefit from the endorsements of licensing agencies (Baum and Oliver, 1991) and from winning certification contests (Rao, 1994), associations with prominent organizations benefit young companies in the competition to mobilize resources. Before formalizing our theory as specific predictions, however, it is important to note that none of the three mechanisms discussed above implies that the prominence of a new venture's affiliates is perfectly or even highly correlated with actual differences in new venture quality. Unlike signaling models of reputation, our argument is only that perceptions of value are shaped by patterns of affiliations. We have been agnostic with respect to the tightness of the coupling between the signal of quality conveyed by the prominence of a new venture's exchange partners and actual differences in firm quality, although being perceived as high quality is, in and of itself, an extremely valuable resource that can be parlayed into myriad advantages. As a result, evolving differences in firm quality may closely mirror differences in the prominence of exchange partners. Therefore, if it is observed, a high correlation between partner prominence and a focal firm's quality may reflect the causal influences of the former on the latter (Podolny, 1993).

The Effects of Endorsements on Performance

We investigate the effect on performance of endorsements through three types of intercorporate affiliations. A young technology company's performance can be affected by the characteristics of its strategic alliance partners, including joint venture partners and collaborators in research, marketing, and product development. Our arguments above suggest that young companies with prominent alliance partners should garner higher attributions of quality than they would otherwise because of the characteristics of their alliance partners, which will be reflected in performance:

Hypothesis 1: The greater the prominence of the strategic alliance partners of a young company, the better the performance of the new venture.

The composition of ownership of a young company may also have a significant effect on its performance. In particular, the characteristics of the organizations that acquire equity stakes in young companies are likely to affect performance through their impact on the reputations of entrepreneurial ventures. We separate the affiliative effect of equity investors from that of nonequity alliance partners because evaluators may perceive an equity tie as a stronger commitment from the partner than the commitment implicit in a strategic alliance. An equity investor signals to a broader community that another organization is impressed enough with a young company to put up a stake in it. Equity relations are akin to "strong" ties (Granovetter, 1973) and may impart an additional level of confidence in the quality of young companies. Thus:

Hypothesis 2: The greater the prominence of the organizations that have acquired ownership stakes in a young company, the better the performance of the new venture.

A final relationship-based determinant of new venture performance is the prestige level of one type of service firm that works with young companies—the investment banks that manage initial securities offerings for private companies. Economists have argued that professional service firms can certify the quality of young companies (e.g., Beatty and Ritter, 1986; Carter and Manaster, 1990; Megginson and Weiss, 1991). In particular, much of the work in this area has demonstrated that firms that use prestigious investment banks are able to garner higher share prices when they first issue securities.[1] According to this work, because presti-

1
Economists have investigated the effect of investment bank prestige on underpricing, defined as the spread between the subscription price of a security (the price at which it is sold by the underwriter) and the value of the security after it is traded on the public markets for one or more days. Underpricing is costly to issuing firms because it implies that firms sell their shares at a low price relative to market value and so garner smaller proceeds from an IPO. Economists argue that low-risk firms attempt to signal their risk position to the market by using high-prestige underwriters. Since investment banks must be concerned about their ability to sponsor new issues in the future, their prestige is a credible signal of the issuing firm's quality because they have a strong incentive to preserve their status levels by avoiding low-quality securities.

gious investment banks jeopardize their reputation if they underwrite low-quality securities, high-status banks will avoid leading syndicates to place the shares of low-quality firms. Therefore, having a prestigious investment bank is an endorsement of a new venture's quality. In much the same way that well-regarded equity and alliance partners will instill confidence in the quality of a new venture, high-status investment banks reduce investors' uncertainty about the value of a new venture, leading to our third prediction:

Hypothesis 3: The greater the prominence of the investment bank of a young company, the better the performance of the new venture.[2]

The Contingency of Endorsements

The arguments we have developed up to this point suggest that young companies with prominent business partners perform better than firms that lack such partners. The mechanism that we have emphasized as creating the hypothesized performance effects is the implicit transfer of status across interorganizational exchange relations (such as intercorporate equity and alliance ties), which builds confidence about the quality of a new venture among potential customers, suppliers, employees, collaborators, and investors. Through this process, young companies with prominent exchange partners gain an advantage in the competition for resources. But there is an alternative process that could create the predicted performance effects. It is well known that relationships serve as channels of access to resources of various kinds (Lin, Ensel, and Vaughn, 1981; Marsden, 1983; Burt, 1992). Under two conditions, the fact that exchange relationships create access to resources might, in and of itself, produce support for the predictions relating exchange partners' prominence to a focal firm's performance. In particular, if prominent organizations have greater or higher-quality resources than other firms and if their exchange partners enjoy access to some of those resources, then our claim that ties to prominent actors are a competitive advantage for young companies could be upheld, even if the underlying social mechanism is not endorsement or certification. Our belief, however, is that reputation and resource-access effects work in tandem to create advantages for young companies with prominent exchange partners. Thus, our objective is neither to challenge the idea that durable exchange relations function as channels for resource flows nor to dispute the presumed correlation between the prominence of an actor and the amount of resources in its possession. Rather, we wish to examine whether interorganizational exchange relations, in addition to conveying corporeal, financial, and knowledge-based resources, also affect reputations, which we should be able to demonstrate by testing for contingencies in the endorsement process. In particular, our empirical strategy for determining whether a reputation transfer process does in fact occur is to investigate whether the magnitude of the effect of an exchange partner's prominence is contingent on the amount of uncertainty about the quality of a new venture.

The theoretical work from which we derived the first three hypotheses suggests that the benefits of interorganizational

2
We acknowledge an anonymous reviewer for encouraging us to include investment bank prestige in our analyses of relationship-based determinants of new venture performance, although two factors may confound the prediction in hypothesis 3. First, Bygrave and Timmons (1992: chap. 8) reported that new companies backed by prominent venture capitalists were more likely to use leading investment banks when they conducted an IPO, due to long-standing relations between leading venture capital firms and prestigious investment banks. Unfortunately, we do not know the identities of the venture capital firms that backed the companies in our sample and, so, cannot explicitly control for the prestige of venture capital firms. Second, leading investment banks may choose not to handle small public offerings, and there may be a positive relationship between venture size and performance (see below). Both of these considerations open the main effect on investment bank prestige to alternative interpretation.

endorsements vary according to the level of uncertainty about the quality of a focal firm. The reason for this is that evaluators will rely on once-removed signals, like the prominence of an organization's exchange partners, when they do not have sufficient information about the firm to reach an independent conclusion about its future prospects. As a result, the prominence of a focal organization's exchange partners should have a particularly strong effect on assessments of its value when there is considerable uncertainty about the young company's quality, a point emphasized in both the signaling literature (Spence, 1974) and in sociological work on status (Podolny, 1994). When evaluators are confident of their ability to assess a firm's quality based on its record of prior achievements, there is little need to infer its quality on the basis of the identity of its exchange partners and, hence, a minimal impact of partners' prominence on a focal firm's performance. In short, endorsements are contingent: the less that is known about a focal organization, the greater the influence of the identities of its affiliates on appraisals of its value. Therefore:

Hypothesis 4: The greater the uncertainty about the quality of the company, the larger the impact of the prominence of the firm's exchange partners on its performance.

The Biotechnology Industry

We tested the four hypotheses on a sample of young, venture-capital-backed biotechnology firms. Two radical innovations—recombinant DNA (rDNA) and hybridoma (cell fusion)—launched contemporary biotechnology. The recombination of DNA first occurred in 1973, when Herbert Boyer and Stanley Cohen successfully introduced genetic material from one cell into the DNA structure of another. Two years later, the groundwork for hybridoma technology was laid by Cesar Milstein and Georges Kohler, who successfully employed cell fusion to create monoclonal antibodies. Hybridoma technology involves fusing two different cells to create a hybrid cell capable of producing highly purified proteins, called monoclonal antibodies, which serve as the body's defense against disease-causing bacteria, viruses, and cancer cells (see Kenney, 1986 for an overview of the core biotechnologies).

At the scientific advent of contemporary biotechnology, established chemical, pharmaceutical, and agriculture firms were poorly positioned to enter the new field. Biotechnology required skills in molecular biology and biochemistry, which were quite distinct from those demanded by the chemistry-based technologies for which they were expected to substitute. Hence, biotechnology represented a competence-destroying development (Tushman and Anderson, 1986): it relied on a novel set of techniques, which existing chemical and pharmaceutical firms found difficult to acquire. As a result, the commercialization of biotechnology was shepherded by start-up, dedicated biotechnology firms.

While 1973 brought the watershed event in the scientific birth of contemporary biotechnology, 1980 marked the first true spurt of entrepreneurial activity in the young field. A considerable increase in the number of foundings of new biotechnology firms in 1981 can be attributed to a number of pivotal events in 1980. First, there was a clarification of patent law as it pertained to living organisms: the 1980 U.S. Supreme Court decision in *Diamond v. Chakrabarty* established the patentability of a new life form, which insured that biotechnology innovators would be able to appropriate the returns from patentable discoveries. Also, the passage of the Patent and Trademark Amendment Act of 1980 enabled universities to apply for patents on discoveries that grew out of federally funded research programs. Finally, Genentech's astonishingly successful initial public offering in 1980 set a record for the fastest increase in stock price for an IPO, from $35 at offering to $89 in only 20 minutes.

Given high scientific entry barriers as well as the usual gamut of inertial forces that constrain the innovative initiatives of established firms, existing pharmaceutical and chemical companies were slow to enter biotechnology (Cahill, Caligaris, and Williams, 1992; Burrill and Lee, 1993). Diversified corporations did recognize the commercial potential of biotechnology, however, and chose to pursue it primarily through strategic alliances with start-up firms (Barley, Freeman, and Hybels, 1992; Burrill and Lee, 1993). In addition, following the 1980 Amendment to the Patent and Trademark Act, biotechnology firms entered into a series of alliances with universities to license and co-develop technology. Moreover, because innovative capabilities were widely dispersed across the players in biotechnology, firms entered into an extensive set of alliances to gain access to different technologies and capabilities (Powell, Koput, and Smith-Doerr, 1996). As a result, there have been many thousands of vertical and horizontal alliances involving dedicated biotechnology companies, universities, and pharmaceutical, chemical, and food and agricultural companies. The upshot of this development is that biotechnology firms became immersed in networks of interorganizational equity and alliance ties; for this reason, the industry offers an ideal setting for investigating how the structural positions of young companies affect early life course performance.

METHOD

Sample and data. Our data describe 301 dedicated biotechnology firms specializing in the development of human diagnostics and therapeutics; excluded, therefore, are firms specializing in agricultural biotechnology, the production of biotechnology-related equipment, and so on. While private, all 301 companies in our sample were funded by venture capital firms.

For young venture-backed companies, two crucial performance variables are the speed at which the company reaches an initial sale of securities on the public equity markets (the time from incorporation to initial public offering) and the valuation of the firm when it goes public. An initial public offering (IPO) is the event that transforms a privately held entrepreneurial venture into a publicly owned company. As a rule, venture capitalists wish to take public the companies in which they invest as soon as they anticipate favorable valuations (Freeman, 1997). From the new venture's perspective, selling equity to the public often generates much-needed capital as well as the opportunity for equity holders to exchange stock for cash, so they too routinely wish to undertake an IPO quickly and always hope for favorable valuations. Therefore, the firm-level performance outcomes that we examine here are the rate at which new ventures undertake an IPO and the market capitalization of the firms that experience IPOs.

Assessing the first of our performance measures—the rate at which new ventures undertake an IPO—required information on early life events for the firms in our sample. Securities and Exchange Commission (SEC) filings contain information on the early-round financial history of the firms that undergo IPOs, necessary for our analyses, but limiting our analyses to firms that experienced an IPO would introduce severe survivor bias into the parameter estimates. Therefore, we obtained data from the biotechnology consulting firm Recombinant Capital, which we supplemented with information from Securities Data Corporation's New Ventures database. These sources were critical for our project because they contained information on venture-backed companies even if they did not have an IPO. We relied on these databases to acquire the early financial histories for firms that were acquired or that failed prior to an IPO or that remained private at the end of the time series.

The time period of our analysis is from January 1, 1978 through December 31, 1991. We concluded the analysis in 1991 because we were unable to gather some of the data that we required for the study beyond that time. A relatively small number of biotechnology companies were founded before 1978, so we begin the analysis very shortly after the emergence of the industry.

In addition to the sources of information on venture capital funding, we drew on two other databases. First, we utilized an extremely comprehensive database on strategic alliances in biotechnology. The primary sources for the alliance data was the *Bioscan* directory (published by Oryx Press), but we also consulted *Genetic Engineering and Biotechnology Firms Worldwide Directory 1985, Genetic Engineering and Biotechnology Yearbook 1985, The Biotechnology Directory: 1986* (Coombs, 1986), *World Biotech Company Directory: 1985–1986* (published by Bioengineering News), *Sixth Annual GEN Guide to Biotechnology Companies* (1987), *Biotechnology Guide: U.S.A.* (Dibner, 1988, 1991), *The Biotechnology Directory: 1989* (Coombs and Alston, 1989), and *1993 GEN Guide to Biotechnology Companies.* Finally, we incorporated information from an unpublished database provided by the North Carolina Biotechnology Center. All alliances involving at least one biotechnology firm (including firms outside of our sample) were coded from the sources cited above. The majority of the partnerships in our database are joint ventures, research and development alliances, and license agreements. One of the authors verified the accuracy of the alliance data through interviews at 10 biotechnology firms in California and Oregon.

Finally, we also collected detailed information on more than 30,000 U.S. biotechnology patents with application dates between 1975 and 1991. The source for these data was the Micropatent Biotechnology Patent Abstract CD (1994), which contains all biotechnology patents granted in the U.S. We use the application date on each patent, which marks the time when a patent application first arrived at the U.S. patent office. For each biotechnology patent, we coded the patent number, its organizational assignee, the application date, and the numbers of all patents that were cited by it. We used the patent data both to control for the intellectual property positions of the firms in the sample and to assess the technological capabilities of their strategic partners and equity investors.

Using the sources cited above as well as the Directory of Corporate Affiliations and Lexis/Nexis, we also constructed detailed, time-varying ownership trees for all of the organizations that appeared in our data. While most of the dedicated biotech firms did not have complex corporate structures, many of their strategic alliance partners did. For the empirical analysis, we have aggregated all of the alliances and the patents of subsidiaries or divisions up to the level of the corporate parent, and we have updated all variables as ownership relationships change (e.g., when Smith Kline acquired Beecham, we assign the alliances and the patents of Smith Kline and Beecham to the combined entity).

Modeling time-to-IPO. Our two measures of new venture performance were the rate of going public and the market capitalization of the firms that undertake IPOs. From the date of founding onward, the venture-backed biotechnology firms in our sample are "at risk" of experiencing an IPO. We have estimated the instantaneous rate of going public (the hazard), denoted r(t):

$$r(t)_i = \lim_{\Delta t \to 0} [q_i(t, t + \Delta t)/\Delta t],$$

where q_i is the probability that a firm goes public between two discrete time points. To estimate the effects of independent variables on the rate of going public, we used a piecewise exponential model because it is extremely flexible with respect to the form of duration (in this case, age) dependence. The model assumes that the baseline transition rate, represented by the coefficients on a vector of v time periods, is constant within each age period but can vary in an unconstrained manner across periods. Hence, the piecewise exponential model does not require a strong assumption about the functional form of age dependence. The model that we estimate can be written as:

$$r(t)_i = r(t)^* \exp\left(\alpha' M_t + \beta' Q_{it} + \delta' \sum_j Z_{ijt} + \gamma' \sum_j D_{it}\right), \qquad (1)$$

where $r(t)^*$ represents the baseline hazard rate, M_t is a matrix of time-varying (but organization invariant) measures of environmental conditions, Q_{it} is a matrix of time-changing variables representing characteristics of the organizations in the sample, Z_{ijt} are time-changing variables representing counts of relations between young biotechnology firms and their business associates, D_{it} are time-varying measures of the prominence scores (in a number of different domains) of the exchange partners of the firms in the sample, and α, β, δ, and γ are parameters to be estimated.

The variables in the hazard models change over time. To accommodate time-varying covariates, we divided the time period during which each organization is observed into quarter-year spells (Tuma and Hannan, 1984). All time-changing covariates were then updated every calendar quarter (i.e., at three-month intervals). Each of the quarterly spells was treated as censored on the right, except for the spells that terminate in an IPO. A very small number of firms experienced a terminal event other than IPO or censoring, which occurred when the firm was still privately owned at the conclusion of our observation window: a handful of firms either disbanded or were acquired while still private. Because only a few of the sample firms experienced terminal events other than an IPO, we chose not to estimate a competing risks hazard model but, rather, just to censor the final spell for all firms that were acquired or disbanded.

All 301 firms in our sample were founded between January 1, 1978 and December 31, 1991. Among these, 121 experienced IPOs prior to the end of calendar year 1991; the remaining 180 firms were right censored on December 31, 1991, or on the date they were acquired or disbanded.

Estimating market valuation regressions. We observed a firm's market capitalization conditional on it undertaking an IPO (market value and all other nominal figures are converted into real dollars). The market value of a firm at IPO was defined as:

$$V^* = (p_u q_t - p_u q_i),$$

where p_u is the IPO subscription price, q_t is the total number of shares outstanding, and q_i is the number of shares offered in the IPO. In other words, we subtracted from the firm's total market capitalization the dollar amount raised in the IPO. V^* is a measure of the market's assessment of the value of a biotechnology company at IPO. We used the IPO subscription price to compute V^*; in unreported models, we observed results similar to the ones we report here when defining V^* on the basis of the first day closing price of a new issue. Because biotechnology firms at IPO have minimal physical assets, the dollar value of the firm as reflected in V^* is contingent on outsiders' estimates of the value of the firm's intellectual property, its scientific capabilities, the quality of its management, its portfolio of strategic alliances, and its reputation. Because 121 of the firms in the sample went to IPO during our analysis period, we have public market capitalization data on 121 of the 301 companies in the sample.

We used OLS to estimate the valuation models. The one complication in these models is that we had to limit the analysis of market capitalization to the firms in the sample that underwent IPOs because the dependent variable was observed for such cases only, but the fact that market capitalization was not observed for some firms may result in sample selection bias in the valuation models. Thus, estimating these models presented the standard censored sample problem, which we addressed by using Lee's (1983) generalization of Heckman's (1976) two-stage estimator. Similar in principle to Heckman's use of the reciprocal of the Mills ratio as an additional regressor to correct for sample selection, Lee's method allowed us to compute a selection variable by transforming the cumulative waiting-time distribution (derived from the hazard rate models), which was then entered as a covariate in the OLS models.[3]

Measures

Independent variables. In operationalizing the prominence of affiliates, our analysis takes into account the fact that there is likely to be uncertainty about the quality of a young technology company in more than one area of its operations. As a result, outsiders' estimates of the worth of the company may be affected by endorsements in different domains of the firm's activities. This has two implications. First, interorganizational relationships will be perceived as endorsements only with respect to the operations of a young company in the area in which the prominent affiliate has experience or expertise (Goode, 1978). For example, having its financial statements prepared by a reputable accounting firm is likely to instill confidence in the accuracy of a new venture's financial reports, but it is unlikely to affect outsiders' perceptions of the technological capability of the company. Second, the value of associations with prominent organizations is likely to be domain-dependent: endorsements of some components of an organization's operations will be more meaningful than will others for the perceived value of the firm. For both of these reasons, it is important to investigate how connections to organizations that are prominent in different domains affect the performance of young companies.

Before describing the measures of prominence, we stress that strategic alliances are very important in the biotechnology industry. Young biotechnology companies are well aware of the significance of intercorporate collaborations as a means of garnering additional resources, bolstering their strategic positions, and enhancing their reputations. Perhaps the most telling indication of this is that biotech firms have entered many thousands of strategic alliances since the emergence of the industry, and the identities of partners and descriptions of alliances figure prominently in biotechnology companies' securities registration statements. We reviewed a large number of S-1 statements, the SEC documents that register securities for an initial public stock offering. In virtually every case in which a focal biotech firm had one or more strategic partners, that firm's S-1 statement profiled its strategic partnerships by the third paragraph of the document. This signals the importance of alliances to potential investors.

We measured the prominence of the alliance partners and equity investors in two areas, which we label the "technological" and the "commercial." We defined technological prominence as a measure of the success of an alliance or equity partner as a biotechnology innovator: technologically prominent organizations are those that have developed many influential biotechnology innovations. When a young company establishes a relationship with a technologically accomplished organization, it benefits from an endorsement of its own technological capability. The effect of this endorsement is to assuage outside evaluators' concerns about the answers to questions such as, How significant are the prior technical achievements of a young company? And, What is

3
Lee (1983) showed that, conditional on y being observed (selection is designated as I = 1), the following censored regression model can be estimated:

$$y_i = x_i\beta - (\sigma\rho)\phi[\Phi^{-1}F(z_i\gamma)]/F(z_i\gamma) + \eta,$$

where $E(\eta|I = 1, x, z) = 0$, y designates market values conditional on IPO, x is a matrix of independent variables, ϕ is the standard normal density function, Φ^{-1} is the inverse normal, $F(z_i\gamma)$ designates the cumulative waiting time distribution (i.e., the complement of the survivor function). Estimates of $F(z_i\gamma)$ are derived from the hazard rate analysis and $\sigma\rho$ is the (estimated) coefficient on the selection variable (denoted as λ in table 4).

the probability that the technological area in which the new venture participates will become significant? Figuring that technologically prominent organizations are competent and selective judges of the technological potential of new ventures in their areas of expertise, outside evaluators upgrade their opinion of the capabilities of the partners of technologically prominent organizations.

We defined commercial prominence as a measure of an exchange partner's experience in evaluating young biotechnology companies: commercially prominent organizations are those that have a long track record of evaluating and working with young firms in the industry. When a new venture forms a relationship with a commercially experienced organization, it benefits from an endorsement that minimizes outside evaluators' concerns about the answers to questions such as, Is the young company organized effectively to research and develop new biotechnologies? Does the firm have the connections needed to develop and market a product? If the firm is able to develop a product, will it effectively produce it? And, Is the company run by a strong management team? To potential investors, employees, customers, suppliers, and collaborators, an alliance or equity relationship with an experienced evaluator of young biotechnology companies conveys an important vote of confidence in the young venture's organizational integrity and managerial ability.

We measured the commercial and technological prominence of partners in terms of the pattern of relations that embed the alliance and equity partners of the biotech firms in our sample into two different networks: a strategic alliance network and a patent citation network. Following the convention in the network literature, commercial (or technological) prominence was defined as the degree to which an organization's position makes it visible to other actors in the alliance (patent citation) network (Knoke and Burt, 1983). Among many potential measures of prominence, the most parsimonious is an actor's degree score, defined as a count of the number of relations in a network involving that actor. For the statistical analysis, we operationalized commercial prominence as an organization's normalized degree score in the network of strategic alliances, defined broadly to include all biotechnology-related partnerships. Technological prominence is a strategic partner's degree score in a network configured from the patent citations between the patent portfolios of all biotechnology innovators.

To construct the measure of commercial prominence, we organized the biotech alliance data as symmetric matrices of organization-to-organization ties, which were updated four times a year (quarterly) to reflect new alliances. The elements of each matrix at period t are the number of alliances established prior to the quarter t between the organization on the row (i) and on the column (j). The alliance matrices include all organizations that had previously formed at least one alliance with a biotechnology firm. We normalized the elements in each matrix by the total number of alliances formed in the industry prior to t so that commercial prominence scores are proportions. Finally, we summed over each row in the alliance matrix to produce a vector of commercial prominence scores. The interpretation of the commercial prominence score for each organization j is the proportion of all biotechnology alliances in which it had participated.

Substantively, the content of the ties that create high degree scores in the biotech alliance network should be an appropriate measure of prominence to study the endorsement process. First, organizations that are central in the alliance network may be the actors with the strongest incentive to protect their reputations by exercising care in their selection of partners. Because they are repeat players, organizations with high degree scores will be concerned about the reputation costs that they will incur if they sponsor salient failures. Perhaps of greater importance, alliance network degree score is an appropriate measure of prominence because it equates prominence with the organizations that have the most experience in evaluating young biotech companies. Because organizations with high degree scores in the alliance network have the most familiarity with the due diligence process, they will be perceived as very capable judges of commercial potential. For both reasons, exchange relationships with central organizations in the biotech alliance network will be perceived by outside parties as a significant endorsement of a young company.

We defined a technologically prominent organization as one with a highly cited portfolio of *biotechnology* patents. Substantively, patent citations denote technological building relationships: to acquire a patent, an inventor must submit an application that includes a list of citations to all previously issued patents that made technological claims similar to those for which the current application seeks intellectual property protection. In other words, patent applicants must acknowledge the existing, patented inventions that are nearest in technical content to the inventions for which they are pursuing patent protection. Previous research has demonstrated that highly cited patents have been shown to be the most important inventions (Trajtenberg, 1990; Albert et al., 1991).

To compute technological prominence scores, we created an organization-to-organization patent citation matrix for each calendar quarter t. The elements in these matrices are counts of the number of citations from the biotechnology patents of the organizations on the columns (j) to the patents of the organizations on the rows (i). We then normalized the elements of the matrix by the total number of patent citations made during period t, again so that technological prominence scores are proportions that can be compared across time. Finally, we summed across each row, yielding a vector of technological prominence scores. Like the alliance centrality variable, the interpretation of the technological prominence score for each organization is the proportion of all biotechnology patent citations flowing to its patent portfolio. These scores are highest for organizations that have developed the most influential stocks of biotechnology inventions.

After computing the prominence measures, we merged into the records of each of the biotechnology firms in the sample the technological and commercial prominence scores of all of their strategic alliance partners and their (non-venture-capital) organizational equity investors. In the statistical models reported below, we chose to define prominence scores for each biotech venture during each time period by summing over the prominence scores of that venture's affiliates (whether we used commercial or technological prominence scores and whether these scores pertained to a focal company's equity investors or alliance partners depends on the model). For example, we defined the commercial prominence of a focal biotech venture as:

$$d_{it} = \sum_{j} z_{ijt}\, d_{jt},$$

where d_{it} denotes the commercial prominence of the partners of a focal biotech venture i at time t, z_{ijt} is coded 1 if there was an alliance between i and organization j at time <t, d_{jt} is the commercial prominence of organization j, and the sum is performed over all organizations that participated in biotechnology.[4] In the event history data, we updated these variables each quarter to reflect the addition of new affiliates. In the valuation models, each variable assumes its value at the time that the firm went public.

Prominence of investment banks. In the market valuation models, we included a measure of the prestige of the investment banks that served as lead managers for the IPOs of the firms in the sample, to test the third hypothesis. We coded from IPO prospectuses the identity of the investment banks that acted as lead manager in each IPO. Our measure of investment bank status is the prestige score for the bank computed by Carter and Manaster (1990). Carter and Manaster constructed prestige scores from the rankings of investment banks in "tombstone" announcements for IPOs. Based on investment banks' positions in the tombstone announcements for new issues, Carter and Manaster constructed a scale of investment bank prestige ranging from 0 (lowest prestige) to 9 (highest prestige).

Control variables. The models include two types of control variables: firm-level controls and measures of time-changing environmental conditions. For the firm-level controls, we included a measure of each firm's intellectual property position, a time-updated count of the number of ultimately successful biotechnology patent applications assigned to it, because patents have intrinsic value and play a signaling role. Because the cost of obtaining a patent is significant and is inversely correlated with a firm's technological capabilities, patents conform neatly with Spence's (1974) definition of a signal. While U.S. patents only become part of the public record after they are issued by the Patent Office (pending and rejected patent applications are not released), young biotechnology companies typically make every effort to publicize their technological accomplishments. These companies often issue press releases when they receive patents, and lengthy discussions of their intellectual property positions are prominently placed in their IPO prospectuses, including descriptions of pending patents. Our expectation is therefore that firms with more pending patents will go to IPO more quickly and will be worth more when they do.

Next, for each firm, we entered a time-changing indicator variable that turns on when a biotechnology company files

4
In unreported models, we computed prominence scores by averaging the prominence scores of all exchange partners and by selecting the maximum prominence score of any of a focal firm's exchange partners. The correct specification of the affiliative effects rests on one's theory about how the underlying social process operates. For example, using the mean prominence of partners would be justified if the addition of low-prestige partners can actually downgrade perceptions of a focal firm's quality. Not surprisingly, however, these measures were all highly correlated, and the results were generally consistent across the three measures.

its first investigational new drug application (IND). Before marketing a new therapeutic, biomedical firms must submit their products to a rigorous and controlled experimental process designed to test the efficacy and safety of the drug as a precursor to gaining Food and Drug Administration approval to sell the drug. The human trials testing process is initiated with the submission of an IND. Hence, the IND dummy variable is a measure of the progress of the firms in the sample toward developing (potentially) marketable products.

The firms in our sample all competed in the same broad market niche—they all focused on the human segment of the industry, including the application of biotechnology to the production of human diagnostics or therapeutics. Still, within this area there are differences in strategic foci. To account for differences in the strategies of the firms in our sample, we included in the models a set of indicator variables representing participation in various segments of biotechnology. To construct these variables, we looked up each firm in the sample in the *Corporate Technology Directory* (CorpTech) in the first year in which it appeared in the directory. The CorpTech directories contain a classification system that is used to characterize each firm according to its presence in fine-grained technology segments. In the models, we experimented with including dummy variables for as many as twelve industry segments; for each observation, we included twelve dummy variables denoting whether or not firm i participated in segment k. In the models that we report, we included the four largest technology segments, because results were not materially different from the 12-segment findings.[5]

The models include three alliance-based control variables. First is a time-varying count of the total number of strategic alliances formed by each of the firms in the sample. Our argument suggests that interorganizational alliances frequently serve as channels of resource access for the young companies in our sample, but because our purpose was to assess the incremental reputational benefit of interorganizational relationships over and above the benefits of access to intellectual and material capital, we chose to treat the alliance count as a control variable.

While the companies in our sample established many different types of strategic alliances, many of these alliances did involve significant amounts of funding for start-up firms, typically payments from a strategic partner to sponsor a research program or to purchase the rights to use an innovation. As a result, alliances can be a direct source of research funding for biotech firms. More often than not, funded research alliances were structured to include a lump sum, upfront payment to the biotechnology company, to be followed with additional payments if technological milestones were achieved within contractually specified time periods. To reflect the fact that strategic alliances are direct funding sources, we coded the dollar value of each alliance that involved a payment to one of the biotechnology firms in our sample (alliance partner funding). Although we do not know if the firms in the sample reached all of the milestones specified in the alliance contracts, we effectively included for

5
Twenty-two percent of the firms in the sample never appeared in the CorpTech directory. For these firms, we found descriptions of their business focus either on the Biospace Web Site (www.biospace.com), in company securities filings, or in the Bioscan directories. Based on these descriptions, we coded the industry segments in which each organization participated.

each firm the upper bound on the dollar amount that it could realize from its strategic partnerships. In the event models, we cumulated these amounts over time as biotechnology firms entered new strategic coalitions. Hence, the models control for the level of research funding supplied by each new venture's alliance partners.

Corresponding to the alliance count variable, we also included in the models a time-changing count of the number of non-venture-capital equity investors in each of the ventures in our sample. It is relatively common for established pharmaceutical, agricultural, and chemical companies to acquire equity positions in privately held biotechnology companies in the human therapeutics and diagnostics segments. Hypothesis 2 predicted that when a new venture's non-venture-capital equity investors are prominent organizations, the firm benefits from a strong endorsement. Paralleling the way that we modeled the hypotheses about the prominence of alliance partners, we controlled for the number of (non-venture-capital) equity investors to assess the incremental effect of the prominence of the investors.

We also used two measures of the uncertainty about the quality of the firms in the sample, firm age and the total amount of pre-IPO, private equity raised. We included both of these variables as main effects and as interactions with the prominence measures to test hypothesis 4, that the value of endorsements are contingent on the level of uncertainty about new ventures. Both of the variables have been shown in the finance literature to be proxies for investor uncertainty about the value of firms.

The age of a firm is indicative of the uncertainty about its quality because very young companies have limited performance histories on which quality can be assessed (Beatty and Ritter, 1986). Supporting the assertion that uncertainty declines with organizational age, venture capitalists themselves are reluctant to invest heavily in very young companies because of their inability to evaluate the quality of such ventures. This reluctance is apparent in the way that the venture financing process has become institutionalized: venture-backed companies receive funding in a sequence of capital infusions, known as "rounds." Each time a company undergoes a financing round, it is subjected to a thorough evaluation by venture capitalists. Typically, the amount of funding in early rounds is relatively small because venture capitalists will not make large financial commitments to young companies about which they lack a sufficient understanding of quality (Gompers, 1995). As they learn more about the company—both from a technological and managerial standpoint—venture capitalists then decide to terminate, maintain, or increase the level of funding for a project. Hence, the fact that staged financing has become institutionalized is, in and of itself, a confirmation of the fact that the amount of uncertainty about a venture declines as it ages.

The second measure of the uncertainty of quality is the total dollar amount of prior venture funding, a cumulating sum of the cash raised by each firm in private financing rounds. A robust empirical finding is that there is more uncertainty about the value of small firms (e.g., Beatty and Ritter, 1986).

Because all of the firms in the sample are venture-backed and all participate in the same industry, the level of funding should be a good approximation of differences in firm size. When other attributes of a young venture are held constant, this variable can also be construed as a reflection of venture capitalists' commitment to a company: the greater the size of their investment, the higher their expectations for the young venture and the more certain they are of venture quality. In the hazard models, we updated this variable quarterly to reflect any changes. In the market valuation models, we included the total amount of cash raised in all private financing rounds.

Environmental conditions. Finally, we controlled for time-changing environmental conditions. The analyses included an equity index consisting of biotechnology stocks, to control for intertemporal differences in the receptivity of the equity markets to new biotech issues. The index, constructed by Joshua Lerner (1994), is re-balanced annually and consists of equal dollar shares of thirteen publicly traded, dedicated biotechnology firms. It has been observed that there are "hot" and "cold" markets for IPOs, implying that the ability of a company to go public may depend on equity market conditions (Ritter, 1984). It is therefore important to control for the receptivity of the market—ideally, for the particular type of company under study—in the time-to-IPO and valuation models. In the hazard rate models, the biotech equity index was updated quarterly. In the valuation models, the index assumes its value at the end of the month prior to when an IPO occurred.

We also coded and included in the models the population density of all dedicated biotechnology firms (the density variable includes non-venture-backed and agriculture biotech firms), which we entered in the models as a monotone and a quadratic term. We entered these variables to link the empirical analysis to the density dependent model of legitimation and competition, which has become a baseline in organizational analysis. Generalizing from the robust empirical findings that organizational founding rates first increase and then decrease with growth in population density (Hannan and Carroll, 1992), we anticipated that density would have an inverted-U-shaped effect on the rate of IPO and on market valuations. The density dependence model would predict that rising legitimation will increase the rate of IPOs and the valuations of new biotechnology issues with initial increases in population density, while the opposing force of competition will decrease the rate of IPOs and market valuations as density increases.

In the valuation models only, we included dummy variables designating the four years in which biotech IPO activity flourished. In the time period covered by our analyses, the majority of IPOs occurred in four years: 1983, 1986, 1987, and 1991. The primary factor that singled out these four years seems to have been the favorable milieu for biotech equities in the public markets—company valuations were generous in these years relative to other time periods. In the valuation models, we included both the year dummies and the level of the IPO index to control for market conditions.

RESULTS

Table 1 reports descriptive statistics. Table 2 presents a correlation matrix, and table 3 contains the results from the time-to-IPO models.

Time-to-IPO. The baseline model (1) in table 3 includes only the firm age segments, variables describing focal venture quality differences and strategic focus, and the measures of environmental conditions. All models include three age periods, which allow the baseline hazard to shift at three points. The piecewise model with three age periods is a statistically significant improvement over an unreported constant rate (exponential) model. Model 1 shows that firms with more patents go to IPO faster. Each additional patent multiplies the rate of going public by a factor of 1.11 ($e^{[.106*1]}$). The "total cash raised" variable and the "investigational new drug" dummy variable are both positive and significant. The coefficient estimate on the former variable implies that each $10 million in additional venture funding multiplied the baseline rate by a factor of 1.16. None of the four market-segment dummy variables achieved statistical significance.

Turning to the controls for environmental conditions, model 1 shows that there is an extremely strong effect of the biotech equity index on the rate of going public (see also Lerner, 1994). The coefficient suggests that a one-point increase in the equity index almost triples the rate of going public, demonstrating the great importance of favorable equity market conditions for the occurrence of biotechnology IPOs. The density variables in model 1 are not statistically

Table 1

Descriptive Statistics*

Variable	Mean (all)	S.D. (all)	Mean (IPO)	S.D. (IPO)	Min.	Max.
Firm characteristics						
Firm age	3.655	2.451	3.543	2.019	0	12.502
Total cash raised	16.740	20.489	16.741	20.484	0	143.218
BT patents	.727	2.377	1.289	3.159	0	19
Investigation new drug dummy	.051	.220	.088	.284	0	1
Genetic engineering dummy	.197	.391	.272	.447	0	1
Protein engineering dummy	.051	.220	.088	.284	0	1
Immunology dummy	.151	.357	.211	.409	0	1
Diagnostics dummy	.151	.357	.219	.415	0	1
Environmental conditions						
BT equity index	3.954	.605	3.484	.762	1.402	4.885
BT density	397.880	36.330	383.577	55.439	114	474
BT density-squared (/1000)	159.627	23.900	150.172	36.447	12.996	224.676
Partner controls						
Alliance count	1.597	2.683	2.526	3.135	0	17
Equity investor count	.440	.880	.667	1.053	0	5
Funding from partners	4.883	13.649	8.349	3.135	0	112.9
Partner prominence						
Com. prominence (alliance)	.013	.026	.023	.034	0	.113
Tech. prominence (alliance)	.004	.008	.005	.010	0	.057
Com. prominence (equity)	.003	.008	.006	.009	0	.095
Tech. prominence (equity)	.002	.005	.004	.007	0	.035
Investment bank prominence			5.395	3.109	0	9

* Statistics from market valuation models. Mean (all) and S.D. (all) include all 301 firms. Mean (IPO) and S.D. (IPO) include only the 121 firms that had IPOs.

Table 2

Correlation Matrix*

Variable	1	2	3	4	5	6	7	8	9	10	11	12
1. Firm age	–											
2. Total cash raised	.38	–										
3. BT patents	.27	.45	–									
4. Invest. new drug (=1)	.36	.25	–.02	–								
5. Genetic engineering (=1)	.15	.06	.24	.11	–							
6. Immunology (=1)	–.05	.08	.13	.17	.26	–						
7. Protein engineering (=1)	.03	.11	.28	–.09	.09	–.08	–					
8. Diagnostic (=1)	.08	.04	–.03	–.08	.08	.06	.06	–				
9. BT equity index	.18	.14	.02	–.02	.11	.05	.15	.17	–			
10. BT density	.33	.18	.06	.02	–.27	–.20	–.02	.07	–.00	–		
11. BT density^2 (/1000)	.33	.18	.05	.01	–.27	–.21	–.04	.06	–.06	.99	–	
12. 1983	–.29	–.15	.02	–.02	.23	.19	.05	.04	.39	–.55	–.62	–
13. 1986	.29	.13	.17	–.03	.09	–.02	.13	.03	.21	.11	.10	–.17
14. 1987	–.11	–.08	–.13	–.11	–.03	–.12	–.12	.01	–.12	.33	.38	–.15
15. 1991	.31	.27	–.02	.14	–.12	–.06	.04	.16	.33	.28	.28	–.28
16. Alliance count	.43	.40	.27	.12	.12	–.01	.16	.00	–.04	.19	.19	–.20
17. Funding from partners	.14	.57	.36	.04	–.07	.12	.15	.04	.13	.13	.13	–.14
18. Equity investor count	.22	.60	.31	.07	.06	.02	.05	.00	.13	.17	.17	–.12
19. Com prom., alliance	.28	.30	.26	.16	.29	.14	.00	.02	–.01	–.17	–.17	–.00
20. Tech prom., alliance	.35	.36	.09	.08	.22	.11	.07	.29	.13	.18	.18	–.17
21. Com prom., equity	.09	.23	–.05	–.08	–.08	.06	–.11	.08	.16	.06	.05	–.05
22. Tech prom., equity	.13	.25	.19	.08	.19	.14	.03	–.09	.03	–.21	–.21	.06
23. Investment bank prestige	.29	.44	.21	.13	.00	.03	.12	.13	.16	.12	.12	–.11

Variable	13	14	15	16	17	18	19	20	21	22
13. 1986	–									
14. 1987	–.15	–								
15. 1991	–.29	–.26	–							
16. Alliance count	.22	–.07	.05	–						
17. Funding from partners	.10	–.10	.20	.28	–					
18. Equity investor count	.08	–.06	.21	.34	.51	–				
19. Com prom., alliance	.19	–.07	–.12	.49	.13	.23	–			
20. Tech prom., alliance	.01	–.11	.30	.58	.29	.32	.31	–		
21. Com prom., equity	.16	–.07	.10	.08	.15	.35	.21	.22	–	
22. Tech prom., equity	.09	.05	–.14	.31	.19	.22	.65	.03	.24	–
23. Investment bank prestige	.03	.01	.29	.19	.18	.24	.31	.25	.18	.31

* Based on market value data set.

significant, and their signs are the reverse of those predicted by density dependence theory. Because the industry was still very young during the course of our analyses and because our analyses did not begin until five or so years after the birth of the industry, we do not view the results as strong evidence against density dependence theory in this population.

Model 2 adds the control variables for the number of alliances, number of organizational equity investors, and the amount of resources committed to a biotech venture by its alliance and equity partners. The alliance count variable is positive and statistically significant: according to the estimates, each new alliance led to a 12-percent increase in the rate of going public. The number of organizational equity investors is also positive and significant. The amount of funding purveyed by alliance partners is positive, but it is not statistically significant.

The next four models add the prominence-of-affiliate variables. Model 3 includes the commercial prominence of alliance partners; model 4 the technological prominence of alliance partners; model 5 the commercial prominence of equity

Table 3

Maximum Likelihood Estimates of Time-to-IPO*

Variable	Model 1	Model 2	Model 3	Model 4	Model 5
Age: <3 years	−4.591•	−4.227•	−4.346•	−4.210•	−6.280•
	(2.250)	(2.131)	(2.241)	(2.231)	(2.569)
Age: 3–7 years	−3.916•	−3.682	−3.831•	−3.669	−5.740•
	(2.270)	(2.258)	(2.285)	(2.252)	(2.591)
Age: >7 years	−4.460•	−4.349•	−4.449•	−4.344•	−6.333•
	(2.287)	(2.271)	(2.300)	(2.240)	(2.588)
Total cash raised	.015•	.003	.005	.003	.002
	(.006)	(.005)	(.005)	(.005)	(.005)
BT patents	.106•	.078•	.075•	.083•	.068•
	(.039)	(.041)	(.040)	(.042)	(.041)
Invest. new drug (=1)	.574	.663•	.601	.692•	.555
	(.354)	(.354)	(.361)	(.364)	(.359)
Genetic engineering (=1)	.080	−.088	−.117	−.094	−.121
	(.232)	(.237)	(.241)	(.239)	(.239)
Immunology (=1)	.227	.209	.271	.299	.320
	(.262)	(.260)	(.261)	(.258)	(.255)
Protein engineering (=1)	.431	.420	.423	.371	.399
	(.401)	(.404)	(.410)	(.410)	(.408)
Diagnostic (=1)	.092	.151	.187	.138	.212
	(.243)	(.242)	(.242)	(.246)	(.241)
BT equity index	1.071•	1.072•	1.060•	1.049•	1.059•
	(.113)	(.116)	(.118)	(.118)	(.118)
BT density	−.011	−.012	−.012	−.012	−.007
	(.015)	(.015)	(.015)	(.014)	(.016)
BT density^2 (/1000)	.016	.016	.016	.016	.016
	(.023)	(.023)	(.023)	(.023)	(.023)
Alliance count		.114•	.066	.107•	.100•
		(.032)	(.051)	(.037)	(.033)
Funding from partners		.003	.005	.003	.004
		(.006)	(.006)	(.006)	(.006)
Equity investor count		.238•	.235•	.231•	.209•
		(.118)	(.118)	(.121)	(.122)
Com. prom., alliance			6.554		
			(4.820)		
Tech. prom., alliance				4.148	
				(12.059)	
Com. prom., equity					25.833•
					(11.150)
Tech. prom., equity					
Tech. prom., alliance × Total cash raised					
Com. prom., equity × Total cash raised					
Com. prom., alliance × Age <3					
Com. prom., alliance × Age 3–7					
Com. prom., alliance × Age >7					
Tech. prom., equity × Age <3					
Tech. prom., equity × Age 3–7					
Tech. prom., equity × Age >7					
Log-likelihood	−313.5	−304.67	−303.85	−304.61	−302.26

• $p < .05$, one-sided tests.
* Standard errors are in parentheses. Total of 4739 spells and 121 events (IPOs).

Table 3 (*continued*)

Model 6	Model 7	Model 8	Model 9	Model 10
−4.037•	−5.097•	−5.555•	−5.023•	−4.122•
(2.280)	(2.248)	(2.495)	(2.287)	(2.240)
−3.595	−4.735•	−5.185•	−4.346•	−3.574
(2.243)	(2.508)	(2.517)	(2.229)	(2.260)
−4.154•	−5.337•	−5.818•	−5.044•	−4.253•
(2.259)	(2.511)	(2.522)	(2.294)	(2.280)
.003	.010	.015•	.003	.003
(.006)	(.007)	(.007)	(.006)	(.006)
.095•	.104•	.097•	.081•	.094•
(.041)	(.041)	(.040)	(.041)	(.042)
.860•	.660•	.935•	.622•	.856•
(.361)	(.364)	(.374)	(.366)	(.359)
−.057	−.154	−.134	−.139	−.077
(.238)	(.243)	(.240)	(.245)	(.241)
.224	.286	.340	.309	.201
(.257)	(.257)	(.252)	(.261)	(.261)
.422	.340	.342	.382	.422
(.410)	(.410)	(.410)	(.419)	(.410)
.065	.137	.112	.174	.117
(.240)	(.247)	(.249)	(.242)	(.243)
1.056•	1.068•	1.048•	1.075•	1.060•
(.117)	(.118)	(.117)	(.118)	(.118)
−.014	−.012	−.012	−.008	−.013
(.015)	(.015)	(.016)	(.015)	(.015)
.016	.016	.016	.016	.016
(.023)	(.023)	(.024)	(.023)	(.023)
.118•	.097•	.107•	.078	.118•
(.033)	(.053)	(.052)	(.054)	(.033)
.007	.008	.011•	.007	.007
(.006)	(.006)	(.006)	(.006)	(.006)
.085	.043	.058	.042	.065
(.133)	(.136)	(.129)	(.138)	(.136)
	.334	2.822		2.938
	(5.218)	(5.658)		(5.023)
	26.492	7.914	1.905	4.700
	(20.893)	(13.809)	(13.347)	(13.084)
	11.561	29.102•	7.888	10.130
	(12.445)	(13.165)	(12.913)	(12.829)
56.289•	46.004•	51.051•	50.724•	
(12.871)	(14.538)	(14.265)	(14.418)	
	−.770			
	(.491)			
		−1.173•		
		(.489)		
			16.917•	
			(8.086)	
			7.113	
			(5.251)	
			.868	
			(12.752)	
				74.630•
				(25.544)
				41.771•
				(16.000)
				18.896
				(137.22)
−299.361	−296.05	293.56	−295.53	−295.33

investors; and model 6 the technological prominence of equity investors. Although all four prominence variables have positive coefficients, only the two measures of equity investor prominence are statistically significant (models 5 and 6).[6] According to the parameter estimates, a standard deviation increase in the commercial prominence of the equity investors in a focal biotech firm multiplies the rate of going public by a factor of 1.23. A standard deviation increase in the technological prominence of equity investors raises the IPO rate by 33 percent.[7]

The remaining models in table 3 include interaction effects between the four affiliate prominence variables and the two measures of uncertainty in focal venture quality, the amount of venture capital funding and the age of the firm. We estimated these models to decouple evidence of an endorsement process from the effects of the more tangible value of an alliance (e.g., access to a partner's resources). Because the arguments for a contingency in the endorsement process are least subject to alternative explanations, hypothesis 4 offers the strongest test of our theory. Our hypothesis is that the amount of uncertainty surrounding the quality of a company determines the degree to which prominent exchange partners affect perceptions of new venture quality. With two measures of alliance partner prominence, two measures of equity investor prominence, and two measures of uncertainty, there are a total of eight possible prominence-by-uncertainty interactions. We report four of the eight possible interactions (one model for each of the four affiliate prominence variables), but the results in the unreported models are similar to those in table 3.

Models 7 through 10 generally provide strong support for the hypothesized endorsement process. Model 7 contains an interaction of total cash raised and the technological prominence of alliance partners. In this model, the technological prominence variable becomes more significant, although it is still shy of the 5-percent level. The interaction between prominence and the measure of uncertainty is negative, as we had predicted, although it too is slightly beneath the conventional significance level. Model 8 includes an interaction of total cash raised and the commercial prominence of equity investors. Here, the commercial prominence main effect is positive and statistically significant, and the coefficient on the interaction between prominence and uncertainty is negative and significant. Therefore, the effect of equity investor prominence does appear to be contingent on the amount of uncertainty about the focal venture's quality. Moreover, the commercial prominence of alliance partners becomes a significant determinant of the IPO rate when it is entered in a specification that permits the variable to depend on the amount of uncertainty about the focal venture's quality.

Models 9 and 10 report interactions of partner prominence with focal firm age. Because firm age is the duration clock in the time-to-IPO models, age dependence in the rate is captured by the coefficients on the three age periods in the piecewise model. Therefore, we interacted the prominence-of-affiliate variables with the age segments to determine how their effects vary across organizational ages. Model 9 includes the commercial prominence of equity investors in-

6
One might suspect a high correlation between the commercial and technological prominence of alliance partners as we have operationalized the concepts. This would occur if firms with the most developed biotech capabilities were also the most active participants in strategic alliances. But the actual correlation between the commercial and technological prominence of alliance partners is only .20. The low correlation indicates that affiliates with high technological prominence (well-honed, in-house biotech operations) are not much more active in biotech alliances than other organizations. While firms do not appear to treat in-house research and alliances as substitutes (the two variables are positively correlated, albeit weakly so), commercial and technological prominence do appear to capture different dimensions of affiliates' activities in biotechnology.

7
Because of the weak effect of the alliance partner prominence variables in models 3 and 4, we wondered if there was an additional contingency that we had failed to consider. In particular, we considered whether technological prominence exerts an effect only in the context of R&D alliances and commercial prominence only in the context of license and marketing alliances. When we reestimated the models to allow for this contingency, we still found weak effects of the alliance partner prominence, paralleling the results that we have reported.

teracted with the age segments, and model 10 reports an interaction of age and the technological prominence of alliance partners. Supporting our theory, in both models the affiliate prominence variable has the greatest effect on the IPO rate for young companies. To illustrate the magnitude of the decline in coefficient magnitudes across age periods, figure 1 plots the IPO rate multiplier as the equity investor prominence variable increases within each age period. Because we are primarily interested in the differential impact of technological prominence across the three age levels, we have not adjusted the intercepts in figure 1 by the estimates of the baseline hazard. As the figure demonstrates, having prominent equity investors had a much greater impact on the IPO rate for very young organizations. This is evidenced by the fact that the effect of technological prominence on the rate multiplier rises most precipitously over the variable's range for young firms (organizations in the 0 to 3 age range).

Market valuation results. The findings from the market valuation models are reported in table 4. In the baseline model (1), older firms and those that had raised larger amounts of cash from their venture capitalists garnered significantly higher valuations. The "protein engineering" segment dummy variable is also positive and statistically significant. The coefficients on the number of biotechnology patents is positive but slightly shy of statistical significance in the baseline model. Among the controls for environmental conditions, new ventures that had IPOs in 1987 and 1991 received more generous valuations than otherwise comparable firms that went public in other years. The direction of the effects on firm density and density-squared is consistent with density dependence theory, but neither variable is statistically significant. The biotechnology equity index is also not significant; the level of the index appears to have a much greater impact on the timing of IPOs than on market

Figure 1. Effect of technological prominence of equity investors on IPO rate.

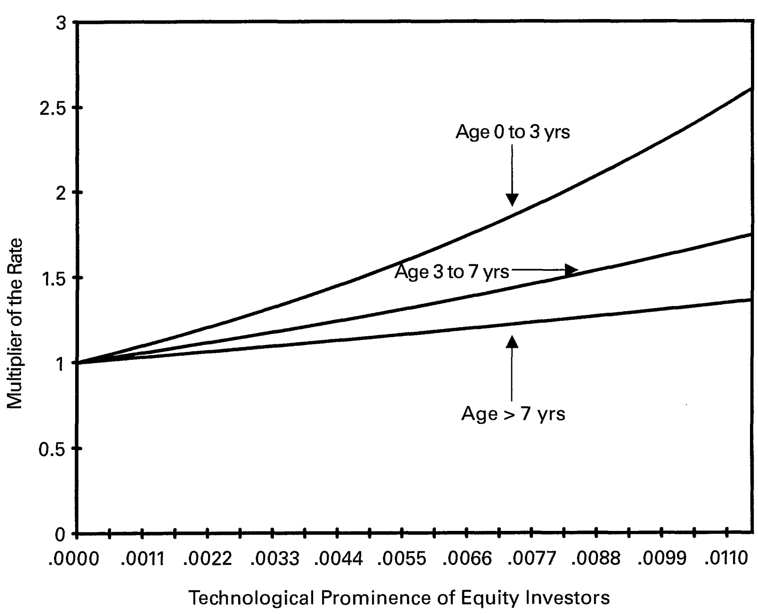


Table 4

OLS Estimates of the Log of Market Value of Biotech Firms at IPO*

Variable	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
Firm age	.150•	.180•	.159•	.179•	.139•	.176•
	(.052)	(.085)	(.085)	(.048)	(.049)	(.049)
Total cash raised	.039•	.039•	.033•	.038•	.034•	.038•
	(.005)	(.005)	(.005)	(.005)	(.005)	(.005)
BT patents	.035	.051•	.042	.055•	.031	.052•
	(.028)	(.027)	(.027)	(.027)	(.027)	(.027)
Invest. new drug (IND=1)	−.158	−.104	−.237	−.100	−.147	−.023
	(.168)	(.279)	(.265)	(.284)	(.253)	(.283)
Genetic engineering (=1)	−.028	−.104	−.159	−.061	−.066	−.032
	(.174)	(.178)	(.169)	(.187)	(.161)	(.177)
Immunology (=1)	.112	.121	.070	.119	.103	.087
	(.179)	(.182)	(.172)	(.185)	(.165)	(.182)
Protein engineering (=1)	.525•	.477•	.464•	.479•	.479•	.486•
	(.245)	(.229)	(.227)	(.229)	(.221)	(.230)
Diagnostics (=1)	.106	.116	.229	.112	.284	.144
	(.294)	(.298)	(.282)	(.302)	(.273)	(.296)
BT equity index	.056	.085	.058	.081	.001	.08
	(.168)	(.168)	(.156)	(.157)	(.154)	(.157)
BT density	.018	.018	.013	.018	.009	.017
	(.013)	(.013)	(.013)	(.014)	(.012)	(.014)
BT density^2(/1000)	−.032	−.032	−.023	−.032	−.014	−.031
	(.023)	(.023)	(.022)	(.023)	(.021)	(.023)
1983 (=1)	.282	.273	.325	.274	.580	.274
	(.396)	(.399)	(.376)	(.401)	(.368)	(.401)
1986 (=1)	.384	.378	.345	.382	.386	.325
	(.320)	(.321)	(.303)	(.328)	(.292)	(.322)
1987 (=1)	1.128•	1.118•	1.059•	1.186•	.813•	1.181•
	(.362)	(.366)	(.344)	(.370)	(.340)	(.362)
1991 (=1)	.936•	.958•	.983•	.957•	.998•	.938•
	(.310)	(.311)	(.292)	(.312)	(.282)	(.310)
Alliance count		.107•	.055	.099•	.068•	.106•
		(.026)	(.043)	(.029)	(.030)	(.026)
Funding from partners		.007	.007	.007	.005	.007
		(.004)	(.005)	(.005)	(.005)	(.004)
Equity investor count		.024	.023	.037	.019	.011
		(.084)	(.076)	(.076)	(.074)	(.079)
Com. prom., alliance			8.851•			
			(3.276)			
Tech. prom., alliance				5.285		
				(8.769)		
Com. prom., equity					27.431•	
					(8.811)	
Tech. prom., equity						1.957
						(1.510)
I-Bank prom.						
Com. prom., equity × Firm age						
Tech. prom., equity × Firm age						
Com. prom., alliance × Tot. cash raised						
Tech. prom., alliance × Tot. cash raised						
I-Bank prom. × Tot. cash raised						
Lambda	−1.375•	−1.898•	−1.606•	−1.920•	−1.430•	−1.862•
	(.316)	(.356)	(.402)	(.359)	(.383)	(.366)
Constant	1.081	.652	.855	.661	1.101	.688
	(1.782)	(1.584)	(1.578)	(1.589)	(1.539)	(1.592)
R-squared	.626	.687	.706	.689	.711	.689

• $p < .05$, one-sided tests.
* Standard errors in parentheses; 121 IPOs.

Table 4 (*continued*)

Model 7	Model 8	Model 9	Model 10	Model 11	Model 12
.142•	.149•	.203•	.071	.045	.085•
(.051)	(.053)	(.0828)	(.052)	(.054)	(.048)
.032•	.030•	.029•	.037•	.038•	.061•
(.005)	(.006)	(.005)	(.006)	(.007)	(.009)
.039	.036	.039	.015	.011	.016
(.027)	(.026)	(.027)	(.026)	(.026)	(.024)
−.088	−.083	−.712	−.087	−.004	−.289
(.268)	(.262)	(.260)	(.284)	(.283)	(.288)
.052	−.053	−.196	−.074	−.064	−.155
(.169)	(.151)	(.166)	(.187)	(.179)	(.165)
.025	.027	.117	.145	.065	.082
(.169)	(.169)	(.169)	(.187)	(.182)	(.163)
.396•	.404•	.504•	.564•	.495•	.566•
(.230)	(.215)	(.225)	(.216)	(.232)	(.222)
.050	.192	.223	.233	.122	.018
(.277)	(.158)	(.275)	(.268)	(.297)	(.266)
.094	.006	−.017	−.006	.099	.022
(.155)	(.156)	(.160)	(.147)	(.160)	(.152)
.013	.004	.011	.005	.019	.018
(.013)	(.009)	(.012)	(.012)	(.012)	(.013)
−.022	−.005	−.020	−.007	−.028	−.035•
(.022)	(.014)	(.021)	(.021)	(.023)	(.020)
.261	.444	.561	.663•	.280	.168
(.395)	(.372)	(.379)	(.360)	(.396)	(.353)
.209	.185	.527•	.459	.346	.384
(.314)	(.301)	(.305)	(.287)	(.322)	(.288)
.761•	.460	1.107•	.771•	1.115•	1.113•
(.346)	(.327)	(.337)	(.333)	(.362)	(.325)
.642•	.767•	1.062•	.980•	1.041•	.677•
(.301)	(.281)	(.287)	(.287)	(.307)	(.279)
.104•	.024	.048	.017	.011	.047
(.026)	(.044)	(.043)	(.044)	(.044)	(.040)
.007	.001	.005	.003	.005	.005
(.004)	(.005)	(.004)	(.004)	(.004)	(.004)
.004	−.014	.002	.009	.016	.030
(.072)	(.076)	(.072)	(.072)	(.069)	(.067)
	1.101	2.745	11.906•	.370	2.445
	(3.309)	(3.451)	(4.982)	(3.252)	(3.088)
	1.552	2.375	5.127	51.219•	.643
	(8.993)	(9.109)	(9.272)	(18.782)	(8.380)
	57.408•	2.631•	15.174	25.636•	21.676•
	(18.321)	(9.781)	(9.755)	(9.200)	(8.773)
	1.552	34.744	−1.206	−2.101	−.961
	(8.994)	(27.256)	(8.878)	(8.875)	(8.443)
.119•	.0632•	.0735•	.068•	.073•	.126•
(.024)	(.023)	(.023)	(.022)	(.022)	(.025)
	−9.501•				
	(4.457)				
		−9.147•			
		(5.197)			
			−.180•		
			(.065)		
				−1.631•	
				(.559)	
					−.004•
					(.001)
−1.677•	−1.283•	−1.231•	−.997•	−.575	−1.036•
(.371)	(.423)	(.429)	(.427)	(.471)	(.396)
1.087	1.955	1.729	1.636	1.596	1.510
(1.539)	(1.499)	(1.513)	(1.456)	(1.448)	(1.381)
.742	.777	.772	.785	.788	.810

valuations, although the effect of the index is dampened in the valuation models because of the inclusion of the year dummy variables. The selection parameter, lambda, is significant in all of the models.

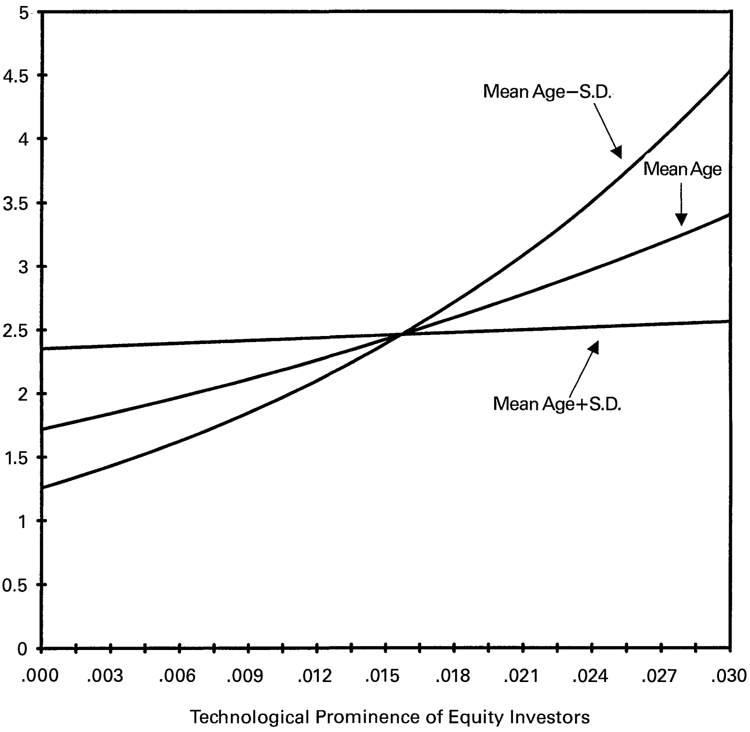
Model 2 adds to the baseline the alliance-based control variables. The alliance count variable has a positive and significant coefficient, the amount of funding from alliance partners is positive and nearly significant, and the number of non-venture-capital, organizational equity investors is positive but insignificant.

Models 3 through 7 add the five affiliate prominence variables. The coefficient on the commercial prominence of alliance partners is positive and significant (model 3): a standard deviation increase in alliance partner prominence raises predicted market value by 35 percent. Both the technological prominence of a focal biotech firm's alliance partners (model 4) and its equity investors (model 6) are positive, but neither has a statistically significant impact on valuations. Model 5 shows that the commercial prominence of equity investors is positive and statistically significant; a standard deviation increase in that variable raises the predicted value by 28 percent. Similarly, model 7 shows that the prestige of the investment banks that lead new securities offerings has a strong effect on value: a standard deviation increase in investment bank prestige increases the predicted value by 45 percent.

Models 8 through 12 report the interactions between the affiliate prominence variables and the two measures of uncertainty about focal firm quality, the total amount of venture capital funding and organizational age. These interactions are included to test the prediction in hypothesis 4 that endorsements have contingent effects on market valuations. With two measures of focal firm uncertainty and five prominence-of-affiliate variables, there are ten possible prominence-by-uncertainty interactions. We present five of the ten interactions, but the results from unreported models confirm a pattern of relationships similar to those reported. In all five of the reported models, the coefficient on the main effect of affiliate prominence is positive, and the coefficient on the interaction of affiliate prominence with firm age or with the amount of venture funding is negative. In all of the models except model 9, the parameter estimates are statistically significant. Paralleling the findings from the time-to-IPO analyses, the models in table 4 offer strong support for the hypothesis that affiliate prominence matters most when there is high uncertainty about the quality of a focal venture. Overall, the results show a precipitous decline in the exchange partner prominence effects when focal ventures are older and when they have raised larger amounts of private funding.

We focus on the results in model 8 to demonstrate the magnitude of the interaction effects. The predicted market values for two firms in the sample, Cytogen and Invitron, offer an interesting comparison. At IPO, both firms had organizational equity investors with almost identical commercial prominence scores: American Cyanamid had purchased a stake in Cytogen, and Monsanto held an equity position in

Figure 2. Effect of technological prominence of equity investors on market value at different ages.



Invitron. Cytogen was six years old at IPO, however, while Invitron underwent an IPO when it was less than three years old. According to our theory and results, the benefit of having a commercially prominent equity investor should be greater for Invitron than for Cytogen, because Invitron went public at a young age. Based on the coefficients in model 8, the effect of having Monsanto as an equity investor was a 91-percent increase in market value for Invitron. By contrast, having Cyanamid as an equity investor would produce a negligible increase (less than 1 percent) in the predicted market value of Cytogen. This difference is created by the decline in importance of affiliate prominence as firms age.[8]

Figure 2 offers a more systematic illustration of the joint effect of age and prominence at different levels of both variables, using the coefficients in model 8. Figure 2 demonstrates the effect of the commercial prominence of equity investors over the variable's range at three different levels of organizational age: the mean of the age at IPO for the firms in the sample, the mean age plus a standard deviation, and mean age minus a standard deviation. The vertical axis of the figure represents the multiplier of market value resulting from the combined effects of age and equity investor prominence, while other variables are held constant. With respect to the determination of market value, the figure demonstrates the powerful effects of prominence and the strong dependence of the prominence-of-affiliate effect on the age of the biotech firm. In particular, the figure shows that the predicted market value increases steeply over the range of technological prominence for young firms, but the increase

8
These estimates are based on the equation: exp(57.41∗prominence − 9.50∗prominence∗age). For both Invitron and Cytogen, prominence was 0.019 (the commercial prominence score for their equity investors, Monsanto and American Cyanamid). For Cytogen (age 6 years), the prominence market value multiplier is 1.01. For Invitron (age 2.83 years), it is 1.78. The reported valuation multipliers (1.01, 1.78) do not incorporate the positive "main effect" of age in model 8. When we add in the positive age term, the predicted multiplier for Invitron is 2.72 and the multiplier for the older Cytogen is 2.47.

for firms a standard deviation above the mean age is relatively modest.

The results thus show strong evidence that the advantage of having prominent affiliates is contingent on the level of uncertainty about the quality of a biotech venture. The greater the uncertainty, the more that outside evaluators rely on the prominence of affiliates to draw inferences about quality.

DISCUSSION AND CONCLUSION

In uncertain contexts, patterns of affiliation become bases for evaluations. Because uncertainty pervades attempts to evaluate new and unproven companies, the social structure of business relationships is a primary consideration in the market's assessment of the quality of new ventures. Foremost among the factors that affect attributions of value are the characteristics of those sponsoring and affiliated with new companies. In this study, we focused on the attributes of three kinds of exchange partners of young biotech companies—alliance partners, equity investors, and investment banks—as determinants of the ability of new ventures to attract resources. Overall, our empirical analyses demonstrated consistent and cogent effects of the prominence of exchange partners on the performance of entrepreneurial ventures. Moreover, the affiliative effects held up in models that included a comprehensive set of control variables capturing firm differences and environmental conditions. Building a new company is a highly competitive endeavor, and it is difficult to overstate the advantages of having the right intercorporate relationships when competing to create a viable organization.

The results raise several points worth emphasizing about the impact of interorganizational relationships on the perceived value of new ventures. First, the analyses clearly demonstrate that sponsorship has the capacity to substitute for accomplishment and experience as a basis for the success of young companies. In both the valuation and the rate models, the exchange partner's prominence had much stronger effects on the performance of companies about which there was high uncertainty. This contingency in the impact of affiliations is exhibited by the precipitously declining effects of the partner prominence variables as firms age and as they garner greater amounts of venture capital funding. By the same token, experience and accomplishments take on added significance for firms that lack notable sponsors. For instance, models 8 and 9 in table 4 show that each additional year of age increases the predicted market value by approximately 20 percent for firms that have no strategic alliance partners and no organizational equity investors (the effect of a one-year change in organizational age evaluated at zero affiliate prominence).

The implications of the positive correlations among the affiliate-prominence variables (table 2) also merit emphasis. Based on the bivariate correlations and the fact that the magnitude of the coefficients on each of the prominence variables declined when all of the prominence variables were entered in the same models, we suspect that new ventures that obtained prominent exchange partners tended to do so across the board: firms that had well-known equity partners were more likely to have prominent alliance partners and to use prestigious investment banks. The tendency for firms that obtain a highly regarded exchange partner to gain others is not surprising. When a new venture secures a prominent exchange partner, that partner often serves as an ally, introducing the company to its associates. For example, Bygrave and Timmons (1992) noted that high-status venture capital firms maintained close relationships with leading investment banks. Thus, start-ups funded by leading venture capital firms tended to secure prestigious investment banks to syndicate their IPOs. Moreover, our theory suggests that in addition to gaining access to the contacts of a prominent affiliate, young companies gain attention and recognition when they first obtain a prominent associate. This recognition may facilitate the acquisition of additional, well-known exchange partners, creating the possibility of a cumulating cycle of advantage accruing to young firms that gain prominent organizational associates.

It is important to stress, however, that credentialing is often an ancillary consideration in the decisions of young biotech firms to form strategic alliances and to solicit equity investments. Alliances in the biotechnology industry are instrumental ties aimed at acquiring resources to fund speculative development projects and to unite complementary assets, such as technical and marketing capabilities, held by different firms. Both parties in the transaction enter it with clearly specified objectives, and agreements are consummated only when extensive contracts detailing the legal terms of the relationship are signed. The instrumental objectives of such agreements notwithstanding, our results show that these interfirm relations carry reputational consequences. Bearing this out, the positive effects of the count of the number of alliance partners and of the number of equity investors in the baseline models in table 3 and table 4 often dropped out once we entered the complete vector of exchange-partner prominence scores, a trend most evident in the valuation models. Overall, the results suggest that the impact of interorganizational relations is driven more by who a company is associated with than by the volume of its relations.

One possible explanation for this pattern of results is that the instrumental value of many interorganizational ties is highly uncertain. For instance, the contractual terms of alliances between young biotech companies and established corporations often permit the latter to terminate the agreements on relatively short notice and without cause. Hence, even if an alliance entails milestone or other payments to the biotech firm, the existence of the contract does not in itself guarantee a future revenue stream. Furthermore, strategic alliances carry claims against a young biotech firm's future outputs. Therefore, even when alliances convey significant resources, the future costs associated with ceding downstream development and commercialization rights often exceed the present financial benefits of the relationships. In contrast, the endorsement benefit derived from obtaining a prominent strategic partner is unequivocally positive: it stems from the mere fact that the biotech company has survived the due diligence of a capable or highly motivated evaluator.

This study raises two issues that are worth discussing. First is causality. Can we be sure that our effects are driven by the hypothesized endorsement process rather than unobserved differences between firms that happen to correlate with affiliate prominence? To rule out this possibility, we made every effort to control for differences in quality between the firms in our empirical analysis. We also restricted our sample to a narrow segment of the market to reduce the effect of differences in firm strategy. While one can never completely rule out unobserved heterogeneity, the contingency in the affiliate effects greatly increases our confidence in the theory. Other than the hypothesized endorsement process, it is difficult to construct a cogent explanation for the strong and consistent pattern of interaction effects observed in tables 3 and 4. The most compelling alternative explanation for the interaction effects is that alliances (independent of partner characteristics) are more valuable to young and small firms, perhaps because these are the organizations that face the greatest resource constraints. Under this scenario, the interaction effects between partner prominence and focal firm age and size could be significant and negative because of the positive correlation between affiliate prominence and the count of alliances. To rule out this possibility, we estimated models that included interactions between the alliance count and firm age along with the prominence-by-age interactions. In about half of the models, the prominence-by-age interactions lost significance—presumably due to collinearity among the predictors—but in no case, however, was the alliance count-by-age variable statistically significant.

The second issue is generalizability. While caution must always be exercised when generalizing from a single industry study, we believe that the processes we have observed in the biotech industry do operate in other contexts. Ours is a study of how relationships affect evaluations under conditions of uncertainty. We believe that the social process underlying the endorsement effects operates widely in organizational domains. Consistent with this belief, others have demonstrated that affiliations resolve uncertainty in adoption decisions (e.g., Burt, 1987; Davis, 1991; Podolny and Stuart, 1995). With the notable exception of Baum and Oliver's (1991, 1992) research on the advantages conferred by ties to certain types of institutions, however, there has not been much work on the status-enhancing properties of interorganizational relations.

The results of this study open some avenues for future research. First, evaluations of new ventures are affected by other types of associations than those that we have scrutinized here. In particular, the characteristics of affiliated organizations, such as law firms, accounting firms, and especially venture capital firms themselves, are likely to affect perceptions of a new venture's quality. Moreover, young companies can acquire status by solidifying relationships with prestigious individuals (Burton, Sorensen, and Beckman, 1999). For example, Gilead Sciences is a biotech firm that has gained attention because of the members of its board of directors. Gilead's board included a former secretary of defense (Donald Rumsfeld), a former secretary of state (George Schultz), and the chairman of Intel (Gordon Moore). Similarly, technology companies often establish scientific advisory boards, and staffing these panels with prestigious researchers is another tactic for enhancing the visibility of the venture. As Werth (1994: 22) succinctly stated, "Most [scientific advisory boards] are ballast for the letterhead." Added to the potential access and information benefits of relationships with prominent individuals, relationships with them confer status on new ventures. It would be useful to know how other types of affiliations affect evaluations of start-ups and the conditions under which they are most beneficial.

Second, we have for the most part ignored the strategic intent and the incentives of the exchange partners of the firms in our sample, yet, in their formal dealings with biotechnology companies, pharmaceutical companies and other types of alliance partners have pursued a wide variety of strategies. Some exchange partners are noted for having established alliances with a large number of biotech firms, many of which have overlapping and competing ambitions. Other firms make more exclusive commitments to their biotech partners, acquiring only one strategic partner in any particular area of development. It is almost certain that the cooperative strategies of the partners of biotechnology firms affect the reputational value of alliances with them. It is therefore important to develop more fine-grained measures of partner characteristics to better understand the boundary conditions around status transfer.

Third, the obvious implication of our findings for new venture strategy is that young technology companies should actively seek prominent exchange partners. The interesting question is the conditions under which they will succeed at recruiting such partners. It would greatly improve our knowledge of the organization-building process to understand the relationship between a focal firm's accomplishments and interorganizational endorsements. Do the achievements of early-stage ventures attract high-status exchange partners, implying that gaining a well-regarded affiliate is an accurate reflection of merit? Do ties to prominent actors facilitate the acquisition of resources and thus the ability to fund expensive projects? If so, this raises the possibility that obtaining a prominent partner invokes a cycle of accumulating advantage for young companies in which the addition of a well-known affiliate expedites the acquisition of the resources that enable future accomplishments. Or are there only weak ex ante and ex post relationships between actual quality and the prominence of an organization's exchange partners?

One possibility is that the short-term advantage of a connection to a prominent actor is followed by sub-par performance. We might expect to find this if the true quality of a biotech firm is orthogonal to the prominence of its affiliates. A research design that could be used to test this hypothesis would be to compute the post-IPO stock market performance of a sample of new ventures and then to investigate the effect of the prestige of pre-IPO affiliates on post-IPO performance. If the prestige of associates is unrelated to a focal firm's quality (and if the "treatment effect" of having high-status partners is not too large), then the performance of new issues will suffer in the years following IPOs, because the market will reassess the values of companies as it learns more about firms' actual quality. In other words, we might observe poor post-IPO performance among firms that have prominent associates because of the "halo" effect stemming from connections to prominent affiliates. Investigating possibilities such as this one will enlighten the processes through which reputations are created and the consequences of intercorporate relations for the performance of the producers in a market.

REFERENCES

Albert, M. B., D. Avery, F. Narin, and P. McAllister
1991 "Direct validation of citation counts as indicators of industrially important patents." Research Policy, 20: 251–259.

Aldrich, Howard, and Ellen R. Auster
1986 "Even dwarfs started small: Liabilities of age and size and their strategic implications." In L. L. Cummings and B. M. Staw (eds.), Research in Organizational Behavior, 8: 165–198. Greenwich, CT: JAI Press.

Aldrich, Howard E., and C. Marlene Fiol
1993 "Fools rush in? The institutional context of industry creation." Academy of Management Review, 19: 645–670.

Barley, Stephen R., John Freeman, and Ralph C. Hybels
1992 "Strategic alliances in commercial biotechnology." In Nitin Nohria and Robert Eccles (eds.), Networks and Organizations: Structure, Form and Action: 311–347. Boston: Harvard Business School Press.

Baum, Joel A. C., and Christine Oliver
1991 "Institutional linkages and organizational mortality." Administrative Science Quarterly, 36: 187–218.
1992 "Institutional embeddedness and the dynamics of organizational populations." American Sociological Review, 57: 540–559.

Beatty, Randolph, and Jay Ritter
1986 "Investment banking, reputation and the underpricing of initial public offerings." Journal of Financial Economics, 15: 213–232.

Blau, Peter M.
1964 Exchange and Power in Social Life. New York: Wiley.

Burrill, G. Steven, and Kenneth B. Lee, Jr.
1993 Biotech 93: Accelerating Commercialization. San Francisco: Ernst & Young.

Burt, Ronald S.
1987 "Social contagion and innovation: Cohesion versus structural equivalence." American Journal of Sociology, 92: 1287–1335.
1992 Structural Holes: The Social Structure of Competition. Cambridge, MA: Harvard University Press.

Burton, Diane, Jesper Sorensen, and Christine Beckman
1999 "Coming from good stock: Career histories and new venture formation." Working paper, Harvard Business School.

Bygrave, William D., and Jeffry A. Timmons
1992 Venture Capital at the Crossroads. Boston: Harvard Business School Press.

Cahill, Scott, Richard Caligaris, and David Williams
1992 "Have pharmaceutical companies missed the boat on biotechnology?" Medical Marketing and Media, January: 28–38.

Carter, Richard, and Steven Manaster
1990 "Initial public offerings and underwriter reputation." Journal of Finance, 45: 1045–1067.

Cohen, Wesley M., and Daniel A. Levinthal
1990 "Absorptive capacity: A new perspective on learning and innovation." Administrative Science Quarterly, 35: 128–152.

Coombs, J.
1986 The Biotechnology Directory: 1986. New York: Stockton Press.

Coombs, J., and Y. R. Alston
1989 The Biotechnology Directory: 1989. New York: Stockton Press.

Davis, Gerald S.
1991 "Agents without principles? The spread of the poison pill through the intercorporate network." Administrative Science Quarterly, 36: 583–613.

Dibner, Mark D.
1988 Biotechnology Guide: U.S.A. New York: Stockton Press.
1991 Biotechnology Guide: U.S.A. New York: Stockton Press.

Freeman, John
1997 "Venture capital as an economy of time." Unpublished manuscript, Haas School of Business, University of California, Berkeley.

Freeman, John, Glenn R. Carroll, and Michael T. Hannan
1983 "The liability of newness and age dependence in organizational death rates." American Sociological Review, 48: 692–710.

Gompers, Paul A.
1995 "Optimal investment, monitoring, and the staging of venture capital." Journal of Finance, 50: 1461–1489.

Goode, William J.
1978 The Celebration of Heroes: Prestige as a Social Control System. Berkeley, CA: University of California Press.

Granovetter, Mark S.
1973 "The strength of weak ties." American Journal of Sociology, 78: 1360–1380.

Hannan, Michael T., and Glenn R. Carroll
1992 Dynamics of Organizational Populations. New York: Oxford University Press.

Hannan, Michael T., and John Freeman
1984 "Structural inertia and organizational change." American Journal of Sociology, 49: 149–164.

Heckman, James J.
1976 "The common structure of statistical models of truncation, sample selection and limited dependent variables and a simple estimator for such models." Annals of Economic and Social Measurement, 5: 475–492.

Henderson, Rebecca, and Iain Cockburn
1994 "Measuring competence? Exploring firm effects in pharmaceutical research." Strategic Management Journal, 15 (special issue): 63–84.

Kenney, Martin
1986 Bio-technology: The University-Industrial Complex. New Haven, CT: Yale University Press.

Kogut, Bruce, and Udo Zander
1996 "What firms do? Coordination, identity, and learning." Organization Science, 7: 502–518.

Knoke, David, and Ronald S. Burt
1983 "Prominence." In Ronald S. Burt and Michael J. Minor (eds.), Applied Network Analysis: 195–222. Beverly Hills, CA: Sage.

Latour, Bruno
1987 Science in Action. Cambridge, MA: Harvard University Press.

Lee, Lung-Fei
1983 "Generalized econometric models with selectivity." Econometrica, 51: 507–512.

Lerner, Joshua
1994 "Venture capitalists and the decision to go public." Journal of Financial Economics, 35: 293–316.

Levinthal, Daniel A.
1991 "Organizational adaptation, environmental selection, and random walks." Administrative Science Quarterly, 36: 397–420.

Lin, Nan, Walter M. Ensel, and John C. Vaughn
1981 "Social resources and strength of ties: Structural factors in occupational status attainment." American Sociological Review, 46: 393–405.

Marsden, Peter V.
1983 "Restricted access in networks and models of power." American Journal of Sociology, 88: 686–717.

Megginson, William L., and Kathleen A. Weiss
1991 "Venture capitalist certification in initial public offerings." Journal of Finance, 46: 879–903.

Merton, Robert C.
1973 "The Matthew Effect in science." (First published in 1968.) In Norman W. Storer (ed.), The Sociology of Science: 439–459. Chicago: University of Chicago Press.

Podolny, Joel M.
1993 "A status-based model of market competition." American Journal of Sociology, 98: 829–872.
1994 "Market uncertainty and the social character of economic exchange." Administrative Science Quarterly, 39: 458–483.

Podolny, Joel M., and Damon J. Phillips
1996 "The dynamics of organizational status." Journal of Industrial and Corporate Change, 5: 453–471.

Podolny, Joel M., and Toby E. Stuart
1995 "A role-based ecology of technological change." American Journal of Sociology, 100: 1224–1260.

Powell, Walter W., Kenneth W. Koput, and Laurel Smith-Doerr
1996 "Interorganizational collaboration and the locus of innovation: Networks of learning in biotechnology." Administrative Science Quarterly, 41: 116–145.

Rao, Hayagreeva
1994 "The social construction of reputation: Certification contests, legitimization, and the survival of organizations in the American automobile industry: 1895–1912." Strategic Management Journal, 15: 29–44.

Ritter, Jay R.
1984 "The 'hot issue' market of 1980." Journal of Business, 57: 215–240.

Singh, Jitendra V., Robert J. House, and David J. Tucker
1986 "Organizational change and organizational mortality." Administrative Science Quarterly, 31: 587–611.

Sorensen, Jesper, and Toby E. Stuart
1999 "Aging, obsolescence and organizational innovation." Working paper, Graduate School of Business, University of Chicago.

Spence, A. Michael
1974 Market Signaling. Cambridge, MA: Harvard University Press.

Stinchcombe, Arthur L.
1965 "Social structure and organizations." In James G. March (ed.), Handbook of Organizations: 142–193. Chicago: Rand McNally.

Stuart, Toby E.
1998 "Network positions and propensities to collaborate: An investigation of strategic alliance formation in a high-technology industry." Administrative Science Quarterly, 43: 668–698.

Trajtenberg, Manuel
1990 "A penny for your quotes: Patent citations and the value of information." Rand Journal of Economics, 21: 172–187.

Tuma, Nancy Brandon, and Michael T. Hannan
1984 Social Dynamics: Models and Methods. Orlando, FL: Academic Press.

Tushman, Michael L., and Philip Anderson
1986 "Technological discontinuities and organizational environments." Administrative Science Quarterly, 31: 439–465.

Tushman, Michael L., and Lori Rosenkopf
1992 "Organizational determinants of technological change: Toward a sociology of technological evolution." In L. L. Cummings and B. M. Staw (eds.), Research in Organizational Behavior, 14: 311–347. Greenwich, CT: JAI Press.

Werth, Barry
1994 The Billion Dollar Molecule. New York: Simon & Schuster.

White, Harrison
1985 "Agency as control." In J. Pratt and R. Zeckhauser (eds.), Principals and Agents: The Structure of Business: 187–212. Cambridge, MA: Harvard Business School Press.