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When does start-up innovation spur the gale of creative destruction?

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THE CENTER FOR THE STUDY
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AT NORTHWESTERN UNIVERSITY

Working Paper #0025

When Does Start-Up Innovation
Spur the Gale of Creative Destruction?*

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When Does Start-Up Innovation Spur the Gale of Creative Destruction?

ABSTRACT

This paper examines the determinants of commercialization strategy for start-up innovators. We examine whether the returns on innovation are earned through product market competition as opposed to cooperation with more established firms (either through licensing, strategic alliances or outright acquisition). Our key hypotheses are that the *relative* returns to cooperation are increasing in (a) the control of intellectual property rights, (b) low transaction costs and (c) the cost of the sunk assets associated with product market entry. We find support for these ideas using a novel dataset of the commercialization strategies of start-up innovators. The results suggest that the pro-competitive benefits of start-up innovation – the gale of creative destruction – depends on the severity of imperfections in the “market for ideas.” *Journal of Economic Literature*
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I. Introduction

Over the past decade, there has been a rapid rise in the level of investment funding provided to technology-oriented start-up firms. Venture capital investments increased by more than an order of magnitude between 1991 and 1999 (VentureOne, 2000), and venture-backed firms currently account for more than 15% of all domestic industrial innovation (Kortum and Lerner, 2000). Not surprisingly, there is considerable interest in the economic implications of this surge in R&D investment in start-up firms (Gompers and Lerner, 1999; Kortum and Lerner, 2000; Hellman and Puri, 2000).

Many analysts suggest that start-up innovation impacts existing sources of market power by spurring the “gale of creative destruction” (Schumpeter, 1943; Christensen, 1997). However, industry studies suggest a more nuanced relationship (Gans and Stern, 2001). For example, in the biotechnology industry, cooperation between start-up innovators and more established firms is the norm (whether through licensing, strategic alliances or outright acquisition) (Orsenegio, 1989; Lerner and Merges, 1998). On the other hand, start-up innovators in the electronics industry often engage in creative destruction, earning their innovation rents through product market entry and competition with more established firms (Christensen, 1997). This paper attempts to understand these different patterns by evaluating how economic factors such as the strength of intellectual property protection shape the *relative* returns to cooperation versus competition.

Consider a cooperation strategy. Start-up innovators and more established firms share (at least) two distinct gains from trade in the “market for ideas”: (1) preserving current market power and (2) avoiding duplicative commercialization investments, such

as those associated with distribution, manufacturing, or a branded reputation. If an ideas market functions efficiently, incumbents can contract for innovations from start-ups (who then serve as technology suppliers) and so foreclose on a potentially important form of competition. Imperfections in the market for ideas, conversely, can spur a competitive strategy by start-up innovators.

We identify three factors that shape start-up commercialization strategy. First, the strength of intellectual property rights (IPR) not only impacts the absolute returns to innovation (regardless of commercialization strategy) by reducing the threat of expropriation but also impacts the relative returns to competition versus cooperation. While expropriation may occur whether the start-up competes or cooperates, the (negotiated) return to the start-up under cooperation reflects their ability to threaten the established firm with competitive entry and the transaction costs of bargaining. These two factors ensure that the returns to cooperation are more sensitive to the strength of IPR than the returns to competition, and so an increase in the strength of IPR increases the relative returns to cooperation. Second, the relative returns to cooperation are increasing in the presence of intermediaries, such as venture capitalists or specialized legal counsel, that reduce search and transaction costs associated with identifying and contracting with incumbents. Third, a start-up's returns to competitive entry are decreasing in the (sunk) costs of market entry. To the extent that incumbent-owned "complementary assets" (such as distribution channels, brand names, or manufacturing expertise) are costly to duplicate, the cost-effectiveness of a competition strategy will decrease in the size of these costs.

This paper empirically evaluates whether commercialization strategy differs with measures capturing variation along these three dimensions – the strength of IPR, the cost

of contracting, and the importance and effectiveness of complementary asset ownership. Perhaps surprisingly, little empirical work has been devoted to this topic. Most prior analyses of the relationship between start-up and established firms have focused on the relative incentives to innovate in the first place, under the assumption that innovation by a start-up is followed by product market competition.¹ As well, several analyses examine the *form* of cooperation between smaller research-oriented firms and larger established firms without considering the potential for product market entry.² By relating the *choice* between cooperation and competition to the firm's economic environment, our analysis suggests that the industrial organization consequences of start-up innovation are endogenous to the commercialization environment, as determined by factors such as the strength of IPR and the availability of venture capital. These commercialization environment parameters depend, at least in part, on various aspects of public policy.

Our findings are based on a dataset composed of the commercialization strategies of 118 projects. We evaluate whether cooperation is associated with (a) innovations that receive formal IP protection (e.g., a patent), (b) firms with access to a network of contacts (e.g., through a relationship with a venture capitalist), and (c) environments where ownership of complementary assets by the start-up is perceived as ineffective in earning profits from innovation. Each factor is associated with a quantitatively significant effect on the probability of cooperation. For example, firms that possess IPR are estimated to be 23 percentage points more likely than non-patent-holders to pursue a cooperative strategy. While the impact of IPR is estimated relatively precisely, the estimates of the

¹ The literature on R&D and product market competition between incumbents and start-up firms is too large to be summarized here. See Cohen and Levin (1989) or Gans and Stern (2000a) for a review.

² See Salant, 1984; Katz and Shapiro, 1987; Pisano, 1990; Anton and Yao, 1995; Lerner and Merces, 1998.

impact of venture capitalists and the costs of complementary assets are noisier (occasionally only significant at the 10% level). These core findings are robust to the inclusion of a variety of controls, varying the definitions of each empirical concept, and relying exclusively on within-industry or cross-industry variation. While we interpret this evidence cautiously given the small sample size and imperfect measurement of key concepts, our results do accord with the presence of strategic interaction between start-up innovators and incumbents in high-technology industries.

The remainder of this paper is organized as follows. The next section develops the key predictions of how the commercialization environment impacts optimal commercialization strategy. After a brief review of the data, the key empirical results are presented in Section IV. A final section concludes.

II. The Determinants of Start-Up Commercialization Strategy

Consider a start-up innovator who has successfully developed a commercializable innovation and now faces a choice between entering the product market – the *competitive* strategy – or “selling” the innovation to an incumbent – the *cooperative* strategy.³ A cooperative strategy may be achieved through several mechanisms (from a licensing agreement to a strategic alliance to acquisition of the entrant by the incumbent). While these mechanisms differ in how they impact *future* incentives to innovate and the locus of decision authority, they share a common feature: if an agreement is reached, the incumbent forecloses on product market competition and monopoly profits are maintained. While most prior research focuses on how changes in key parameters such

³ A commercializable innovation is one in which all technological uncertainty has been resolved (e.g., a prototype exists) and so, with (known) investments, the innovation could be introduced into the market.

as the strength of IPR impact the absolute returns to innovation, the drivers of commercialization strategy depend on how these parameters impact the relative returns to competition versus cooperation.

Consider the impact of IPR (see Appendix A for a brief formal model). In general, start-up innovation incentives and commercialization strategy will depend on the “expropriation” threat (Arrow, 1962; Anton and Yao, 1994). This threat is present whether a start-up competes or cooperates. Under competition, incumbent firms will attempt to reverse-engineer and commercialize an imitation of the start-up’s innovation. Under cooperation, negotiating over the sale of an idea inevitably involves the risk of disclosure of that idea, reducing the start-up’s bargaining position and the incumbent’s willingness-to-pay for the innovation. Since increasing the strength of IPR reduces the expropriation threat for either commercialization strategy, an increase in the strength of IPR increases the absolute expected returns to start-up innovators.

Two factors, however, bias the impact of IPR so that an increase in the strength of IPR increases the relative returns to cooperation. First, the bargaining between a start-up and incumbent in the market for ideas takes place in the “shadow” of potential product market competition. The return to cooperation reflects both the intrinsic value of the start-up’s proprietary knowledge and the start-up’s ability to threaten competitive entry. As such, increasing the strength of IPR reduces the threat of expropriation during bargaining and increases the start-up’s outside option (breaking off negotiations and entering the product market). Since the (negotiated) returns to cooperation will reflect the start-up’s improved competitive prospects, an increase in the strength of IPR will increase the relative returns to cooperation over competition. As well, the availability of

certain types of IPR (specifically, patents) reduces the transaction costs associated with cooperation. The presence of a well-defined technology specification and a clear delineation of legal ownership reduces the costs associated with bargaining and reaching an agreement, particularly in the context of licensing. Together, these effects make the payoffs to cooperation more sensitive to the strength of IPR relative to the payoffs to competition. Consequently, we expect that the probability of cooperation will be increasing in the strength of IPR.

A second factor determining start-up commercialization strategy is the level of search and bargaining costs associated with cooperation. Even when IPR are well defined, there may be uncertainty about the value (or other characteristics) of the start-up technology; this uncertainty may necessitate detailed bargaining between the parties about royalty rates and other contingent contracting provisions (Arora, Fosfuri, and Gambardella, 1999). As such, the presence of bargaining intermediaries that substantially reduce the cost of forging an agreement between the parties may increase the relative likelihood of cooperation (Burt, 1992). Specifically, we evaluate whether these costs of trade may be lower in the presence of third-party “brokers” (such as venture capitalists), who have long-term reputations with incumbents and can therefore credibly certify the expected value of specific innovations.

Finally, cooperation allows start-up innovators to exploit “complementary assets” controlled by incumbents, including distribution channels, regulatory or manufacturing expertise, and brand-name recognition (Teece, 1986). While avoiding duplication of sunk assets is important in some environments (such as when biotechnology firms exploit the regulatory expertise and distribution channels of established pharmaceutical

companies), incumbent-owned assets confer minimal value in other settings (e.g., when start-ups develop incompatible technology). As the “cost” of product market entry increases, the gains from trade between start-up innovators and incumbents increase and so start-ups will be more likely to forego competition and earn their returns through the market for ideas.

III. Data

The remainder of the paper evaluates the empirical salience of the predictions associated with these factors. Our approach is straightforward (as in the spirit of Mansfield, Schwartz and Wagner, 1981). We evaluate how the cooperation probability of a sample of start-up innovators varies with observable characteristics of the commercialization environment. We begin by reviewing the novel dataset employed in this study and discussing our empirical measures in some detail.

The Commercialization Strategies Survey

Our empirical approach requires measuring the commercialization environment and strategy, data that are unavailable from either public or commercial databases (Gompers and Lerner, 1999; Hellman and Puri, 2000). To address this challenge, we developed and administered a start-up commercialization strategy survey during the first half of 1999 (see Appendix B). The survey population is composed of start-ups receiving external R&D financing from one of two sources: private venture capital (VC) or the Small Business Innovation Research program (SBIR). Dividing the sample between SBIR and VC-funded firms incorporates variation in the costs of identifying and

contracting with partners while maintaining the ability to evaluate the impact of IP strength and sunk costs across a cross-section of firms.

The sample consists of 63 SBIR-backed and 55 VC-backed firms (for a total of 118 observations).⁴ Following Lerner (1999), we use a “matching” process to identify the sample population in an effort to preserve within-sample consistency. First, we collected the sample of SBIR-funded projects (drawn from the top 200 SBIR award winners between 1990 and 1993) and then matched each SBIR project with a single VC-backed project. The matching criteria is based on each firms’ four-digit SIC code, initial sales, and geographic location.⁵ The key requirement for inclusion in the sample is that the firm successfully commercialized an externally-funded technology, either independently or through some form of cooperative agreement. This prerequisite ensures that our evaluation of commercialization strategy is conditioned on the fact that the innovation has been commercialized.

The projects are distributed across five SIC codes: biotechnology (2836), computer software (7372), industrial machinery and equipment (35), electronic equipment (36) and scientific instruments (38). We collected data on each firm’s employees, promotion policies, corporate ownership and governance, as well as financial information including expenditures and revenues. For each project, we collected information about commercialization and financing history, revenue information

⁴ The survey response rate was approximately 50%. Non-responders seemed randomly mixed between firms not having a commercial product and those declining for other reasons. The respondent was typically the director of R&D, sales or marketing, or the CEO. The surveys were first pre-tested with a small sample of potential respondents. Thereafter, we collected survey responses by phone, fax and mail.

⁵ Specifically, we first searched the *Venture Economics* database for candidate venture-backed companies whose primary line of business matched the 4-digit SIC codes for a given SBIR-backed company. Among this set, we eliminated those that themselves received SBIR funding. We then consulted the *Corptech Directory of Technology Companies* (1998) to select the firm which most closely matched in initial sales revenues, and where possible, geographic location (Lerner, 1999).

including sales and licensing, the importance of the technology in achieving firm objectives, and the key personnel associated with the firm's commercialization strategy.⁶

It is useful to compare the institutional features associated with the two sources of financing for firms in the sample. The SBIR program provides R&D grants to U.S. firms with 500 or fewer employees (USGAO, 1995). The level of funding for the program by each Federal agency is equal to a fixed percentage of the total level of R&D funding for that agency. Grant applications are peer-reviewed and awarded through a competitive process (less than 15% of applications are granted).⁷ Once awarded, the SBIR grant is a "hands-off" subsidy; the government neither takes over managerial control nor maintains an equity stake in funded organizations. Because it is administered through all R&D-performing Federal agencies, the SBIR program funds a diverse array of firms and technologies relative to the concentrated distribution of private VC financing (Gans and Stern, 2000b). We ensure comparability by evaluating a sample drawn from five industrial segments heavily funded by both VCs and the SBIR program.

In contrast to the SBIR program, VCs provide capital to start-ups in exchange for equity and managerial control. In addition to their financial role, VCs are believed to aid start-up firms by offering a network of contacts and potential partners as well as providing experience in corporate governance (Gompers and Lerner, 1999; Stuart, Hoang

⁶ When possible, we used publicly available databases to verify survey responses. For example, the number of patents assigned to each organization was verified at www.uspto.gov.

⁷ There are two award types. Phase I awards are proof of concept awards which were capped at \$100,000 during the early 1990s. During that time period, development-oriented Phase II awards were capped at \$750,000 (USGAO, 1995). Our sample of SBIR firms received Phase II awards. Grants are based, in principle, on three legislative goals: (a) increasing the commercialization rate of innovations derived from Federal R&D, (b) enhancing the "competitiveness" of small firms in technology-intensive sectors, and (c) increasing participation of underrepresented groups in Federal contracting (USGAO, 1995). The policy rationale for the SBIR is a belief that entrepreneurial firms are highly productive, associated with high spillovers and subject to potential R&D under-investment (Lerner, 1999). However, the program's objectives and administration may conflict insofar as administrators may have incentives to grant funding to infra-marginal projects (Wallsten, 2000).

and Hybels, 1999). While SBIR and VC-funded projects differ insofar as VC funding directly affects the operation and decision rights of the firm, projects from either source are comparable in several key respects: (a) firms tend to be young, (b) the projects are R&D-intensive, (c) project selection is competitive and (d) the size of financing is comparable in the study period.

Variable Definitions and Summary Statistics

Cooperation measures. Table 1 reports variable definitions and summary statistics. Our key dependent variable is a combination of two distinct measures associated with a cooperative commercialization strategy. LICENSED is a dummy variable indicating whether the firm earned licensing revenues from its innovation, a practice undertaken by 22% of the firms in the sample.⁸ Similarly, ACQUIRED is a dummy variable indicating whether the firm was acquired since the project was funded (mean = .14). Together, LICENSED and ACQUIRED form a meaningful concept of cooperative behavior for firms within our sample. In Figure A, we plot the percentage of overall revenues derived from cooperation (either through licensing or equal to one if ACQUIRED). The histogram is bimodal; for over 80% of the sample, revenues are derived solely from either licensing/acquisition or from independent commercialization. Accordingly, our key measure of cooperation is COOP (LIC + ACQ), a dummy equal to one if either LICENSED or ACQUIRED is equal to one. It is interesting to note that there is substantial heterogeneity of COOP (LIC + ACQ) across industrial sectors. For example, while the probability of cooperation is above 50% in biotechnology, less than 25% of industrial equipment firms cooperate in commercialization.

⁸ Over 95% of the technology licenses are assigned on an exclusive basis.

We also explore alternative measures of cooperation. First, we explore differences between the determinants of LICENSED and ACQUIRED themselves. As well, building on a mostly descriptive literature highlighting the impact of strategic alliances on cooperative activity (Gomes-Casseres, 1996), we define HI ALLIANCES as a dummy variable equal to one for firms with a high level of strategic alliance activity (in the top quintile). We also group HI ALLIANCES with our previous definition of COOP (LIC + ACQ) to form COOP (ALL) (mean = .41).

Commercialization environment measures. Our analysis relates these cooperation measures to variables associated with the strength of IPR, the costs of transacting with potential partners, and the role of sunk cost asymmetries.

We measure the strength of intellectual property in several distinct ways. For most of our analysis, we focus on whether the start-up innovator has received at least one patent associated with the technology (PATENT THRESHOLD = 1). While the mean number of project-specific patents across firms is just over six, less than two-thirds of the sample firms' projects possess at least one patent. To ensure that these measures reflect the commercialization environment at the time of the commercialization strategy choice, we are careful to check that the patents included in our sample are granted prior to the event of cooperation (either acquisition or the receipt of licensing revenues). In addition, we also have collected several more qualitative measures of the level of appropriability (in the spirit of Levin, *et al.* (1987)). Specifically, we asked each firm to rank several appropriability strategies on a five-point Likert scale, including the importance of patents (PATENT LIKERT) and trade secrecy (SECRECY LIKERT).

By construction, the sample is (approximately) equally divided between exclusively VC-backed firms ($VC = 1$) and SBIR-funded firms ($VC = 0$). This feature allows us to compare the commercialization strategies of firms differing in relative costs of negotiating cooperative agreements with more established firms. While we use the VC dummy in most of the analysis, we also employ an alternative dummy measure, EVER VENTURE FUNDED, which groups together firms for which $VC = 1$ and firms initially funded by the SBIR which received some form of venture financing by the end of 1999.

Measuring the investment costs that entrants face in acquiring complementary assets necessary for effective competitive commercialization (relative to the costs associated with a cooperative strategy) is extremely difficult, especially in a cross-industry study. Because “objective” measures of relative investment costs are elusive (a problem not confined to the current study), we developed a set of five point Likert scales for our survey. Respondents rated the “importance and effectiveness of control” over key assets in earning returns from their innovation: manufacturing, distribution channels, brand development, and servicing. Based on our discussions in field interviews, we believe that respondents rated the importance of each complementary asset element depending on their perception of the relative attractiveness and cost-effectiveness of ownership of that element.

The empirical analysis uses two measures summarizing these survey responses. First, we defined CA LIKERT MAX as the maximum Likert score over the set of questions. The highest level of CA LIKERT MAX (i.e., CA LIKERT MAX = 5) suggests that the respondent perceived that ownership of at least *one* of the complementary assets elements was cost-effective for earning profits from the

innovation. As such, we define EXPENSIVE COMP ASSET OWNERSHIP as a dummy variable equal to one if CA LIKERT MAX is less than five. EXPENSIVE COMP ASSET OWNERSHIP = 1 reflects a perception by the respondent that ownership of relevant complementary assets would not be cost-effective relative to cooperation with pre-existing owners of those assets (mean = .32).

Firm-level control variables. A benefit of our survey-based data collection method is our ability to collect detailed firm- and project-level controls for use in the empirical analysis. To control for differences across firms in their resources and capabilities, we measure the pre-innovation size of firms with categorical variables related to INITIAL EMPLOYEE SIZE (while the mean number of initial employees is 25, we group these data into four size categories in the empirical work as the impact of size may vary across its distribution). Two additional variables measure differences among firms in their overall commercialization orientation and strategy. PHD EMP SHARE is the share of firm employees with Ph.D. level training, and CEO FOUNDER is a dummy variable indicating whether the founder of the firm has remained the CEO. Firms with a high PHD EMP SHARE might have specific objectives of avoiding direct entry into product markets, perhaps to maintain a “scientific” firm culture (Stern, 2000), while the presence of a CEO-founder may be associated with the presence of “empire-building” motives (Roberts, 1991).

Project-level control variables. We also define project-level controls to capture the timing and technological type of different innovations. TIME TO MARKET is the time in months from idea conception to first sale of the product. Projects requiring long development times, for example, might be commercialized more frequently via

cooperation due to firm resource constraints. Furthermore, YEAR OF PRODUCT INTRO (the year in which a product is initially commercialized) may also impact commercialization strategy, perhaps because of random time-varying market effects.

Finally, the *nature* of the technological innovation may also influence the firm's cooperative behavior. For example, radical innovations may result in more competitive behavior (Reinganum, 1983; Henderson, 1993). We include NOVEL SYSTEM INNOVATION and PRODUCT INNOVATION in the empirical analysis to control for the degree to which the innovation might be incompatible with the incumbent's current technology (for example, almost 40% of the innovations were recorded as "novel systems"). With this data overview in mind, we now turn to our analysis of how start-up commercialization strategy is impacted by the economic environment.

IV. Empirical Results

Our analysis proceeds in three steps. First, we review pairwise and cross-industry correlations to highlight the basic facts present in the data. Second, we present regression estimates relating commercialization strategy to the commercialization environment, exploring various control structures and alternative measures of key variables. Finally, we disaggregate the *form* of cooperation by separating the determinants of licensing and acquisition to examine the sensitivity of the results to our definition of cooperation.

Our analysis begins in Table 2 which reports the pairwise conditional means of the probability that COOP (LIC + ACQ) = 1 and each of the three key variables. The results are striking. Changes in each of the (binary) commercialization environment measures are associated with over a 70% increase in the probability of cooperation, in the

direction predicted by economic theory (each of these differences is statistically significant at the 5% level). For example, firms with at least one project-related patent are more than twice as likely to cooperate relative to those with no patents.

In addition, these variables relate to varying commercialization strategy choices across industrial sectors. The first panel of Figure B displays a scatter plot of the mean of project-level patenting for each industrial sector and the industry-specific probability of cooperation. Consistent with qualitative assessments of the differences across industries (Gans and Stern, 2001), industries with higher levels of project-level patenting are more likely to pursue a cooperative commercialization strategy. The second panel of Figure B reports an analogous result for the industry-specific mean of EXPENSIVE COMP ASSET OWNERSHIP. The probability of cooperation is highest in segments such as biotechnology where the relative costs of acquiring complementary assets are particularly high.⁹ While suggestive, these results do not control for project- and firm-level factors, and so we turn to a more systematic regression analysis.

Table 3 presents the principal binary probit results. For each specification, the dependent variable is the dummy cooperation measure COOP (LIC + ACQ). Inclusion of all three commercialization environment measures without additional controls shows that each is associated with cooperation, even controlling for the other two (including any two of the three also yields similar results). In addition to their statistical significance (at 5% for PATENT THRESHOLD, just below 5% for VC and EXPENSIVE COMP ASSET OWNERSHIP), the estimates in (3-1) suggest strong quantitative effects. A change in one of the three (indicator) variables at the means of the other variables is associated with

⁹ Note that the construction of the sample through matched VC and SBIR-funded firm pairs implies that the mean of VC will be constant across industrial segments.

a predicted change in the probability of cooperation by 23% (PATENT THRESHOLD), 17.3% (VC), and 18.4% (EXPENSIVE COMP ASSET OWNERSHIP).

So far, we have assumed that the commercialization environment variables are exogenous to the firm's commercialization strategy choice. While this seems reasonable for sunk asset costs associated with product market entry, the observed level of IPR and VC funding might be related to the firm's commercialization strategy. We therefore paid close attention to the sequence of commercialization events. Specifically, we checked that patent awards and external financing by VCs and the SBIR program preceded cooperation events. Of course, the sequencing of events does not make these variables predetermined, so the remainder of Table 3 exploits our detailed survey data to provide industry-, firm-, and project-level controls for omitted factors potentially correlated with commercialization strategy and the commercialization environment.

In (3-2), we include industry segment dummies, suggesting evidence for our key hypotheses in the within-industry variation of commercialization strategy. As well, the positive coefficient on BIOTECHNOLOGY suggests that some segments offer an extremely favorable environment for cooperation, above and beyond our commercialization environment measures.

We now turn to analyses addressing the chief "candidate" for potential bias: our inability to fully control for the underlying quality of projects. It is possible that PATENT THRESHOLD and VC-FUNDED are also associated with higher quality projects. We address this issue in three ways. First, we include several controls for the type of technology and the timing of product introduction (3-3). Neither the time from project conception to product introduction nor the type of technology impact

commercialization strategy; as well, our commercialization environment results remain effectively unchanged. While these results are in contrast to the prior (mostly theoretical) literature highlighting the importance of the pro-competitive effects of “radical” technologies, we do not overemphasize these findings, as the type of innovation is self-reported by each firm. Our main point is simply that our core results are robust to project-level measures of innovation “radicalness,” such as NOVEL SYSTEM INNOVATION. Second, we ran a number of specifications including measures of project-level “performance” as an explanatory variable in the cooperation probit, including, among others, TOTAL PROJECT REVENUES and 1998 PROJECT REVENUES. Of course, project-level performance measures are endogenous to chosen commercialization strategy (and so we do not report these results formally). However, it is interesting to note that (a) measures of project-level performance are positively correlated with COOP (LIC+ACQ) and (b) inclusion of project-level performance measures substantially *strengthens* each of the commercialization environment estimates. Our results are therefore robust to the inclusion of measures of realized project quality.

Finally, conflating strong IPR or association with VCs with “high-quality” projects likely reduces the power of our empirical work to detect the impact of the commercialization environment. Suppose that control of IP (or association with VCs) is simply proxying for “high-quality” or “radical” projects. Most earlier research would then suggest that our measures of the commercialization environment would be associated with higher rates of independent product market entry (Foster, 1986; Christensen, 1997), implying that our empirical work is providing a *lower* bound on the impact of the commercialization environment measures.

Additional potential sources of unobserved differences exist at the firm level. Specifically, firms may differ in the resources available for commercialization or in their overall corporate strategy (beyond the specific project included in our sample). In (3-4), we include controls for initial firm size (divided into categories since preliminary empirical analysis suggested the relationship may be nonlinear). Interestingly, relative to firms with the largest initial sizes in our sample (the excluded category), smaller firms are not significantly more likely to cooperate (indeed, the estimates for each of the included categories is negative). In the final column of Table 3, we include all of our prior controls together as well as two additional firm-level controls, CEO FOUNDER and PHD-TRAINED EMPS. In line with our other findings, the commercialization environment variables continue to have similar predicted effects on commercialization strategy, with little evidence that the composition of employees or ownership impacts the probability of cooperation.

By simultaneously including industry-, firm-, and project-level variables, we control for many potential sources of unobserved heterogeneity in the data. As well, we ran a wide number of additional specifications to establish robustness of the key results. In addition, we experimented with an instrumental variables procedure where, for firm j , we instrument for PATENT THRESHOLD with the average, excluding firm j , of PATENTS and PATENT LIKERT in firm j 's industry segment. While the results on the complementary asset variables tend to be reduced in significance, our results regarding the role of IPR and VC-FUNDED continue to be robust.¹⁰

¹⁰ We do not separately report these results since the essential empirical relationship is highlighted in Figure B (which suggests that the substantial cross-industry variation in the rate of cooperation is related to the variation in the commercialization environment across sectors).

Taken together, we interpret these results as providing support for a model in which start-up innovators earn their returns on innovation through the market for ideas when the environment offers a strong intellectual property regime, and, at the same time, the start-up faces high relative costs in acquiring and controlling key complementary assets necessary for commercialization success. As imperfections arise in the market for ideas (e.g., through increases in the expropriation hazard), start-up innovators are more likely to pursue competitive strategies, which in turn contribute to the gale of creative destruction.

Alternative Measures. In Table 4, we document the robustness of our core results to alternative measures of the key variables. This is particularly important in the context of exploring a novel dataset in which we had some latitude in defining the variables used in the analysis. In (4-1) and (4-2), we employ Likert-based measures of strength in the IPR regime, PATENT LIKERT and SECRECY LIKERT. While the results are indeed robust to PATENT LIKERT, the SECRECY LIKERT measure, when used as the sole proxy for IP regime weakens the result (though VC-FUNDED and EXP. COMP ASSET OWNERSHIP remain significant). This is consistent with the role that *formal* IPR may place in reducing the transaction costs associated with cooperation. When PATENT THRESHOLD is included with SECRECY LIKERT (equation 4-2), the former variable is significant (as are our other core results). While PATENT THRESHOLD and PATENT LIKERT do have interpretational problems,¹¹ the robust relationship between each and COOP (LIC + ACQ) provides support for one of our key hypotheses: stronger IPR is positively associated with cooperation between start-up entrants and incumbents.

¹¹ For example, PATENT THRESHOLD might be proxying for quality while it is difficult to ensure comparability from Likert-based survey responses.

Next, we vary the measure of external project funding in equation (4-3) to include projects that have *ever* been funded by venture capital. EVER VENTURE-FUNDED is a variable that includes SBIR-backed firms that went on to receive VC funding by the beginning of 1999. This variable captures the idea that entrants associated at any time with VCs may face lower transaction costs in transacting with established firms. Each of the key variables remains robust to the inclusion of this measure. Our results are also robust to an alternate measure of the complementary asset regime. CA LIKERT MAX, the maximum value of the set of Likert measures of the importance of complementary assets in earning returns from the firm's innovation, is marginally significant at the 10% level (4-4), suggesting that the absence of cost-effective competitive commercialization investments makes cooperation more likely.

Finally, recognizing that the definition of cooperation itself is subject to interpretation, (4-5) includes a broader definition (COOP), which adds firms with HI ALLIANCES = 1 to the set of cooperators in the sample. Though the magnitude and significance of VC-FUNDED is modestly reduced, our results regarding PATENT THRESHOLD and EXP. COMP ASSET OWNERSHIP remain unchanged.

Form of Cooperation. We conclude the empirical analysis by “unbundling” the COOP (LIC + ACQ) measure to explore whether an alternate definition alters our results. Table 5 shows the results of multinomial logits using a dependent variable of LICENSED or ACQUIRED (the default commercialization choice is “compete”). Disaggregating the dependent variable in this way yields additional insight into the nature of cooperation. In equation (5-1), note that licensing behavior is associated with the IPR and complementary asset regimes, whereas acquisitions are associated with VC funding. The

final regression, (5-2), includes industry dummies, which do not alter the PATENT THRESHOLD or VC-FUNDED effects, but weakens the EXP. COMP ASSET OWNERSHIP result (to just below the 10% significance level). Since the parameters for each type of cooperation are not statistically different than each other, the differences between the forms of cooperation are only suggestive. However, the fact that licensing is more strongly associated with the presence of patents reinforces our hypothesis that IPR may be important both for reducing the risk of expropriation and reducing the transactional costs of bargaining over the legal ownership of technologies. Similarly, the presence of VCs seems particularly salient for facilitating acquisition rather than licensing or competition activity.

V. Discussion and Conclusions

In economic environments such as those observed in the biotechnology industry, where patents are relatively effective in protecting IPR, firms face high relative investment costs, and brokers are available to facilitate trade, start-up innovators tend to earn their returns from innovation through the market for ideas, acting as an upstream supplier of “technology” rather than as a horizontal innovation-oriented competitor. In contrast, when investment costs for the entrant are relatively low and the technological innovation is not protected by patents, as in the disk drive industry, the severe disclosure threat tends to foreclose the ideas market. Start-up innovators in this environment are more likely to commercialize their innovations through product market competition.

We found empirical support for these ideas by directly gathering data about start-up commercialization strategy. Perhaps most strikingly, firms who control IPR are more

likely to pursue a cooperative strategy. These results suggest that the role of intellectual property on the competitiveness of product markets is subtle. While most prior work emphasizes how IPR increase the absolute returns to innovation, our evidence is consistent with a more nuanced idea – IPR impacts the *relative* returns to cooperation by facilitating the market for ideas.

Our study is not without limitations. First, the empirical measures may be imperfect in capturing the key concepts from economic theory. The results are robust, however, to alternative measures of both cooperation and the start-up's commercialization environment, increasing our confidence in the results. Second, our measures of the commercialization environment may be endogenous. We addressed this issue in two ways: (1) the sample was constructed so as to include only pre-existing patent and external funding events relative to cooperation events; and (2) we include detailed controls to limit the risk of omitting variables that may be correlated with both the start-up's commercialization strategy and its commercialization environment. Finally, the control of IPR or association with VCs may be correlated with underlying project quality. Our results are, however, robust to controls for both the type and size of innovation. Indeed, cooperation is positively associated with a revenue-based measure of the realized commercial returns from the project. Whereas most earlier research assumes or suggests that product market entry and competition would be associated with projects with higher quality (Christensen, 1997), our findings suggest that projects able to obtain IPR, funded by venture capitalists, and associated with higher revenues are all more likely to be commercialized through *cooperation*.

These findings suggest several directions for further research. First, we plan to investigate commercialization strategies for both entrants and incumbents in “mixed” economic environments. For example, in environments where IPR are weak and a dominant incumbent would prefer to take advantage of the R&D productivity of smaller firms, established firms may be motivated to develop a reputation for “non-expropriation” in order to provide incentives for innovation and cooperation by start-ups. Indeed, Gawer (2000) finds qualitative evidence for this hypothesis in the semiconductor industry. Second, our findings suggest that venture capitalists play a non-financial role in the strategy of start-up firms. Identifying the mechanisms by which VCs facilitate transactions and whether they earn additional economic returns by doing so remains an additional area for further investigation.

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Figure A. Share of Revenues from Cooperation: Frequency Distribution

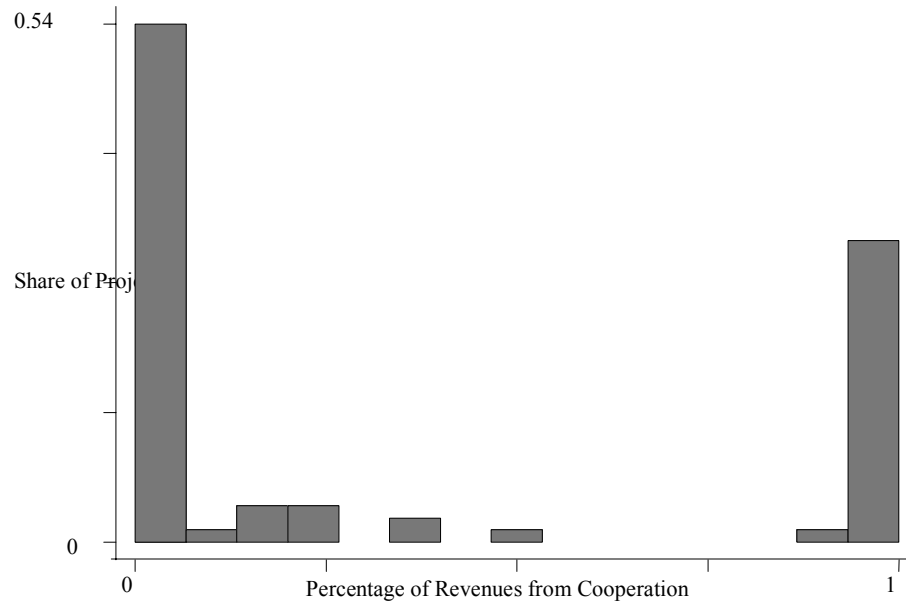


Figure B. Probability of Cooperation by Industry and Key Variables

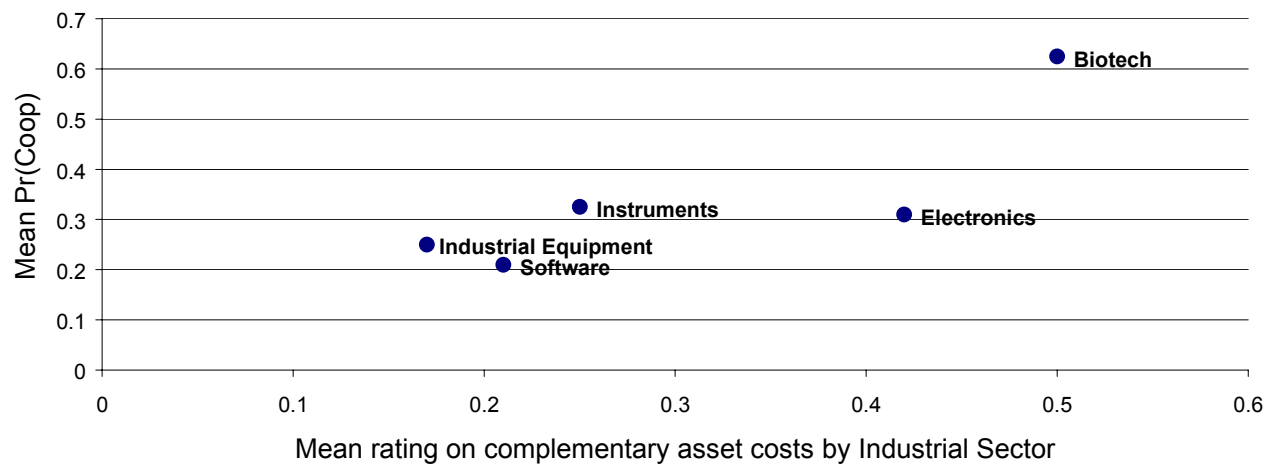
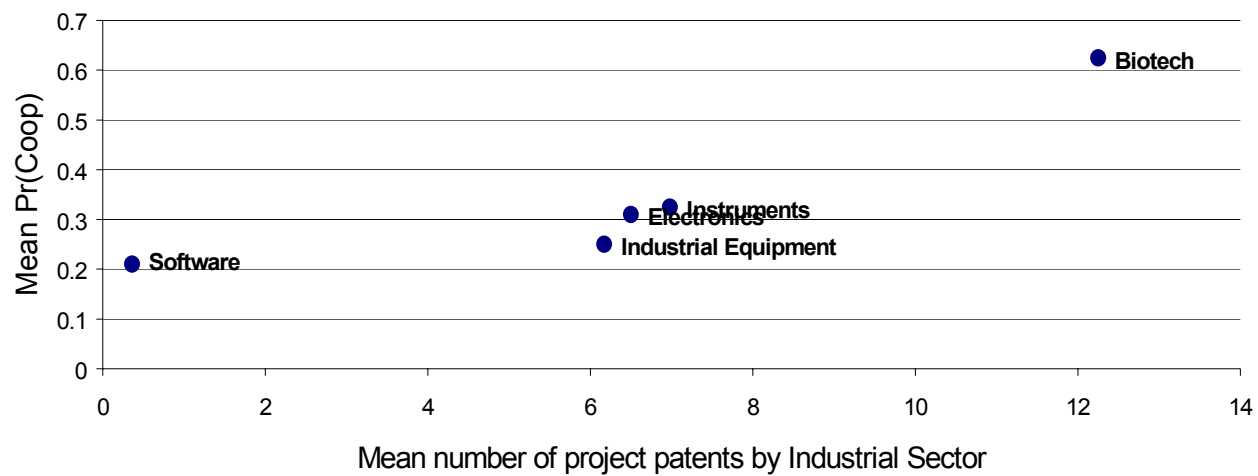


TABLE 1
VARIABLES & DEFINITIONS

<i>VARIABLE</i>	<i>DEFINITION</i>	<i>MEAN</i>	<i>STD. DEV.</i>	<i>SOURCE</i>
COOPERATION DUMMIES				
LICENSED	Dummy =1 if licensing revenues > 0	0.220	0.416	MIT Survey
ACQUIRED	Dummy=1 if firm acquired since project initiation	0.144	0.353	MIT Survey
HI ALLIANCES	Dummy = 1 if firm' strategic alliance activity is in the top ten percent	0.110	0.314	MIT Survey
COOP (LIC + ACQ)	Dummy=1 if LICENSED=1 <i>or</i> ACQUIRED=1	0.339	0.475	Authors Calc
COOP (ALL)	Dummy = 1 if LICENSED = 1 <i>or</i> ACQUIRED = 1 <i>or</i> HI ALLIANCES = 1	0.407	0.493	Authors Calculation
APPROPRIABILITY MEASURES				
PROJECT PATENTS	# patents associated with project	6.678	14.189	MIT Survey, USPTO
PATENT THRESHOLD	Dummy = 1 if at least one patent has been granted to this project	0.653	0.478	MIT Survey, USPTO
PATENT LIKERT	5-Point Likert scale rating of importance of patents for appropriating returns	3.475	1.478	MIT Survey
SECRECY LIKERT	5-Point Likert scale rating of importance of trade secrecy for appropriating returns	3.678	1.371	MIT Survey
FUNDING SOURCE MEASURE				
VC-FUNDED	Dummy = 1 if project is initially VC-funded	0.466	0.501	MIT Survey, Venture Econ
COMPLEMENTARY ASSET MEASURES				
CA LIKERT MAX	Max over 5-point Likert scales measuring the <i>importance and effectiveness of ownership</i> of complementary assets (Branding, Manufacturing, Distribution, & Service).	4.627	0.596	MIT Survey
EXPENSIVE COMP ASSET OWNERSHIP	Dummy = 1 if CA LIKERT MAX < 5	0.322	0.469	MIT Survey
FIRM-LEVEL CONTROLS				
INIT. EMPLOYEES	# of employees at project initiation	25.481	43.662	MIT Survey
CEO FOUNDER	Dummy = 1 if current CEO is firm founder	0.598	0.492	MIT Survey
PHD EMP SHARE	Share of employees with Ph.D. education	0.142	0.177	MIT Survey
INDUSTRY SEGMENTS	Dummy variable for primary SIC industrial segment: biotechnology, industrial equipment, instruments, and software			Corptech Directory
PROJECT-LEVEL CONTROLS				
TIME TO MARKET	Time in months from conception of product idea to first sale	44.925	49.068	MIT Survey
YEAR OF PRODUCT INTRO	First year in which product was introduced for commercial sale	92.492	4.644	MIT Survey
PRODUCT INNOVATION	Dummy = 1 if the project results in a product innovation	0.678	0.469	MIT Survey
NOVEL SYSTEM INNOVATION	Dummy = 1 if the project results in a novel overall system	0.373	0.486	MIT Survey
MASS-PRODUCED PRODUCT	Dummy = 1 if the technology requires mass production	0.636	0.483	MIT Survey

TABLE 2
PROBABILITY OF COOPERATION BY
COMMERCIALIZATION ENVIRONMENT

	PATENT THRESHOLD		VC FUNDED		EXPENSIVE COMP ASSET OWNERSHIP	
	= 0	= 1	= 0	= 1	= 0	= 1
COOP (LIC + ACQ) = 1	0.20	0.42	0.25	0.44	0.28	0.47
t-stat for equality of means	2.45		2.15		2.11	

TABLE 3
COOPERATION PROBITS

	Dependent Variable = COOP (LIC + ACQ)				
	N = 118 observations				
	(3-1) Baseline	(3-2) (3-1) w/ industrial segments	(3-3) (3-2) w/ project & firm controls	(3-4) (3-1) w/ initial employee size	(3-5) (3-1) w/ all segment, project & firm controls
PATENT THRESHOLD	0.684 (0.273)	0.674 (0.292)	0.636 (0.298)	0.645 (0.278)	0.647 (0.317)
VC-FUNDED	0.481 (0.250)	0.553 (0.261)	0.589 (0.272)	0.478 (0.262)	0.730 (0.309)
EXP. COMP ASSET OWNERSHIP	0.497 (0.262)	0.458 (0.273)	0.513 (0.286)	0.491 (0.273)	0.499 (0.303)
INDUSTRY SEGMENTS (DEFAULT = ELECTRONIC EQUIPMENT)					
BIOTECHNOLOGY		0.862 (0.405)	1.043 (0.497)		0.895 (0.537)
INDUSTRIAL EQUIPMENT		-0.179 (0.492)	-0.160 (0.505)		-0.108 (0.545)
INSTRUMENTS		0.209 (0.323)	0.069 (0.343)		0.015 (0.356)
SOFTWARE		0.141 (0.468)	0.042 (0.035)		-0.054 (0.556)
FIRM-LEVEL CONTROLS					
CEO FOUNDER					-0.194 (0.275)
INIT. EMPS (1-2)				-0.261 (0.581)	-0.195 (0.641)
INIT. EMPS (3-10)				-0.518 (0.510)	-0.543 (0.573)
INIT. EMPS (11-74)				-0.177 (0.499)	-0.075 (0.560)
PHD EMP SHARE					0.014 (0.010)
PRODUCT-LEVEL CONTROLS					
TIME TO MARKET			0.001 (0.003)		-0.001 (0.003)
YEAR OF PRODUCT INTRODUCTION			-0.043 (0.035)		-0.051 (0.036)
PRODUCT INNOVATION			0.178 (0.313)		0.203 (0.334)
NOVEL SYSTEM INNOVATION			-0.140 (0.285)		-0.157 (0.302)
MASS-PRODUCED PRODUCT					-0.127 (0.321)
CONSTANT	-1.288 (0.280)	-1.503 (0.377)	2.433 (3.149)	-0.938 (0.526)	3.523 (3.294)
LL	-68.338	-65.511	-64.248	-67.107	-61.760

TABLE 4
ALTERNATIVE MEASURES OF IP, VC, CA, AND COOPERATION:
COOPERATION PROBITS

	Dependent Variable = COOP (LIC + ACQ)				
	(4-1) PATENT LIKERT measure for IP strength	(4-2) (3-1) including Secrecy Likert	(4-3) Varying VC definition	(4-4) CA LIKERT MAX as measure of comp asset importance	(4-5) Dep Var = COOP (ALL)
PATENT THRESHOLD		0.711 (0.276)	0.602 (0.274)	0.651 (0.272)	0.721 (0.264)
PATENT LIKERT	0.208 (0.103)				
SECRECY LIKERT		0.084 (0.096)			
VC-FUNDED	0.487 (0.249)	0.492 (0.251)		0.497 (0.249)	0.395 (0.245)
EVER VENTURE-FUNDED			0.525 (0.257)		
EXP. COMP ASSET OWNERSHIP	1.452 (0.785)	0.529 (0.265)	0.514 (0.261)		0.537 (0.259)
CA LIKERT MAX				-0.328 (0.202)	
EXP. COMP ASSET * PATENT LIKERT	-0.275 (0.199)				
CONSTANT	-1.537 (0.420)	-1.637 (0.491)	-0.793 (0.279)	0.409 (0.982)	-1.087 (0.267)
LL (N = 118)	-69.429	-67.943	-68.082	-68.824	-72.262

TABLE 5
COOPERATION MULTINOMIAL LOGITS

	Dependent Variable = LICENSED or ACQUIRED (DEFAULT = COMPETE) N = 118 observations			
	(5-1)		(5-2)	
	LICENSED = 1	ACQUIRED = 1	LICENSED = 1	ACQUIRED = 1
PATENT THRESHOLD	1.660 (0.674)	0.719 (0.610)	1.667 (0.771)	0.603 (0.629)
VC-FUNDED	0.358 (0.505)	1.587 (0.626)	0.475 (0.538)	1.684 (0.647)
EXP. COMP ASSET OWNERSHIP	1.001 (0.512)	0.602 (0.582)	0.868 (0.541)	0.724 (0.625)
INDUSTRY EFFECTS			Insig.	Insig.
CONSTANT	-2.974 (0.715)	-3.125 (0.735)	-3.019 (0.861)	-3.972 (0.975)
Log Likelihood	-92.826		-86.543	

Appendix A: A Simple Model of Commercialization Strategy

This simple model formalizes our key comparative statics. Consider a start-up innovator, E , who has successfully developed a commercializable innovation, and faces a choice between the competitive and cooperative strategy. Monopoly profits are denoted π^m , while E and I both earn π^c under the competitive strategy. Sunk costs are incurred by the start-up under either strategy. To compete, E must invest K (to create the relevant complementary assets), while undertaking the cooperative strategy involves a transaction cost, c , associated with bargaining with I . Since these costs are irreversible, E compares expected profits associated with each path in choosing its commercialization strategy.

Figure C illustrates the model. Regardless of its strategy, E faces a risk that I imitates the innovation. If E competes, I may imitate E 's innovation with probability $1-p_r$, but, with probability θ , E successfully enforces its IPR. Therefore, with probability $(1-p_r)(1-\theta)$, I commercializes an imitative technology. For simplicity, we assume that successful commercial imitation by I raises I 's profits by Δ and reduces E 's by a similar amount, leaving industry profits unchanged.¹² By choosing to compete, E earns expected profits of $\pi^c - \Delta(1-p_r)(1-\theta) - K$, which are increasing in the strength of IPR (θ).

Under the cooperative strategy, E 's return is determined through the outcome of a bargaining game with I , which involves a potential “expropriation” hazard. When E negotiates with I , I imitates the innovation with probability $1-p_d$, but as in the competition setting, E can enforce its IPR with probability θ . For simplicity, we assume that θ governs the strength of IPR under both the competition and cooperation strategies,¹³ and that the impact of expropriation by I is to increase its potential product market profits by Δ and reduce E 's by a similar amount. As such, E faces a risk, with probability $(1-\theta)(1-p_d)$, that I commercializes an imitative technology in the event negotiations break down.

The possibility of expropriation impacts the expected outcome of negotiations between E and I . Allowing the bargaining outcome – that is, the transfer (τ) from I to E – to be determined by the Nash bargaining solution (as in Aghion and Tirole, 1994), each party “splits” the gains from trade. E 's profits in the absence of expropriation is equal to:

$$\underbrace{\tau - (\pi^c - \Delta(1-p_r)(1-\theta) - K)}_{E's \text{ Net Return}} = \underbrace{\pi^m - \tau - \pi^c - \Delta(1-p_r)(1-\theta)}_{I's \text{ Net Return}} \Rightarrow \tau = \frac{1}{2}(\pi^m - K) - \Delta(1-p_r)(1-\theta).$$

On the other hand, expropriation by I reduces the share of the monopoly profits E expects to receive. Expropriation by I does not entirely eliminate E 's rents since (a) E can still credibly threaten to reduce I 's profits by competing in the product market (Anton and

¹² Expropriation may also change the level of industry profits. However, several illustrative models suggest that as long as imitation does not decrease total industry profits too much, our comparative statics are unchanged. As well, the bargaining game can be enriched considerably to incorporate the incumbent's ability to invest in expropriation during the bargaining process (Gans and Stern, 2000a).

¹³ Our comparative statics hold as long as the probability of enforcement under each regime is impacted similarly by changes in factors such as the ease and scope of patent protection or the availability of legal remedies against IP infringement.

Yao, 1994; 1995) and (b) E may be able to enforce its IPR with probability θ . However, relative to payoffs in the absence of expropriation, disclosure increases I 's potential competitive position (and similarly decreases E 's position). As such, using the same bargaining rule as above, E 's share under expropriation, $\underline{\tau}$, will equate:

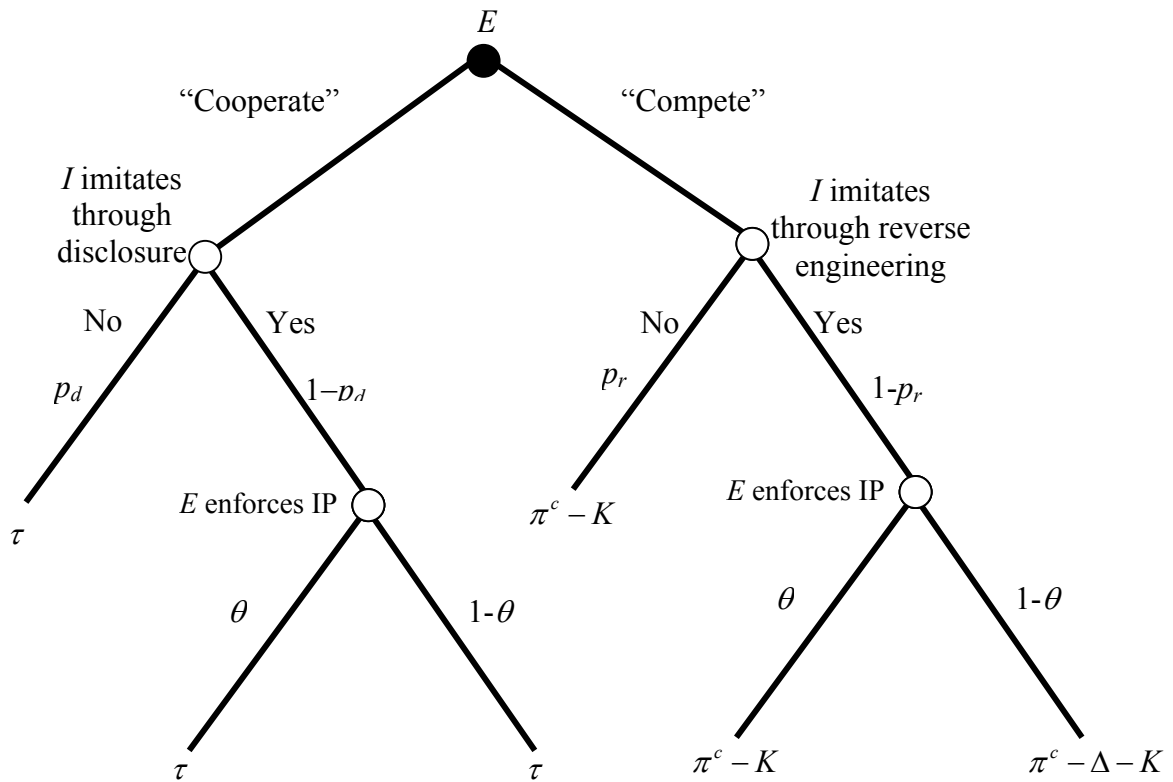
$$\underbrace{\underline{\tau} - (\pi^c - K - \Delta(1 - \theta))}_{E's \text{ Net Return}} = \underbrace{\pi^m - \underline{\tau} - (\pi^c + \Delta(1 - \theta))}_{I's \text{ Net Return}} \Rightarrow \underline{\tau} = \frac{1}{2}(\pi^m - K) - \Delta(1 - \theta).$$

Since E chooses to cooperate as long as

$$p_d \tau + (1 - p_d) \underline{\tau} - c \geq \pi^c - \Delta(1 - p_r)(1 - \theta) - K \Rightarrow \frac{1}{2} \pi^m - \Delta p_r (1 - p_d)(1 - \theta) - c \geq \pi^c - \frac{1}{2} K$$

E is more likely to choose cooperation as K rises, c falls, θ rises or Δ falls. Cooperation is more likely when the sunk costs of product market entry are high relative to the costs of transacting with established firms. As well, since the start-up's bargaining outcome is equal to its *absolute* return under competition plus a fraction of the *surplus* associated with cooperation, an increase in the strength of IPR (through an increase in θ or a decrease in Δ) increases the *relative* return to cooperation over competition. The returns to cooperation are increasing in θ because the bargaining process that internalizes E 's ability to threaten I with competitive entry.

Figure C. Start-Up Choices and Payoffs



**APPENDIX B: MIT SLOAN SCHOOL
COMMERCIALIZATION STRATEGIES SURVEY**

Principal Investigator: Professor Scott Stern, MIT Sloan School & NBER

Researchers: David Hsu, MIT; Joshua Gans, University of Melbourne

The goal of this project is to evaluate how companies commercialize innovative new technologies. We are exploring different commercialization strategies and how success at a technical level affects firm strategy.

Enclosed is a survey, which asks you to describe the circumstances surrounding a specific innovative project or initiative. We would like to focus on your firm's involvement in its main business area. Within that frame, please choose a research and/or development project which is internally perceived as an important source of value for your firm. We would like you to choose a project which provided direct financial returns for the firm, through direct sales, licensing agreements, or in strengthening the bargaining position of the firm.

Once the project is chosen, the survey is divided into two parts:

- General background of your company
- Commercialization history of the innovation

Participation in this study is entirely *voluntary*, and you can decline to answer any questions or decline further participation at any time. The survey should take no more than 25 minutes to complete. Responses will be kept both **confidential** and **anonymous**. Please return this survey and direct inquiries to:

Professor Scott Stern
MIT Sloan School
E52-554
Cambridge, MA 02142
TEL: 617-253-5219
FAX: 617-253-2660
e-mail: sstern@mit.edu

Thank you for your participation!

Number of patents issued directly related to this technology: _____

Number of patents issued to your organization since founding: _____

Please check the terms which best describe this technology:

Assembled Non-Assembled

Please check the terms which best describe the innovation (check all that apply):

- Product Innovation
 Process Innovation
 Novel components within a relatively standard system
 Novel overall system

What year was the product's first commercial introduction? 19_____

Time from conception of technology to first prototype: _____ months

Time from prototype to first sale: _____ months

Financing history of this project:

Year	Source	Amount
------	--------	--------

For this project, what activities did the following actors facilitate?

	venture capitalist	angel investor	other board members	legal counsel
Locating key personnel such as managers and technologists	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Locating sources of additional capital	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Gaining access to critical technologies	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Increasing the firm's focus on a small number of projects, technologies, or markets	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Locating and arranging introductions with potential alliance partners	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Participating in discussions over licensing and commercialization strategies	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Other (specify)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

What are the sources of revenue (on a percentage basis) associated with this technology?

Sales	Licensing Revenue	Intellectual Property
_____%	_____%	Asset Sale
		_____%

Share of revenues of this project from government contracts: _____%

What is the number of distinct customers for this project?:

< 10 10 - 100 101 - 500 > 500

Form of sales (check all that apply):

made to order mass produced mass customized

Total sales of the product

Sales attributable to this product in 1998?	\$ _____
Sales attributable to this product since the inception of this project?	\$ _____

Has your firm been acquired since the development of this technology? Yes No

If so, by whom? _____

Does the new firm (after the merger) have more than 500 employees? Yes No

Why did your company decide to undergo an acquisition? _____

Has the product been substantially modified/upgraded since development of the first working prototype?

No Yes; If yes, please describe the modifications: _____

If this technology resulted in licensing revenues,

What was the first year in which the technology was licensed?	19_____
What was the licensing revenue? 1998 \$ _____	Total \$ _____
What were the terms? <input type="checkbox"/> Exclusive	<input type="checkbox"/> Non-Exclusive

Were other technologies bundled in the license? Yes No

Who were the licensees? (mark all that apply)

Product Market Incumbents Product Market Entrants
 Government Agencies Non-market agents (e.g., universities)

Why did your company decide to license-out this technology? _____

Please rate the importance of the strategic goals this technology enabled for your company:

	LOW			HIGH		
Attraction of venture capital or outside funding	N/A	1	2	3	4	5
Attraction of scientists or other employees	N/A	1	2	3	4	5
Enable further government grants	N/A	1	2	3	4	5
Provided visibility of the company to customers or suppliers	N/A	1	2	3	4	5
Was an important factor for the firm getting acquired	N/A	1	2	3	4	5

Who were the key personnel involved in formulating the commercialization strategy for this product?

- CEO Technology/R&D Manager Marketing and sales manager

You mentioned before that the project's first prototype was developed around 19___. From that time onwards, your success with this technology likely depended, at least in part, on your control of resources which were not directly linked to the technology itself and on your ability to protect the innovation from imitation by others through intellectual property protection. Let's first consider how important your firm's control over resources has been in earning profits from this innovation. For each factor below, rate the importance over access and control of this resource on a scale from 1 to 5. A rating of "5" would mean that control over this resource was critical for earning profits from this innovation while a "1" would imply that control over this resource was not important at all.

	LOW			HIGH		
The capability to manufacture the product	1	2	3	4	5	
The principal distribution channels for the technology	1	2	3	4	5	
The association of the technology with a well-known brand name or the development of a brand name for the product through marketing or advertising	1	2	3	4	5	
Control over the sales force and servicing resources for this product or technology	1	2	3	4	5	

Now, let's turn to your ability to protect the innovation from imitation by others through intellectual property protection. For each factor below, rate the effectiveness of each factor in deterring imitation of the technology on a scale from 1 to 5. A rating of "5" would mean that this factor was very effective in deterring imitation of the technology while a rating of "1" implies that this factor had no impact on your ability to deter imitation.

	LOW			HIGH		
Trade secrecy	1	2	3	4	5	
Patents & copyright protection	1	2	3	4	5	
Active patent or copyright litigation	1	2	3	4	5	

What activities were involved in the process of commercializing this technology and deciding how to earn returns from the innovation?

- Took an outside offer for purchasing the rights to the technology
 Shopped the technology around but was unable to sell a license to the technology
 Shopped the technology around and sold a license to the technology
 Did not shop the technology: Always had the intention of competing with the technology
 Other: _____