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Universities as Research Partners

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Abstract

Universities are a key institution in the U.S. innovation system, and an important aspect of university involvement is the role universities play in private-public partnering activities. This study seeks to gain a better understanding of the performance of university-industry research partnerships by using a survey of a sample of pre-commercial research projects funded by the U.S. Advanced Technology Program (ATP). Although results must be interpreted cautiously because of the small sample size, the study finds that projects with university involvement tend to be in areas involving "new" science and therefore the projects may experience more difficulty and delay but also are more likely to end successfully. This finding implies that universities are contributing to basic research awareness and insight among the partners in ATP-funded projects.

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Executive Summary

This study examines the contributions by university scientists who collaborate in industry research funded by the Advanced Technology Program (ATP). Interviews were held with responsible officers from the industrial firms that had participated in the ATP research. In general, universities are more likely to be invited to participate as partners or as subcontractors in research into "new" science; that is, research that is expected to be difficult because it is intended to broaden the frontiers of knowledge. Projects with university involvement experience more difficulty and delay, presumably because the projects are more ambitious technically. The projects also are less likely to be aborted in failure. When compared with joint venture projects, single company applicant projects without university participation are more likely to have difficulty in accomplishing the technical goals, and thus are more likely to be aborted. Caution must be used in generalizing the findings of this exploratory inquiry because of the small sample size.

Background

Industry-university research collaboration has been increasing for several decades. As several earlier studies showed, there are more research joint ventures, more joint R&D centers (up 60 percent in the 1980s), and more members of science faculties who wish to work with industry. Business often wants access to particular faculty members or to research that is complementary to their own research. University faculty and administrators welcome the money they expect from the collaboration. For universities, the disadvantages may be diversion from teaching, the conflict between industrial secrecy and traditional academic openness, and the intramural friction that can arise when some departments or schools receive sizeable funding.

Issues

The survey was designed to explore three questions:

- What roles do universities play in research partnerships?
- Do universities enhance the research efficiency of research partnerships?
- Do universities affect the development and commercialization of industrial technology?

Method

New data at the project level were collected from a sample of ATP-funded research projects, some projects with university collaboration and some without. (This approach, however, will not yield a complete picture of university-industry collaborations because projects receiving ATP financial assistance are only a small subset.) ATP-funded projects are more likely to be perceived as having high social value, being generally riskier, involving generic technology, and at such an early stage of development that the technology is not easily appropriable. From April 1991 through October 1997 ATP funded 352 projects. This population was winnowed to a sample of 54 after various criteria were applied. Forty-seven of the 54 contact persons responded to the inquiry. Twenty-nine were involved in joint venture projects, of which 21 had university involvement. Eighteen were involved in single company applicant projects, of which nine had university participation, and the rest had universities involved as subcontractors. In all there were 12 information technology, 12 biotechnology, 9 materials, 6 manufacturing, 3 electronics, 1 energy and environment, and 4 chemicals (and other continuous manufacturing) projects.

Role of University

In ATP-funded joint venture projects, universities participate as partners or as subcontractors. In ATP-funded single company applicant projects, universities participate as subcontractors only.

Difficulty in Acquiring Knowledge

Respondents with a university participant were more likely to report difficulty in acquiring and assimilating basic knowledge needed for progress toward the project's goal. These projects may be closer to "new" science and that may be the reason universities were invited to participate in the first place. The industrial contact people also indicated that experience working with a university diminished the difficulty of acquiring new knowledge. Larger projects had less difficulty. Projects in the electronics area experienced substantially more difficulty.

Research Efficiencies

Project contact persons were asked several questions to explore whether the presence of university personnel was associated with greater efficiency: Were more research problems encountered—conceptual, equipment, or personnel-related—than were expected, and how many? What percent of research time, in retrospect, was unproductive? What percent of financial resources was unproductive? No clear pattern with respect to universities emerged from the responses, except that when universities were subcontractors to joint ventures there were more personnel problems. But joint ventures with university partners were less likely to respond to the survey, so the picture remains murky.

As for unproductive use of time and money, electronics projects ranked highest and manufacturing lowest. Biotechnology projects reported less unproductive expenditures but more unproductive time. Larger firms that led projects did better in using time and money effectively—or at least that was how larger firms viewed their own efforts.

Accelerated Development and Commercialization

One question asked was whether projects with university participation were more likely to recognize new applications of the technology being developed and were more likely to develop and commercialize new technology sooner than expected. The responses indicated that university participation seemed to have no impact on the generation of new applications. However, the data also suggested that projects with larger ATP contributions were more likely to develop unanticipated applications. Projects with university participation, however, were less likely to finish sooner than expected, perhaps because the projects tended to focus on more ambitious research. Single company applicant projects were more optimistic than joint venture projects about finishing early, and the most optimistic were single company applicant projects with no university involvement. By sectors, research in information technology, chemicals, materials, and energy and the environment were more likely to commercialize sooner than expected, and manufacturing, electronics and biotechnology were less likely to commercialize sooner than expected.

Various potential misconceptions also were uncovered. Those who participated in projects in which universities took part experienced difficulties in acquiring and assimilating basic knowledge. It is true that university participation may create problems, but the opposite may be true: that having a university partner creates greater awareness of research problems. University participation, it was found, especially in ATP-funded projects, generally meant that the project would end successfully, albeit in a longer time span than projects without university participation. The other partners in the venture saw universities as taking on the role of ombudsman with the task of anticipating and explaining the complexities of the research. Additionally, projects with larger budgets take on research of a broader scope, and with larger budgets more personnel are needed. With more personnel more difficulties arise. However, projects with larger budgets also tend to focus energy on fundamental research rather than on pursuit of new applications of that research.

These conclusions should be taken with caution. They reflect only statistical associations—albeit robust ones—but not dispositive demonstrations of causality. There is no general theoretical foundation for research of this kind. The concepts are new and the survey questions are exploratory in construction. This study sets the stage for more research to be carried out on the general subject of universities as research partners before causal relationships and statistically significant results can be determined.

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1 Introduction

> The U.S. research and development enterprise finds itself in a wrenching period of change with the end of the Cold War, the globalization of the world economy and the drive to eliminate the federal deficit.... The U.S R&D establishment has now entered a pivotal phase of transition—one that will determine our nation's long-term capacity to make and exploit discoveries and innovations in critical areas, while providing world-class institutions, facilities, and education in science, mathematics, and engineering.
>
> R&D partnerships hold the key to meeting the challenge of transition that our nation now faces.... Over the next several years, participants in the U.S. R&D enterprise will have to continue experimenting with different types of partnerships to respond to the economic constraints, competitive pressures, and technological demands that are forcing adjustments across the board ... [and in response] industry is increasingly relying on partnerships with universities ....

This view by the Council on Competitiveness (1996, pp. 3–4) is not surprising. There are indications that industry-university research relationships have strengthened over the past few decades. For example, university participation in formal research joint ventures has increased steadily since the mid-1980s (Link, 1996), the number of industry-university R&D centers has increased by more than 60 percent during the 1980s (Cohen et al., 1997), and a recent survey of U.S. science faculty revealed that many desire even more partnership relationships with industry (Morgan, 1998). Mowery and Teece (1996, p. 111) contend that such growth in strategic alliances in R&D is indicative of a "broad restructuring of the U.S. national R&D system."

It is, however, surprising that little is known about the types of roles that universities play in research partnerships or about the economic consequences associated with those roles. Our investigation is a first effort to provide some empirical information about these issues.

What research there is on the topic of universities as research partners falls broadly into either examinations of industry motivations or of university motivations for engaging in an industry-university research relationship. The existing research has not investigated the economic effects associated with university participation as thoroughly, especially at the project level.

The literature has identified two broad *industry motivations* for engaging in an industry-university research relationship. The first is access to complementary research activity and research results.[1] Cohen et al. (1997) provide a selective review of this literature, emphasizing the studies that have documented that university research enhances firms' sales, R&D productivity, and patenting activity.[2] As Rosenberg and Nelson (1994, p. 340) note: "What university research most often does today is to stimulate and enhance the power of R&D done in industry, as contrasted with providing a substitute for it." Pavitt (1998) is more specific and concludes that academic research augments the capacity of businesses to solve complex problems. The second industry motivation is access to key university personnel.[3]

University motivations for partnering with industry seem to be financially based. Administration-based financial pressures are growing for faculty to engage in applied commercial research with industry.[4] Zeckhauser (1996, p. 12746), for example, is subtle when he refers to the supposed importance of industry-supported research to universities as he describes how such relationships might develop: "Information gifts [to industry] may be a part of [a university's] commercial courtship ritual." Along those same lines, Cohen et al. (1997, p. 177) contend that:[5] "University administrators appear to be interested chiefly in the revenue generated by relationships with industry." They are also of the opinion that faculty, who are fundamental to making such relationships work:[6] "… desire support, *per se*, because it contributes to their personal incomes [and] eminence … primarily through foundation research that provides the building blocks for other research and therefore tends to be widely cited."

On the other hand, several drawbacks to university involvement with industry have been identified, such as the diversion of faculty time and effort from teaching, the conflict between industrial trade secrecy and traditional academic openness, and the distorting effect of industry funding on the university budget allocation process (in particular, the tension induced when the distribution of resources is vastly unequal across departments and schools).

1. See Blumenthal et al. (1986), Jaffe (1989), Adams (1990), Berman (1990), Feller (1990), Mansfield (1991, 1992), Van de Ven (1993), Bonaccorsi and Piccaluga (1994), Klevorick et al. (1994), Zucker, Darby, and Armstrong (1994), Henderson, Jaffe, and Trajtenberg (1995), Mansfield and Lee (1996), Zeckhauser (1996), Campbell (1997), Cohen et al. (1997), and Baldwin and Link (1998).

2. Cockburn and Henderson (1997) show that it was important for innovative pharmaceutical firms to maintain ties to universities. Perhaps research ties with universities increase the "absorptive capacity," in the Cohen and Leventhal (1990) sense, of the innovative firms.

3. See Leyden and Link (1992) and Burnham (1997). Link (1995) documents that one reason for the growth of Research Triangle Park (North Carolina) was the desire of industrial research firms to locate near the triangle universities (University of North Carolina in Chapel Hill, North Carolina State University in Raleigh, and Duke University in Durham).

4. See Berman (1990), Feller (1990), Henderson et al. (1995), and Siegel, Waldman, and Link (1999).

5. Siegel et al. (1999) document that university administrators consider licensing and royalty revenues from industry as an important output from university technology transfer offices.

6. As an aside, while this argument is prevalent, the fact is that federal support to universities has increased over the past decade in real terms, from $10.6 billion dollars in 1990 to $14.1 billion dollars in 1999 (National Science Foundation/SRS, 1997).

The remainder of this paper is outlined as follows. In the second section we describe the sample of research partnerships studied. This sample comes from the population of research projects funded by the Advanced Technology Program (ATP) between 1991 and 1997. Our quantitative inquiry into the role of universities in research partnerships, based on survey data, is presented in the third section. We ask about the roles and effects of universities in research partnerships, and we provide descriptive information to answer each based on an analysis of university involvement in ATP-funded projects. Finally, in the last section we offer concluding observations in an effort to set the stage for future research in this area.

2 Analysis of the Data

No systematic data exist regarding universities as research partners at either the firm level or the project level. While general information can be gleaned about formal research joint ventures and university participation in them from the *Federal Register* (such information is filed in accordance with the National Cooperative Research Act of 1984), it is insufficient for a detailed investigation of universities as research partners.[7] We preferred project-level data. One source of project-level data is the ATP.

As background, ATP was established within the National Institute of Standards and Technology (NIST) by the Omnibus Trade and Competitiveness Act of 1988,[8] and was modified by the American Technology Preeminence Act of 1991. The goals of ATP, as stated in its enabling legislation, are to assist U.S. businesses in creating and applying the generic technology and research results necessary to (a) commercialize significant new scientific discoveries and technologies rapidly and (b) refine manufacturing technologies.

These same goals were restated in the *Federal Register* on July 24, 1990: "The ATP . . . will assist U.S. businesses to improve their competitive position and promote U.S. economic growth by accelerating the development of a variety of pre-competitive generic technologies by means of grants and cooperative agreements." The ATP received its first appropriation from Congress in FY 1990.

Because ATP has a very particular set of goals, it is important to emphasize that studying ATP projects will not give a complete picture of the university-industry R&D interaction. When compared with a random sample of university-industry projects, the projects analyzed in this study are more likely to be perceived as having high social value, will generally be riskier, involve generic technology, and be at such an early stage in development that the technology is not easily appropriable. In spite of this qualification we feel it is worth obtaining a picture of this section of the public R&D infrastructure while keeping the nature of the selection process firmly in mind.

7. These data have been analyzed in Link (1996). See also Hagedoorn, Link, and Vonortas (2000).

8. This section of the Omnibus Trade and Competitiveness Act of 1988 is also known as the Technology Competitiveness Act.

THE POPULATION OF ATP-FUNDED PROJECTS

The ATP classifies each funded project by the size of the lead participant. Each lead participant is placed into one of four ATP-defined size categories. Not-for-profit organizations are designated as a size category; small is defined as an organization with fewer than 500 employees; large is defined as a *Fortune* 500 or equivalent organization (a moving definition; at the time of our analysis, a *Fortune* 500 had at least $2.578 billion in revenue); and medium organizations are all others. Small companies lead more than one-half of the projects, including single company applicant projects and joint venture projects. The following results present a snapshot of the projects awarded between 1991 and 1997 at the time of this study.

ATP awards presented from April 1991 through October 1997: 352; that is, 256 projects were active, 75 had been completed, 16 had been terminated for not meeting project goals, and 5 had been terminated during the negotiation stage before a cooperative agreement was signed.

Number of single company applicant projects: 234, with 54.7 percent involving a university as a subcontractor.

Number of joint venture projects: 118, with 60.2 percent involving a university either as a research partner or as a subcontractor.[9]

Mean total (ATP plus industry funding) proposed cost of funded projects: $6.59 million, with a range from $490,000 to $62.97 million. By statute, ATP's maximum contribution to single company applicant projects is $2 million in direct costs;[10] ATP's maximum contribution to joint venture projects cannot exceed 50 percent of total costs (direct and indirect costs). The mean project cost for a joint venture project is just over four times that of a single company applicant project: $13.24 million compared with $3.24 million.

Percent of total cost funded by ATP: 56.1 percent, with a range between 11.8 percent and 94.6 percent.[11] Average ATP contribution for joint venture projects is less than for single company applicant projects: 47.9 percent compared with 60.3 percent. Not only is the average level of ATP support, in percentage terms, less for joint venture projects but the range of that support is more narrow. The range for single company applicant projects is between 11.8 percent and 94.6 percent, compared with between 32.4 percent and the statutory 50.0 percent limit for joint venture projects.

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9. The generic term "partner" is being used to refer to a university-industry relationship where the university is either a subcontractor to a single company or to a joint venture or where the university is a research partner in a joint venture, which means that the university is a formal member of the joint venture. To refer to this latter case, we describe the university as a "research partner."

10. Since December 1997, single applicant, large company participants must provide for at least 60 percent of direct and indirect project costs.

11. Participants in joint venture projects must provide for at least half the total costs of the project while single applicant, non-large company, participants are at a minimum responsible for indirect costs.

Percent of ATP-funded projects: information/computer systems, 29 percent; biotechnology, 19 percent; materials,16 percent; electronics,12 percent; discrete manufacturing, 11 percent; chemicals and chemical processing, 7 percent; energy and the environment, 6 percent.

Involvement of universities as research partners, by type of project: biotechnology, 42 percent; discrete manufacturing, 39 percent; information/computer systems, 33 percent; and electronics, 7 percent. Other technology areas did not have university involvement.

Percent of funded projects expected to last three years or longer: 70 percent. (By statute, single company applicant projects cannot exceed three years, and joint venture projects cannot exceed five years.[12])

SELECTION OF A SAMPLE OF ATP-FUNDED PROJECTS

Samples were selected by using a series of filters, some under our control and others not. The process of selection is summarized in Table 1. Twenty-one projects terminated early and were therefore unavailable for sampling. (An analysis of the reasons for early termination is provided in the next section.) Each project must be active and must have been so for at least one year. *A priori*, we reasoned that these constraints would help to ensure the respondent's capability to rely on a research project history when answering the questions. These two filters reduced the population of 352 projects to 192 projects (see column 2 in Table 1).

These 192 projects were then grouped according to the six types of projects with/without university involvement listed in Table 1 (column 1). From each of the categorical groupings, a sample of nine projects was selected (column 4). Attention was also given in the selection of nine projects to technology areas, size of lead participant, length of time the project had been active, and the total proposed research budget of the projects. Also reported in Table 1 (column 5) are the sampling probabilities by type of university involvement.[13] This process of random stratified sampling yielded 54 projects.

Separate and distinct survey instruments were designed to obtain information about the nine projects selected in each of the six categories of type of university involvement.[14] The surveys were pre-tested with at least one lead participant of a project that could in principle have been included in the sample of nine but was not.

12. Expected project duration is agreed upon at the time ATP funds the project.
13. Variability in these probabilities reflects the fact that the sample size is constant at nine and that the size of the population of appropriate projects to sample, by category type, varies (column 4).
14. Copies of the survey instruments are in Appendix B.

Table 1. Distribution of ATP-Funded Projects by Type of University Involvement

(1) *Type of university involvement*	(2) *Number of projects*	(3) *Filtered projects*[a]	(4) *Sample projects*[b]	(5) *Sampling probability, percent*	(6) *Number responding*
Joint venture	118	81	36	44	29
No university involvement	47	31	9	29	8
Universities involved as subcontractor	42	28	9	32	8
Universities involved as research partner	16	11	9	82	8
Universities involved as both partner and subcontractor	13	11	9	82	5
Single applicant	234	111	18	16	18
No university involvement	106	45	9	20	9
Universities involved as a subcontractor	128	66	9	13	9
Total	352	192	54	28	47

a. Filtered projects are projects that were active one year or more and were still active in the beginning of 1998.

b. Sample projects were selected from the filtered project universe to ensure an equal number in each category. The projects are mutually exclusive.

The ATP provided the name of a contact person in each of the 54 companies who was then contacted by telephone, explained the nature of the study, asked to participate in a survey, and assured that specific responses would remain confidential and reported only in summary form. Each agreed to participate in the survey. The respective category-specific survey was sent to each respondent. Each non-respondent was re-contacted up to three times on a weekly basis and urged on each occasion to complete and return the survey. Table 1 (column 6) shows the number of surveys received by category of university involvement.[15] The sample for analysis became 47, as shown at the bottom of Table 1. Seven did not respond.

We emphasize, again, that we are aware of the limitations of the self-reported data that we analyzed. While our survey instruments were pre-tested, the possibility that our primary data

15. Because there are multiple dimensions of ATP-funded projects, we do not claim that our sample of 47 respondents is representative of the filtered population or of the whole population in all dimensions. We offer our sample as one sample to consider, and possibly to generalize about, given the stated filtering and selection process.

reflect the personal attitudes of the respondents as well as objective characterizations of their program is still present. Thus, efforts to generalize from our findings should be made with caution.

ANALYSIS OF TERMINATED PROJECTS IN THE POPULATION

Reasons for the early termination of the 21 projects were investigated and ranged from the financial health of the participant(s) to lack of research success in the early part of the project: 11 were joint venture projects, and 10 were single company applicant projects. Joint ventures represent 34 percent of the population of ATP-funded projects, but they are 52 percent of terminated projects. Thus, joint ventures appear to have a higher probability of termination than single company projects. Of the 11 joint ventures that were terminated, three included a university as a research partner and two others included a university as a subcontractor. Four of the single company applicant projects included a university as a subcontractor. Thus, 9 of the 21 terminated projects involved a university in some research capacity.

To consider in a more systematic manner the relationship between university involvement in an ATP-funded project and the probability that the project will terminate early, we estimated a probit model of termination probability conditional on ATP's share of funding, involvement of a university, type of project, size of the lead participant, and technology area. A time variable denoting the year in which each project was initially funded was also included.

To be precise, we estimated the following model:

$$\text{Pr (project } i \text{ terminates early)} = F(X_i \beta) \quad (1)$$

where F is the cumulative normal probability function and X_i is a vector of variables that characterizes project i.

> The probit model estimates the probability of an event as a function of explanatory variables. An unobserved indicator variable is a linear combination of the explanatory variables and random standard normal error. When the indicator variable exceeds zero, the event is observed. Thus, the observed response variable is dichotomous, taking the value zero or one. Given the specification of the unobserved indicator variable, the model allows maximum likelihood estimates of the parameters linking the explanatory variable to the probability of the event being studied (Maddala, 1983, pp. 22-23).

The probit estimates from alternative specifications of equation (1) are reported in Appendix A (Table A1), and the predicted probabilities as a function of key variables are shown in Table 2. Of particular interest is the nature of the relationship between university involvement and termination. Results imply that projects with university involvement as either a research partner or subcontractor have a lower probability of early termination. The probability of early termination decreases as ATP's share of funding increases, although the effect is barely significant, and only for the specification to simulate the results shown in Table 2. Termination rate does not vary across technology area,[16] but projects where the lead partner is of medium size are more likely to terminate early than do the others.

Table 2. Simulation of Probability of Termination of ATP Information Technology Projects Begun in 1991

	University involved	*No university involved*
Size of lead participant (50% ATP share)		
Small	0.036	0.094
Medium	0.189	0.344
Large	0.042	0.106
Not-for-profit	0.081	0.179
ATP share of funding (medium size, lead participant)		
Zero	0.423	0.612
25 percent	0.296	0.477
50 percent	0.189	0.344
75 percent	0.111	0.228
100 percent	0.059	0.138

Note: This simulation is based on specification (1) in Table A1.

The top portion of Table 2 presents the calculated probabilities for a project terminating early by size of the lead participant. For this example (information technology projects begun in 1991), the calculated probability of early termination is lower for each size category when a university is involved in the project. Similarly (bottom portion of Table 2), the calculated probability of early termination is lower for each discrete level of ATP's share of funding when a university is involved in the project. Similar relationships exist across other research

16. This conclusion needs to be qualified slightly. Because no projects in discrete manufacturing terminated early, these projects could not be included in the models estimated in the first 2 columns of Table A1 (where technology dummies are used). Clearly projects in this technology area have a lower early termination rate than projects in the other technology areas.

technology areas. In the population of ATP projects, university involvement is clearly associated with a lower probability of early termination.[17]

Perhaps university participation reduces the likelihood of early termination simply because the projects are more complex and thus project managers may have more difficulty seeing that the project will fail to reach the technical goals until late in the project. Also, more complex projects, even if they fail to achieve their ultimate objective, may still generate knowledge of potential utility to the award recipients.

ESTIMATION OF THE PROBABILITY OF RESPONSE TO THE SAMPLE SURVEY

Only two of the six categories of university involvement listed in Table 1 (column 6) had a 100 percent response rate. Contact persons in joint venture projects were less likely to respond, with the least responsive category being joint venture projects with universities as both partners and subcontractors (only five of nine surveys were returned). The probability of survey response was examined using a probit model to quantify the potential bias because of non-response.

The probit estimates for a model of the probability of responding are reported in Appendix A (Table A2). When all of the independent variables are included, the results are not very significant. The only variable that is even marginally informative about the probability of survey response is the dummy for joint ventures with universities as both partner and subcontractor,[18] which are arguably the most complex arrangement contractually. Other factors held constant, contact persons in joint ventures with universities as research partners and as subcontractors have a lower probability of response than other contact persons. The associated predicted probabilities of response by selected technology areas and type of university involvement are reported in Table 3.[19]

17. The information in Table A1 is used to calculate a hazard rate for the probability that a project does not terminate early for use in the subsequent statistical analyses of a sample of ATP-funded projects to control for possible sample selection bias. To anticipate the use of this variable in later survey question equations it is important to note that its inclusion in an ordered probit or tobit is not really econometrically correct if it actually enters. That is, if the probability distribution in the termination equation and the distribution in the survey question equation are dependent, then the appropriate method is to specify a full maximum likelihood model for the two random variables and estimate jointly (such a model is outlined in the appendix to Hall, Link, and Scott 2000). In fact, we found that the termination hazard and the sample response hazard never entered significantly, and that joint maximum likelihood estimates did not differ significantly from our single equation estimates, which implies that sample selection is unlikely to produce significant bias in our estimates. However, our sample size is small, so the power of all these tests is low.

18. The same university cannot be both a partner and a subcontractor in a joint venture.

19. The sample size in Tables A2 and Table 3 is quite small (only 29 observations), because all projects with large lead participants or whose technology area was electronics, biotechnology, chemicals, energy, or the environment responded to the survey and hence these projects could not be used to estimate the probability equation (they had one or more characteristics that were perfect predictors). In later estimations, a response probability equation was used that does not depend on technology and is therefore defined for the whole sample.

Table 3. Predicted Probability of Survey Response

Project type	*Predicted probability*	*Sample probability*	*Number in sample*	*Number of responses*
JVUS in materials or information technology	0.27	0.25	4	1
JVUS in manufacturing	0.66	0.50	2	1
Non-JVUS in materials or information technology	0.84	0.80	15	12
Non-JVUS in manufacturing	0.98	1.00	5	5
All other projects	1.00	1.00	28	28

Notes: The predicted probabilities are based on specification (1) in Table A2.
JVUS, joint ventures with universities as both partner and subcontractor.

In the results presented later, response bias will be corrected in two ways: (a) by simply including the dummy for joint ventures with universities as both partner and subcontractor in estimations to test for response bias[20] and (b) estimating a full two equation model using maximum likelihood, where one equation is the equation of interest and the other is the equation for response probability. The implication of the first strategy will be that we cannot identify the direct effects of being a joint venture with a university participating as a partner and as a subcontractor separately from the impact on the probability of survey response.

20. As with our analysis of the probability of early termination, the results in Table A2 could be used to calculate a survey hazard rate to be used in the statistical analyses that follow. The survey hazard rate is the conditional probability density of responding to the survey. However, in practice, the only variable that predicted response or non-response in a simple probit model was joint venture projects with universities as both partner and subcontractor. We therefore used a simpler and more robust method to correct for response bias, by including the dummy for joint ventures with universities as both partner and subcontractor directly in the estimated model. Unlike the use of a hazard rate, this correction does not require normality of the response probability equation to be valid. In the case of a single dummy variable predictor, of course, the two approaches for converting any response bias would be equivalent if normality held.

3 Role of Universities in ATP-Funded Projects

ROLE OF UNIVERSITIES: REASON FOR INCLUSION IN PROJECTS

What research role do universities play in ATP-funded projects? At one level, the answer to this question comes from the organizational or administrative role that universities have in various projects. Universities participate either as formal partners or subcontractors in joint venture projects, or as subcontractors in single company applicant projects.

Four of the six groups of contact persons for the survey were asked the reason university subcontractors were selected for their projects. The most frequent response in the case of joint venture projects where a university is only involved as a subcontractor and in the case of single company applicant projects where the university is only involved as a subcontractor was selecting a university subcontractor to gain access to eminent researchers. Joint venture projects in which the university is only involved as a research partner reported that the university was invited to participate most commonly because of previous research interactions with other members of the joint venture. And, finally, the dominant response when universities are involved in a joint venture project as research partners and as subcontractors was that each was selected based on their overall research reputation.

The research role played by universities was explored by asking each contact person to respond to the following statement using the 7-point Likert scale noted below:

> *This research project has experienced difficulties acquiring and assimilating basic knowledge necessary for the project's progress.*
>
> strongly agree…………………………………………....strongly disagree
> 7 6 5 4 3 2 1

Respondents in general disagreed with this statement (e.g., responded to the statement with a 1 or a 2). Those who agreed with the statement (e.g., responded to the statement with a 6 or a 7) most frequently were involved in single company applicant projects with no university involvement.[21] To examine this issue of the research role that universities play in ATP-funded projects more systematically, ordered probit models were estimated to explain inter-project differences in responses by the contact person to the statement above. Held constant in these

21. See Table A4. In estimation, responses 1 and 2 and responses 6 and 7 were combined because of the small number of responses.

models are several characteristics of the project as determined from ATP information about the project and from responses to survey questions. The estimates are listed in Table 4.[22]

Table 4. Determinants of Difficulty Acquiring Basic Knowledge

Variable	(1) Ordered probit coefficient (s.e.)		(2) Ordered probit coefficient (s.e.)		(3) Ordered probit/ sample selected coefficient (s.e.)	
Log of total project budget	–0.72	(0.36)**	–0.51	(0.30)*	–0.52	(0.27)*
ATP share (fraction)	–2.31	(5.38)				
D (university participant)	0.80	(1.38)	0.98	(0.51)*	0.90	(0.48)*
D (no experience)	1.14	(0.50)**	1.04	(0.50)**	0.99	(0.47)**
Log (revenue of lead participant, $M)			0.08	(0.06)	0.09	(0.06)
Small lead participant	–1.39	(2.73)				
Large lead participant	–0.32	(2.49)				
Non-profit lead participant	–0.04	(1.49)				
Chi-square for 3 size variables (probability)	3.03	(0.39)				
Information technology	0.08	(0.65)				
Manufacturing	–1.22	(1.01)				
Electronics	3.01	(1.06)***	2.75	(0.84)***	2.66	(0.80)***
Biotechnology	0.00	(0.63)				
Chemicals, energy, and environment	–1.04	(0.88)				
Chi-square for 5 technical variables (probability)	12.30	(0.03)**				
Non-termination hazard	0.71	(3.67)				
JVUS	–0.48	(0.81)				
Correlation coefficient					–0.99	(596)

(*Table continues on the following page.*)

22. In column 1 we include the hazard rate for non-termination (the conditional probability density that the project will go forward to completion) and the proxy for the survey response hazard (joint ventures with universities participating as both partner and subcontractor) in the model. Neither of these enters into the equation significantly, implying that selection bias is unlikely to be a problem for our estimates. However, the full model for sample selection (an ordered probit equation plus an equation for the probability that the survey was returned) is barely identified in these data, with a correlation coefficient between the disturbances near minus one with a large standard error.

Table 4. (continued)

Variable	(1) Ordered probit coefficient (s.e.)	(2) Ordered probit coefficient (s.e.)	(3) Ordered probit/ sample selected coefficient (s.e.)
Number of observations	47	47	54 (47)
Log likelihood	–44.09	–46.27	–62.39
Scaled R-squared	0.150	0.127	
Chi-square (degrees of freedom)	23.90 (14)	17.54 (5)	

Notes: The response scale (1 to 7) has been collapsed from 7 to 5, using the groupings (1 and 2), 3, 4, 5, (6 and 7).

The excluded category is a project in materials with no university participant.

The excluded category in column 2 is a project where the lead participant is of medium size.
Coefficient significance levels are denoted by * (10 percent) ** (5 percent) *** (1 percent).
Estimates in column 3 are combined ordered probit/sample selection estimates.
The selection equation estimates are Pr [1.79 - 1.28 (joint venture with university as partner) - 0.93 (non-profit lead partner)].

The correlation coefficient is that between the disturbances in the two equations.

The scaled R-squared is a measure of goodness of fit relative to a model with only a constant term, computed as a nonlinear transformation of the LR test for zero slopes (see Estrella, 1998).

JVUS, joint ventures with universities as both partner and subcontractor.

Four observations about the ordered probit model estimates in Table 4 seem relevant:

- Respondents with a university participant (as a research partner or as a subcontractor) were more likely to agree that their projects had experienced difficulties acquiring and assimilating basic knowledge necessary for progress toward completion (a relationship opposite to that seen from the descriptive data in Table A4, because now we have controlled for project size, and experience). The university's presence may create a greater awareness that such difficulties exist.

- Experience working with a university as a research partner or as a subcontractor is a significant factor in decreasing the difficulty of acquiring and assimilating basic knowledge.

- Acquisition and assimilation difficulties with basic knowledge decrease slightly as overall project size increases.

- Projects in the electronics area have substantially more difficulty in acquiring and assimilating basic knowledge than do projects in other technology areas.

ROLE OF UNIVERSITIES: EFFECT ON RESEARCH EFFICIENCY

Each contact person responded to a series of five statements. The first three of these statements investigate unexpected research problems encountered to date relative to when the project began. The last two statements relate to the productive use of complementary research resources. The first three statements were of the following form:

> The number of [conceptual/equipment-related/personnel] research problems encountered in this project has been _____ (please select one response: more than/less than/about the same as) expected when the project began.

It appears from the univariate statistics that unexpected conceptual and personnel research problems occur more frequently among single company applicant projects than among joint venture projects, whereas equipment-related problems are more common among joint venture projects.[23] There is no clear response pattern that relates to the involvement of a university in the project with the exception that joint venture projects with universities involved as subcontractors reported the greatest number of unexpected personnel-related research problems.

Ordered probit models were estimated to examine responses to this statement more systematically. Held constant in these models are several characteristics of the project as determined from ATP information about the project and from responses to survey questions. Also held constant is the survey response hazard rate variable as discussed.[24] As seen in the specifications in Table 5 (columns 1 and 2), none of the individual variables is significant in explaining the existence of unexpected conceptual or equipment-related research problems. Because only very few projects had fewer problems of any type than expected, the three categories "of less than/about the same as/more than" were collapsed into two: "more than expected, or about the same as or less than expected." Even when re-estimated in this form in probit models (results not shown), essentially no identifiable individual variable effects explained the existence of unexpected research problems. Thus, we suggest that the presence of unexpected problems is perhaps random or a complex result of many factors that we cannot disentangle; that is, that they are truly "unexpected" given the information available to the firm (and to us).

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23. See Tables A5, A6, and A7 in Appendix A. In estimating the models for the presence of unexpected conceptual, equipment, or personnel problems, the response scale (1–7) was collapsed as follows: (1 and 2), (3, 4, and 5), and (6 and 7) were combined because of the small number of responses.

24. Ordered probit models that allowed for sample selection were also estimated, but proved to be difficult to identify because of the small sample. Therefore, we rely mainly on the ad hoc correction terms discussed in the footnotes above.

Table 5. Determinants of the Problems in the Project: Ordered Probit Estimates

Variable	*(1) Conceptual coefficient*	*(s.e.)*	*(2) Equipment-related coefficient*	*(s.e.)*	*(3) Personnel-related coefficient*	*(s.e.)*
Log of total project budget	–0.10	(0.34)	0.46	(0.31)	0.61	(0.39)*
D (university participant)	0.03	(0.73)	–0.54	(0.56)	1.16	(0.79)
D (no prior experience)	0.61	(0.51)	0.23	(0.49)	0.65	(0.54)
Small lead participant	1.16	(1.55)	–0.32	(1.39)	–1.48	(1.64)
Large lead participant	0.91	(1.45)	–0.96	(1.31)	0.20	(1.55)
Non-profit lead participant	1.29	(1.11)	–0.90	(1.03)	–2.64	(1.35)**
Chi-square for 3 size variables (probability)	1.49	(0.684)	2.38	(0.498)	11.27	(0.010)***
Information technology	0.82	(0.67)	–1.07	(0.66)	1.77	(0.74)**
Manufacturing	0.06	(0.84)	–0.78	(0.85)	2.16	(0.97)**
Electronics	–0.96	(0.98)	–0.03	(0.99)	2.63	(1.21)**
Biotechnology	–0.13	(0.64)	–0.55	(0.63)	2.01	(0.76)***
Chemicals	0.51	(0.78)	–0.25	(0.75)	0.47	(0.80)
Chi-square for 5 technical variables (probability)	4.31	(0.506)	3.02	(0.697)	9.0	(0.110)
Non-termination hazard	0.13	(1.81)	0.62	(1.68)	0.26	(1.80)
JVUS	–0.84	(0.76)	–0.14	(0.69)	–1.90	(0.85)**
Number of observations	46		45		44	
Log likelihood	–30.24		–33.02		–27.00	
Pseudo R-squared	0.146		0.131		0.428	
Chi-square (degrees of freedom)	10.45 (13)		7.10 (13)		24.13 (13) **	

Notes: The response scale (1 to 7) has been collapsed from 7 to 3, using the groupings (1 and 2), (3, 4, and 5), (6 and 7).

The excluded category is a project in materials or energy with no university participant and where the lead participant is of medium size.

Coefficient significance levels are denoted by * (10 percent) ** (5 percent) *** (1 percent).

JVUS, joint ventures with universities as both partner and subcontractor.

The estimates in column 3 of Table 5 suggest that the presence of "unexpected" personnel-related problems are associated mainly with the technology field. Project budget size is a marginally significant explanatory variable in explaining the presence of unexpected personnel problems: projects with non-profit lead partners are less likely to experience this kind of problem. Joint venture projects with university partners are both more likely to have personnel-related problems and also less likely to respond to the survey, so we cannot disentangle these two effects.

The fourth and fifth statements addressed aspects of research efficiency that are related to the productive use of complementary research resources. These statements were:

> To date, approximately ___ percent of the research time devoted to this project has, in retrospect, been unproductive.
>
> To date, approximately ___ percent of the financial resources devoted to this project has, in retrospect, been unproductive.

These two statements are analyzed together because of the high correlation between responses. Twenty-two of 42 contact persons responded to both questions with the same percentage.

According to the raw statistical data, the least amount of unproductive research time and cost was reported by single company applicant projects with a university as a subcontractor.[25] However, our tobit estimates (Table 6) reveal that this is because the technology mix varies across project type. [26] Although all variables in the estimation were originally included, only the size of the lead partner and the technology variables were significant in either equation. Unproductive time and cost seem to be most associated with electronics projects and least associated with information technology and manufacturing projects.

In comparing the estimates in the two columns of Table 6, projects in electronics have the largest share of time and money that is unproductively used whereas projects in manufacturing have the least. [27] Unproductive research time and money in electronics may be related to the fact that projects in this field also have difficulty acquiring and assimilating the basic research they need. Biotechnology projects have relatively little unproductive research cost, although somewhat more unproductive research time. Larger (profit-making) lead partners seem to be better at making productive use of research time and expenditure, or at least they perceive that to be the case.

25. See Tables A8 and A9 in Appendix A.

26. Note that this survey statement addresses realized unproductive research time and not expected unproductive research time. The same is true for the unproductive use of financial resources.

27. This is a hard question for participants in projects that are still active to answer. Often there is a significant lag between obtaining the research result and knowing with certainty that it will or will not apply to the problem. Projects in the electronics area might have the answer more quickly and that might be the reason their numbers are higher.

Table 6. Percentage of Unproductive Research Time and Cost: Sample Selection Estimates

Dependent variable	*(1) Research time coefficient (s.e.)*		*(2) Research cost coefficient (s.e.)*	
Log (total project budget of lead participant, $M)	–0.88	(0.30)***	–0.84	(0.27)***
Information technology	–5.92	(2.89)**	–5.76	(1.87)***
Manufacturing	–10.54	(4.19)**	–8.64	(4.72)*
Electronics	11.08	(4.96)**	13.99	(5.58)**
Biotechnology	–0.85	(3.13)	–10.47	(3.23)***
Chemicals, energy, and environment	8.24	(3.58)**	6.55	(1.13)***
Chi-square for 5 technical variables (probability)	28.6	(0.001)***	26.7	(0.001)***
Intercept	18.39	(3.21)***	15.40	(3.12)***
Standard error	6.32	(0.70)***	7.40	(0.73)***
		Probit for Sample Response		
Intercept	1.17	(0.26)***	0.97	(0.20)***
JVUS	–0.55	(0.50)	–0.77	(0.26)***
Non-profit lead participant	–1.08	(0.46)**	–0.30	(0.33)
Rho (correlation between 2 equations)	0.09	(0.57)	0.99	——
Number of observations (number responding)	54 (42)		54 (42)	
Log likelihood	–151.34		–155.65	

Notes: The excluded category is a project in materials.
Coefficient significance levels are denoted by * (10 percent) ** (5 percent) *** (1 percent).
JVUS, joint ventures with universities as both partner and subcontractor.

ROLE OF UNIVERSITIES: EFFECT ON ACCELERATION AND COMMERCIALIZATION OF TECHNOLOGY

Contact people were asked to respond to two statements: The first statement posed to the lead participant was:

> *Potential new applications of the technology being developed have been recognized over the course of the project.*
>
> strongly agree...strongly disagree
>
> 7 6 5 4 3 2 1

A much larger percentage of joint venture projects with a university involved as a research partner reported agreement to this statement than did joint venture projects with no university or with only a university serving as a subcontractor. On average, though, respondents from single company applicant projects agreed more often to the statement than did respondents from joint ventures.[28]

Ordered probit estimates for this question (corrected for response probability) were for the most part insignificant. Column 1 of Table 7 shows a minimal specification of the model. It may be that the generation of new applications from a technology project in process cannot be attributed to any particular individual project characteristic and is essentially unpredictable regardless of the technology area. Projects with a higher ATP share of the costs are more likely to develop unanticipated applications for the technology. Perhaps a higher ATP share of the costs brings greater resources for ATP monitoring or imparts to the research performers a greater leveraging effect to search for or to recognize new applications of the technology. University participation seems to have no impact on the generation of new applications of the technology.

The second statement posed to the lead participant was:

> At this stage of the research, it appears that the technology will be developed and commercialized sooner than expected when the project began.
>
> strongly agree...strongly disagree
>
> 7 6 5 4 3 2 1

28. See Table A10 in Appendix A.

Table 7. Performance Determinants: Ordered Probit Estimates with Correction for Response Probability

Dependent Variable	*(1) New applications of technology developed Coefficient (s.e.)*		*(2) Commercialized sooner than expected Coefficient (s.e.)*	
Log of total project budget			–0.91	(0.37)**
ATP share (fraction)	3.29	(1.41)**		
D (university participant)	–0.14	(0.42)	–0.78	(0.42)*
D (no experience)			–0.94	(0.44)*
Small lead participant			–1.34	(0.54)**
Large lead participant			–1.73	(0.67)***
Chi-square for size variables (probability)			8.43	(0.015)**
Information technology			1.08	(0.52)**
Manufacturing			omitted	
Electronics			omitted	
Biotechnology			omitted	
Chemicals, energy, and environment			1.21	(0.74)*
Materials			1.64	(0.76)**
Chi-square for technical variables (probability)			6.92	(0.074)*
	Probit for Sample Response			
Intercept	1.79	(0.40)***	1.47	(0.34)***
JVUS	–1.39	(0.46)***	–0.69	(0.49)
Non-profit lead participant	–0.97	(0.48)**	–1.21	(0.51)**
Correlation coefficient	–0.96	(0.67)	–0.95	(0.28)***
Number of observations (number responding)	54 (47)		54 (47)	
Log likelihood	–79.72		–87.12	

Notes: The dependent variable takes on only six values because one of the cells ($y = 3$) is empty.
The excluded category in column 2 is a project where the lead participant is of medium size.
The correlation coefficient is that between the disturbances in the two equations.
Coefficient significance levels are denoted by * (10 percent) ** (5 percent) *** (1 percent).
JVUS, joint ventures with universities as both partner and subcontractor.

Single company applicant respondents were more optimistic than joint venture respondents about completing the research and commercializing the results sooner than expected, and the most optimistic of all were single company applicant projects with no university involvement.[29, 30]

The response-corrected ordered probit estimates for this question are shown in column 2 of Table 7. A number of variables are significant leading to five interesting conclusions.

- Projects involving universities as partners are less likely to develop and commercialize technology sooner than expected. Universities perhaps are involved in more difficult projects to begin with.

- Large projects and/or projects with large lead participants are less likely to expect to develop and commercialize their technology sooner than expected in comparison with projects with non-profit or medium-sized lead participants. To the extent that larger research budgets are associated with research projects that can stretch the frontiers of knowledge then less time will be devoted toward looking for early-on commercialization opportunities of the technology. An alternative explanation is that if there are near-term commercialization opportunities, then a large company will be more likely to do the R&D on their own rather than partner with the government, especially if the project is not large.

- Projects with a small lead participant are less likely to expect to develop and commercialize technology sooner than expected. Recall that this group is very small firms, and this may reflect resource constraints they face in development when the project budget does not cover the full cost of making the technology commercially viable.

- Lack of experience with a university partner reduces the expectation of early commercialization, as does university involvement, perhaps because the award recipients are not familiar with the technical abilities of the university researchers or are more uncertain about the success of university work. Another possible reason could be that some adjustment costs are included as the participants learn to work with a university.

- Projects in information technology, chemicals, energy and the environment, and materials are significantly more likely to commercialize earlier than expected than are projects in manufacturing, electronics, and biotechnology.

29. See Table A11 in Appendix A.
30. In future work, it would be interesting to look at these data with only completed projects to see if this optimism holds since companies may be more optimistic in their outlook when the projects are underway.

4 Concluding Observations

The general topic that we have investigated has not previously been studied by academic scholars or professionals in sufficient detail for us to have a theoretical foundation from which to base our inquiry. Many of the concepts we attempted to quantify are new, and certainly the survey questions posed to address them are exploratory in construction.

In addition, our analytical tools are not sufficiently sophisticated to draw conclusions about directions of causality. The statistical associations that were emphasized in the previous sections are just that, statistical associations (albeit robust associations), and not evidence of independent and dependent relationships. More research will certainly need to be done on the general subject of universities as research partners before such inferences can be made.

Finally, our analyses are based in some cases on very small sample sizes (e.g., when we control for technology field) so that analysis is in many cases subject to substantial sampling error (reflected in the standard errors) and some effects are difficult to identify owing to the sparseness of the relevant covariates.

Two additional conclusions follow but they must be judged in the context of the foregoing caveats. The first relates to how universities create research awareness and the other to how universities influence the scope of the research.

UNIVERSITIES CREATE RESEARCH AWARENESS IN ATP-FUNDED PROJECTS

Those involved in projects with university involvement, either as a research partner or as a subcontractor, (a) experience difficulties acquiring and assimilating basic knowledge for the project's progress (Table 4) and (b) do not anticipate being able to develop and commercialize technology sooner than expected when the project began (Table 7).

At one level, university involvement may be creating research problems. We eschew that interpretation; ATP-funded projects with university involvement are less likely to terminate early compared with projects without university involvement (Tables 2 and A1). We conclude, albeit cautiously, that university involvement may be creating a greater awareness of research issues than would otherwise be the case.

Thus, we offer a possible interpretation of the research role of a university.[31] Universities are included (e.g., invited by industry) in those research projects that involve what we have called "new" science. It is the collective perception of the other research participant(s) that the university may provide insight into what might be a future research problem down the road. Universities may also anticipate and translate the complex nature of the research being undertaken. Thus, universities may be purposively involved in projects that are difficult in nature, where basic knowledge is somewhat lacking, and where the resulting research will not move quickly toward a commercial application.

RESEARCH FUNDING INFLUENCES THE SCOPE OF THE RESEARCH

Projects with larger budgets take on research of a broader scope. With larger budgets more personnel are needed. With more personnel, more difficulties arise (Table 5). However, projects with larger budgets also tend to focus energy on research requiring a longer time until commercialization (Table 7). These statistical associations are not inconsistent with projects attempting to expand frontiers of research. It is, however, also true that larger budgeted projects have fewer problems acquiring and assimilating basic knowledge (Table 4). Thus, if the larger budgeted projects were broader, the scope and breadth would appear to address new applications (new generic technology across many industries) rather than fundamental basic research. Or perhaps the larger budgets allow for more experienced project managers to work on ATP projects.

We do not speculate as to the extent to which our findings can be generalized to other projects that are partially publicly funded or to private sector joint ventures with and without university research interactions. As more research is conducted on this topic, the wider applicability of the observations in this concluding section will and should be tested.

31. Absent baseline information about the technical difficulty of the projects or their closeness to "new" science other than technology field, this interpretation is offered cautiously.

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Appendix A: Additional Results Supporting Findings in the Study

Table A1. Determinants of the Probability of Early Termination: Probit Estimates Dependent Variable = 1, if Project Were Terminated Early

Variable	*(1)* *Coefficient*	*(s.e.)*	*(2)* *Coefficient*	*(s.e.)*	*(3)* *Coefficient*	*(s.e.)*
D (university involvement)	–0.434	(0.258)*	–0.537	(0.269)**	–0.478	(0.249)*
ATP share of funding	–1.783	(0.943)*	–1.472	(0.957)	–1.374	(0.899)
Time trend	–0.112	(0.082)	–0.112	(0.084)	–0.079	(0.075)
Small lead participant	–0.716	(0.317)**	–0.818	(0.326)**	–0.914	(0.302)***
Large lead participant	–0.929	(0.348)***	–0.943	(0.351)***	–0.848	(0.335)***
Non-profit lead participant	–0.401	(0.466)	–0.337	(0.467)	–0.516	(0.419)
Chi-square for 3 size variables (probability)	8.47	(0.037)**	9.47	(0.024)**	10.50	(0.015)**
Information technology	0.025	(0.338)	–0.074	(0.347)		
Electronics	–0.488	(0.465)	–0.478	(0.389)		
Biotechnology	–0.533	(0.455)	–0.510	(0.569)		
Chemicals, energy, and environment	–0.039	(0.387)	–0.022	(0.457)		
Chi-square for 4 technical variables (probability)	2.90	(0.575)	2.16	(0.675)		
Intercept	0.738	(0.655)	0.662	(0.664)	0.285	(0.569)
Number of observations	313		312		351	
Log likelihood	–67.33		–64.42		–67.89	
Scaled R-squared	0.126		0.133		0.115	
Chi-square (DF)	19.38 (10)		19.75 (10)		17.67 (6)	

Notes: Column 1 includes the full sample excluding projects in other manufacturing (none of which was terminated).

Columns 2 and 3 delete a single observation for a project that was terminated prior to starting.

The excluded category is a project in materials with no university participation and where the lead participant is of medium size.

Coefficient significance levels are denoted by * (10 percent) ** (5 percent) *** (1 percent).

The scaled R-squared is a measure of goodness of fit relative to a model with only a constant term, computed as a nonlinear transformation of the LR test for zero slopes (see Estrella, 1998).

Table A2. Probit Estimates for the Probability of Survey Response Dependent Variable = 1, if Survey Were Returned

Variable	*(1)* *Coefficient*	*(s.e.)*	*(2)* *Coefficient*	*(s.e.)*	*(3)* *Coefficient*	*(s.e.)*
Joint venture with university as partner	–0.08	(1.05)				
Joint venture with university as subcontractor	–0.54	(1.23)				
Joint venture with university as participant and subcontractor	–1.75	(0.95)*	–1.36	(0.65)**	–1.21	(0.53)
Small lead participant	0.29	(1.10)				
Large lead participant						
Non-profit lead participant	–0.31	(1.23)	–0.34	(0.60)	–0.96	(0.52)*
Information technology	0.42	(0.90)				
Manufacturing	1.24	(1.09)				
Intercept	0.76	(1.34)	1.16	(0.42)***	1.78	(0.36)***
Number of observations (number responding)	26 (19)		26 (19)		54 (47)	
Log likelihood	–10.69		–12.12		–15.50	
Scaled R-squared	0.294		0.229		0.213	
Chi-square (DF)	8.91 (7)		6.05(2)		10.66 (2)	

Notes: The sample in columns 1 and 2 is joint ventures with small, medium, or nonprofit lead participants in the information technology, manufacturing, or materials areas. All other technologies predict perfectly.

The excluded category is a project in materials with no university participant and where the lead participant is of medium size.

Coefficient significance levels are denoted by * (10 percent) ** (5 percent) *** (1 percent).

The scaled R-squared is a measure of goodness of fit relative to a model with only a constant term, computed as a nonlinear transformation of the LR test for zero slopes (see Estrella, 1998).

Table A3. Overall Determinants of Sampling Probability: Probit Estimates Dependent Variable = 1, if Project Were Sampled and Responded

Variable	(1) Coefficient	(s.e.)	(2) Coefficient	(s.e.)	(3) Coefficient	(s.e.)
Joint venture with university partner	2.16	(0.52)***	1.74	(0.36)***	1.75	(0.36)***
Joint venture with university partner and subcontractor	1.44	(0.46)***	1.74	(0.36)***	1.75	(0.36)***
Joint venture with no university	0.632	(0.310)**	0.651	(0.210)***	0.563	(0.200)***
Joint venture with university subcontractor	0.647	(0.322)**	0.651	(0.210)***	0.563	(0.200)***
Single with university	–0.434	(0.253)				
ATP share of funding	0.570	(0.792)				
Time trend	–0.071	(0.062)	–0.065	(0.060)		
Small lead participant	–0.118	(0.295)				
Large lead participant	0.194	(0.304)				
Non-profit lead part.	–0.838	(0.509)*	–0.704	(0.410)*	–0.693	(0.391)*
Chi-square for 3 size variables (probability)	5.20	(0.158)				
Information technology	0.064	(0.297)	–0.024	(0.280)		
Manufacturing	0.155	(0.366)	0.045	(0.352)		
Electronics	–0.293	(0.398)	–0.393	(0.372)		
Biotechnology	0.447	(0.323)	0.323	(0.298)		
Chemicals, Energy, and Environment	–0.004	(0.344)	–0.016	(0.338)		
Chi-square for 4 technical variables (probability)	4.51	(0.479)		4.04	(0.543)	
Intercept	–1.59	(0.60)***	–1.25	(0.30)***	–1.42	(0.12)***
Number of observations (number responding)	351 (47)		351 (47)		351 (47)	
Log likelihood	–118.82		–120.67		–122.98	
Scaled R-squared	0.112		0.101		0.088	
Chi-square (DF)	38.78 (15)		35.06 (9)		30.44 (3)	

Notes: A single observation for a project that was terminated prior to starting has not been used.

In column 1, the excluded category is a single participant project in materials with no university participation and where the lead participant is of medium size.

Coefficient significance levels are denoted by * (10 percent) ** (5 percent) *** (1 percent).

Table A4. Difficulties Acquiring and Assimilating Basic Knowledge

Type of university involvement	*Number responding*	*Disagree 1,2*	*Somewhat 3,4,5*	*Agree 6,7*	*Percent 6,7*
Joint venture	29	19	8	2	6.9
No university involvement	8	7	0	1	12.5
Universities involved as subcontractor	8	4	4	0	0.0
Universities involved as research partner	8	5	2	1	12.5
Universities involved as both partner and subcontractor	5	3	2	0	0.0
Single company applicant	18	9	7	2	11.1
No university involvement	9	5	2	2	22.2
Universities involved as a subcontractor	9	4	5	0	0.0
Total	47	28	15	4	8.5

Table A5. Conceptual Research Problems Versus Expectations

Type of university involvement	*Number responding*	*Less than*	*About the same as*	*More than*	*Percent more than*
Joint venture	28	0	18	10	35.7
No university involvement	7	0	5	2	28.6
Universities involved as subcontractor	8	0	6	2	25.0
Universities involved as research partner	8	0	3	5	62.5
Universities involved as both partner and subcontractor	5	0	4	1	20.0
Single company applicant	18	1	8	9	50.0
No university involvement	9	1	3	5	55.6
Universities involved as a subcontractor	9	0	5	4	44.4
Total	46	1	26	19	41.3

Table A6. Equipment-Related Research Problems Versus Expectations

Type of university involvement	*Number responding*	*Less than*	*About the same as*	*More than*	*Percent more than*
Joint venture	27	1	13	13	48.1
No university involvement	6	0	2	4	66.7
Universities involved as subcontractor	8	0	5	3	37.5
Universities involved as research partner	8	1	2	5	62.5
Universities involved as both partner and subcontractor	5	0	4	1	20.0
Single company applicant	18	1	14	3	16.7
No university involvement	9	0	7	2	22.2
Universities involved as a subcontractor	9	1	7	1	11.1
Total	45	2	27	16	35.6

Table A7. Personnel-Related Research Problems Versus Expectations

Type of university involvement	*Number responding*	*Less than*	*About the same as*	*More than*	*Percent more than*
Joint venture	27	3	14	10	37.0
No university involvement	6	1	5	0	0.0
Universities involved as subcontractor	8	1	1	6	75.0
Universities involved as research partner	8	1	3	4	50.0
Universities involved as both partner and subcontractor	5	0	5	0	0.0
Single company applicant	17	0	9	8	47.1
No university involvement	8	0	4	4	50.0
Universities involved as a subcontractor	9	0	5	4	44.4
Total	44	3	23	18	40.9

Table A8. Percent Unproductive Research Time on Project

Type of university involvement	*Number responding*	*<10%*	*10–19%*	*>19%*	*Percent >19%*
Joint venture	25	4	13	8	32.0
No university involvement	6	2	2	2	33.3
Universities involved as subcontractor	8	0	5	3	37.5
Universities involved as research partner	6	1	3	2	33.3
Universities involved as both partner and subcontractor	5	1	3	1	20.0
Single company applicant	17	6	7	4	23.5
No university involvement	8	3	2	3	37.5
Universities involved as a subcontractor	9	3	5	1	11.1
Total	42	10	20	12	28.6

Table A9. Percent Unproductive Financial Resources for Project

Type of university involvement	*Number responding*	*<10%*	*10-19%*	*>19%*	*Percent >19%*
Joint venture	25	7	12	6	24.0
No university involvement	6	2	3	1	16.7
Universities involved as subcontractor	8	1	5	2	25.0
Universities involved as research partner	6	3	1	2	33.3
Universities involved as both partner and subcontractor	5	1	3	1	20.0
Single company applicant	17	7	9	1	5.9
No university involvement	8	5	2	1	12.5
Universities involved as a subcontractor	9	2	7	0	0.0
Total	42	14	21	7	16.7

Table A10. Potential New Applications of the Technology Have Been Recognized

Type of university involvement	*Number responding*	*Disagree 1,2*	*Somewhat 3,4,5*	*Agree 6,7*	*Percent 6,7*
Joint venture	29	3	9	17	58.6
No university involvement	8	0	5	3	37.5
Universities involved as subcontractor	8	3	2	3	37.5
Universities involved as research partner	8	0	2	6	75.0
Universities involved as both partner and subcontractor	5	0	0	5	100.0
Single company applicant	18	1	2	15	83.3
No university involvement	9	0	1	8	88.9
Universities involved as a subcontractor	9	1	1	7	77.8
Total	47	4	11	32	68.1

Table A11. Technology to be Commercialized Sooner Than Expected

Type of university involvement	*Number responding*	*Disagree 1,2*	*Somewhat 3,4,5*	*Agree 6,7*	*Percent 6,7*
Joint venture	27	12	12	3	11.1
No university involvement	7	3	4	0	0.0
Universities involved as subcontractor	8	4	2	2	25.0
Universities involved as research partner	7	3	3	1	14.3
Universities involved as both partner and subcontractor	5	2	3	0	0.0
Single company applicant	18	2	12	4	22.2
No university involvement	9	2	3	4	44.4
Universities involved as a subcontractor	9	0	9	0	0.0
Total	45	14	24	7	15.6

Appendix B: Survey Instruments[32]

Appendix B1. Survey instrument for joint ventures with no university involvement

UNIVERSITIES AS RESEARCH PARTNERS:
A Survey Conducted for the Advanced Technology Program at NIST
by
Professor Bronwyn Hall — University of California at Berkeley
Professor Albert Link — University of North Carolina at Greensboro
Professor John Scott — Dartmouth College

Thank you for agreeing to participate in this ATP-sponsored survey. The primary purpose of this survey is to explore the composition of the membership of your ATP-funded joint venture. All specific information from this survey will remain confidential; only summary findings will be incorporated into a final report to ATP.

Please respond to each of the following background questions using the response format noted in each question.

Question 1:
Prior to this ATP-funded project, my organization has __________ (please select one response—frequently/infrequently/never) been involved with a university in a research project.

Frequently = 3, infrequently = 2, never = 1; mean = 2.38

Question 2:
Did you or the members of the joint venture consider a university research partner?

_____YES _____NO

Yes = 0, No = 1; mean = 0.75

Question 3:
If NO to Question 2, was there a particular reason why a university was not considered as a research partner?

32. The spacing on the survey instruments has been compressed for this report. Univariate statistics for our respondents are shown on the surveys.

Question 4:
If YES to Question 2, did you or the members of the joint venture proceed to identify a research partner?

_____YES _____NO
Yes = 0, No = 1; mean = 0.50

Question 5:
If YES to Question 4, what criteria did you use to identify a university research partner?

Question 6:
If YES to Question 4, briefly explain why the partnership did not come about? For example, were intellectual property issues a stumbling block? Were particular universities problematic?

Question 7:
If NO to Question 4, were there barriers that prevented identification of potential university partners, and if so what were they?
Please respond from the perspective of the joint venture to the following statements using a response scale ranging from 7 = strongly agree to 1 = strongly disagree. If you do not have an opinion, please respond with "n/a."

Statement 1:
This research project has experienced difficulties acquiring and assimilating basic knowledge necessary for the project's progress.

strongly agree...strongly disagree **mean = 2.38**
7 6 5 4 3 2 1

Statement 2:
Potential new applications of the technology being developed have been recognized over the course of the project.

strongly agree...strongly disagree **mean = 5.38**
7 6 5 4 3 2 1

Statement 3:
At this stage of the research, it appears that the technology will be developed and commercialized sooner than expected when the project began.

strongly agree...strongly disagree **mean = 3.14**
7 6 5 4 3 2 1

Please complete the following statements.

Statement 4:
The number of conceptual research problems encountered in this project has been _____ (please select one response—more than/less than/about the same as) expected when the project began.

More than = 3, about the same = 2, less than = 1; mean = 2.29

Statement 5:
The number of equipment-related research problems encountered in this project has been _____ (please select one response—more than/less than/about the same as) expected when the project began.

More than = 3, about the same = 2, less than = 1; mean = 2.67

Statement 6:
The number of personnel-related research problems encountered in this project has been _____ (please select one response—more than/less than/about the same as) expected when the project began.

More than = 3, about the same = 2, less than = 1; mean = 1.83

Statement 7:
To date, approximately ___ percent of the research time devoted to this project has, in retrospect, been unproductive.

mean = 12.5%

Statement 8:
To date, approximately ___ percent of the financial resources devoted to this project has, in retrospect, been unproductive.

mean = 11.67%

Please return by facsimile as soon as possible your completed questionnaire to **Professor Albert Link.** Again, thank you for your participation in this project.

Appendix B2. Survey instrument for joint ventures with university involvement as a subcontractor.

UNIVERSITIES AS RESEARCH PARTNERS:
A Survey Conducted for the Advanced Technology Program at NIST
by
Professor Bronwyn Hall — University of California at Berkeley
Professor Albert Link — University of North Carolina at Greensboro
Professor John Scott — Dartmouth College

Thank you for agreeing to participate in this ATP-sponsored survey. The primary purpose of this survey is to explore the role of university subcontractors in your ATP-funded project. All specific information from this survey will remain confidential; only summary findings will be incorporated into a final report to ATP.

Please respond to each of the following background questions using the response format noted in each question.

Question 1:
Prior to this ATP-funded project, my organization has __________ (please select one response—frequently/infrequently/never) been involved with a university as a subcontractor in a research project.

Frequently = 3, infrequently = 2, never = 1; mean = 2.38

Question 2:
Prior to this ATP-funded project, my organization has __________ (please select one response—frequently/infrequently/never) been involved in a research relationship with a university.

Frequently = 3, infrequently = 2, never = 1; mean = 2.75

Question 3:
The university subcontractors in this ATP-project were selected because of (please rank the items below from 1 = most important to least important; no ties please):

__ geographic proximity to research members of the joint venture
__ access to specialized equipment
__ access to eminent researchers **[this was the dominant response]**
__ overall research reputation
__ previous subcontracting relationships with research members of the joint venture
__ other (please explain and rank)

Question 4:
The decision to involve a university in the project as a subcontractor as opposed to as a research partner was based on which of the following factors (please rank the items below from 1 = most important to least important; no ties please):

__ perception that there would be less "red tape" involved if the university was a subcontractor as opposed to a research partner
__ insufficient time during the preparation of the research proposal to identify appropriate university research partners
__ limited technical needs that a university could provide as research support for the project
__ concerns by members of the joint venture that critical technical information would become public
__ need for university expertise did not become evident until the project had already begun
__ members of the research joint venture were concerned that technologically sensitive information would "leak" from the project
__ other (please explain and rank) **[this was the dominant response]**

Please respond from the perspective of the non-university members of the joint venture to the following statements using a response scale ranging from 7 = strongly agree to 1 = strongly disagree. If you do not have an opinion, please respond with "n/a."

Statement 1:
This research project has experienced difficulties acquiring and assimilating basic knowledge necessary for the project's progress.

strongly agree...strongly disagree **mean = 3.13**
7 6 5 4 3 2 1

Statement 2:
Potential new applications of the technology being developed have been recognized over the course of the project.

strongly agree...strongly disagree **mean = 4.13**
7 6 5 4 3 2 1

Statement 3:
At this stage of the research, it appears that the technology will be developed and commercialized sooner than expected when the project began.

strongly agree...strongly disagree **mean = 3.25**
7 6 5 4 3 2 1

Statement 4:
The decision to involve a university as a subcontractor compared to a for-profit company as a subcontractor was based primarily on cost considerations.

strongly agree…………………………						...strongly disagree	**mean = 2.86**
7	6	5	4	3	2	1	

Statement 5:
The decision to involve a university as a subcontractor compared to a for-profit company as a subcontractor was based primarily on technical capabilities.

strongly agree…………………………						...strongly disagree	**mean = 5.00**
7	6	5	4	3	2	1	

Statement 6:
Based on the performance of the university subcontractor thus far in the project, a university would be selected over a for-profit company as a subcontractor again for a similar research project.

strongly agree…………………………						...strongly disagree	**mean = 4.00**
7	6	5	4	3	2	1	

Please complete the following statements.

Statement 7
The number of conceptual research problems encountered in this project has been _____ (please select one response—more than/less than/about the same as) expected when the project began.

More than = 3, about the same = 2, less than = 1; mean = 2.25

Statement 8:
The number of equipment-related research problems encountered in this project has been _____ (please select one response—more than / less than / about the same as) expected when the project began.

More than = 3, about the same = 2, less than = 1; mean = 2.38

Statement 9:
The number of personnel-related research problems encountered in this project has been _____ (please select one response—more than / less than / about the same as) expected when the project began.

More than = 3, about the same = 2, less than = 1; mean = 2.63

Statement 10:
To date, approximately ___ percent of the research time devoted to this project has, in retrospect, been unproductive.

mean = 15.6%

Statement 11:
To date, approximately ___ percent of the financial resources devoted to this project has, in retrospect, been unproductive.

mean = 13.8%

Statement 12:
If intellectual property issues were an important reason for being concerned about including a university as a subcontractor in your joint venture, would you briefly describe the types of issues that were of concern?

Do you perceive that these issues would have been __________ (please select one response—greater / lesser / the same) if the university was included as a research partner rather than as a subcontractor? Please explain.

Please return by facsimile as soon as possible your completed questionnaire to **Professor Albert Link**. Again, thank you for your participation in this project.

Appendix B3. Survey instrument for joint ventures with university involvement as a research partner.

UNIVERSITIES AS RESEARCH PARTNERS:
A Survey Conducted for the Advanced Technology Program at NIST
by
Professor Bronwyn Hall — University of California at Berkeley
Professor Albert Link — University of North Carolina at Greensboro
Professor John Scott — Dartmouth College

Thank you for agreeing to participate in this ATP-sponsored survey. The primary purpose of this survey is to explore intellectual property issues associated with the universities participating as research partners in your ATP-funded project. All specific information from this survey will remain confidential; only summary findings will be incorporated into a final report to ATP.

Please respond to each of the following background questions using the response format noted in each question.

Question 1:
Prior to this ATP-funded project, my organization has __________ (please select one response—frequently/infrequently/never) been involved in a research relationship with a university.

Frequently = 3, infrequently = 2, never = 1; mean = 2.38

Question 2:
The university research partners in this ATP-project were invited to participate because of (please rank the items below from 1 = most important to least important; no ties please):
__ geographic proximity to the non-university research members
__ access to specialized equipment
__ access to eminent researchers
__ overall research reputation
__ previous research interactions with the non-university research members **[this was the dominant response]**
__ ability to coordinate basic research activities
__ other (please explain and rank)

Please respond from the perspective of the non-university members of the joint venture to each of the following statements using a response scale ranging from 7 = strongly agree to 1 = strongly disagree. If you do not have an opinion, please respond with "n/a."

Statement 1:
I expected at the time that this project was proposed to ATP that the technology to be developed in this project would be licensed outside of the joint venture.

strongly agree...strongly disagree **mean = 4.63**
7 6 5 4 3 2 1

Statement 2:
I now expect that the technology developed in this project will be licensed outside of the joint venture.

strongly agree...strongly disagree **mean = 5.00**
7 6 5 4 3 2 1

Statement 3:
University research participation in this project has increased the probability that the technology developed will be licensed outside of the joint venture.

strongly agree...strongly disagree **mean = 3.75**
7 6 5 4 3 2 1

Statement 4:
I was concerned at the time that the project was proposed to ATP that if universities were involved in the project, demands for licensing rights to the technology being developed would be difficult to resolve.

strongly agree...strongly disagree **mean = 2.88**
7 6 5 4 3 2 1

Statement 5:
I am now concerned that university demands for licensing rights to the technology being developed will become difficult to resolve.

strongly agree...strongly disagree **mean = 2.38**
7 6 5 4 3 2 1

Statement 6:
If the technology developed in this project is licensed outside of the joint venture, I expect the research universities to share revenues equally with the non-university members of the joint venture.

strongly agree………						….strongly disagree	**mean = 3.50**
7	6	5	4	3	2	1	

Statement 7:
I expected at the time that this project was proposed to ATP that the technology to be developed in this project would be patented.

strongly agree………						….strongly disagree	**mean = 6.00**
7	6	5	4	3	2	1	

Statement 8:
I now expect that the technology developed in this project will be patented.

strongly agree………						….strongly disagree	**mean = 6.13**
7	6	5	4	3	2	1	

Statement 9:
University research participation in this project has increased the probability that the technology being developed will be patented.

strongly agree………						….strongly disagree	**mean = 4.88**
7	6	5	4	3	2	1	

Statement 10:
I was concerned at the time that the project was proposed to ATP that if universities were involved in the project the ability of members of the joint venture to appropriate the technical knowledge from the project would be impaired.

strongly agree………						….strongly disagree	**mean = 3.29**
7	6	5	4	3	2	1	

Statement 11:
I am now concerned that university involvement in the project will impair the ability of members of the joint venture to appropriate the technical knowledge from the project.

strongly agree………						….strongly disagree	**mean = 2.38**
7	6	5	4	3	2	1	

Statement 12:
I was concerned at the time that the project was proposed to ATP that there would be research delays owing to university “red tape” about intellectual property rights issues.

strongly agree……………………………………………....strongly disagree **mean = 4.14**
7 6 5 4 3 2 1

Statement 13:
I am now concerned that there will be research delays owing to university “red tape” about intellectual property rights as the project approaches completion.

strongly agree……………………………………………....strongly disagree **mean = 3.25**
7 6 5 4 3 2 1

Statement 14:
University involvement as a research participant in this project provides a window on the various uses of the technology being developed that non-university members of the joint venture would not likely have recognized.

strongly agree……………………………………………....strongly disagree **mean = 4.63**
7 6 5 4 3 2 1

Statement 15:
This research project has experienced difficulties acquiring and assimilating basic knowledge necessary for the project’s progress.

strongly agree……………………………………………....strongly disagree **mean = 2.38**
7 6 5 4 3 2 1

Statement 16:
Potential new applications of the technology being developed have been recognized over the course of the project.

strongly agree……………………………………………....strongly disagree **mean = 5.88**
7 6 5 4 3 2 1

Statement 17:
At this stage of the research, it appears that the technology will be developed and commercialized sooner than expected when the project began.

strongly agree……………………………………………....strongly disagree **mean = 3.71**
7 6 5 4 3 2 1

Please complete the following statements.

Statement 18:
The number of conceptual research problems encountered in this project has been _____ (please select one response—more than/less than/about the same as) expected when the project began.

More than = 3, about the same = 2, less than = 1; mean = 2.63

Statement 19:
The number of equipment-related research problems encountered in this project has been _____ (please select one response—more than/less than/about the same as) expected when the project began.

More than = 3, about the same = 2, less than = 1; mean = 2.50

Statement 20:
The number of personnel-related research problems encountered in this project has been _____ (please select one response—more than/less than/about the same as) expected when the project began.

More than = 3, about the same = 2, less than = 1; mean = 2.38

Statement 21:
To date, approximately ___ percent of the research time devoted to this project has, in retrospect, been unproductive.

mean = 15.0%

Statement 22:
To date, approximately ___ percent of the financial resources devoted to this project has, in retrospect, been unproductive.

mean = 10.8%

Statement 23:
If intellectual property issues were an important reason for being concerned about including a university in your joint venture, would you please elaborate on the types of issues that were of concern?

Statement 24:
If there are arrangements that entail the sharing of future revenues with the university partners, would you please elaborate on the nature of these arrangements (e.g., licensing fees, royalties, etc) including some of the specifics of the arrangements (e.g., relevant percentages).

Please return by facsimile as soon as possible your completed questionnaire to **Professor Albert Link.** Again, thank you for your participation in this project.

Appendix B4. Survey instrument for joint ventures with university involvement as both research partners and as subcontractors.

UNIVERSITIES AS RESEARCH PARTNERS:
A Survey Conducted for the Advanced Technology Program at NIST
by
Professor Bronwyn Hall — University of California at Berkeley
Professor Albert Link — University of North Carolina at Greensboro
Professor John Scott — Dartmouth College

Thank you for agreeing to participate in this ATP-sponsored survey. The primary purpose of this survey is to explore the research role versus subcontractor role of universities in your ATP-funded project. All specific information from this survey will remain confidential; only summary findings will be incorporated into a final report to ATP.

Please respond to each of the following background questions using the response format noted in each question.

Question 1:
Prior to this ATP-funded project, my organization has __________ (please select one response—frequently/infrequently/never) been involved in a research relationship with a university.

Frequently = 3; infrequently = 2, never = 1; mean = 2.00

Question 2:
Prior to this ATP-funded project, my organization has __________ (please select one response—frequently/infrequently/never) been involved with a university as a subcontractor to a research project.

Frequently = 3, infrequently = 2, never = 1; mean = 2.00

Question 3:
The university research partners in this ATP-project were selected to participate because of (please rank the items below from 1 = most important to least important; no ties please):

__ geographic proximity to the non-university research members
__ geographic proximity to the university subcontractors
__ access to specialized equipment
__ access to eminent researchers
__ overall research reputation **[this was the dominant response]**
__ previous research interactions with the non-university research members
__ previous research interactions with the university subcontractors

__ ability to coordinate basic research activities
__ other (please explain and rank)

Question 4:
The university subcontractors in this ATP-project were selected because of (please rank the items below from 1 = most important to least important; no ties please):
__ geographic proximity to the non-university research members
__ geographic proximity to the university research members
__ access to specialized equipment
__ access to eminent researchers
__ overall research reputation **[this was the dominant response]**
__ previous research interactions with the non-university research members
__ previous research interactions with the university research members
__ previous subcontracting relationships with the non-university research members
__ other (please explain and rank)

Question 5:
What are the extended research benefits (i.e., research benefits beyond the scope of this particular research project) associated with having a university involved as a research partner compared to as a subcontractor?

Question 6:
What differences are there in the intellectual property issues associated with a university as a research partner compared to a university as a subcontractor?

Please respond from the perspective of the non-university members of the joint venture to the following statements using a response scale ranging from 7 = strongly agree to 1 = strongly disagree. If you do not have an opinion, please respond with "n/a."

Statement 1:
University research partners are more integral to the overall research project than are university subcontractors.

strongly agree……………………………………………....strongly disagree **mean = 5.60**
7 6 5 4 3 2 1

Statement 2:
Technological capabilities are the primary factor that determines whether a university has the role of a research partner as opposed to the role of a subcontractor.

strongly agree……………………………………………....strongly disagree **mean = 4.50**
7 6 5 4 3 2 1

Statement 3:
The decision to involve a university as a subcontractor compared to a for-profit company as a subcontractor was based primarily on technical capabilities.

strongly agree..strongly disagree **mean = 6.00**

7 6 5 4 3 2 1

Statement 4:
The decision to involve a university as a subcontractor compared to a for-profit company as a subcontractor was based primarily on cost considerations.

strongly agree..strongly disagree **mean = 3.33**

7 6 5 4 3 2 1

Statement 5:
The decision to involve a university as a subcontractor was made after the project began in response to an unexpected technical need.

strongly agree..strongly disagree **mean = 4.00**

7 6 5 4 3 2 1

Statement 6:
At this stage of the project I am of the opinion that the most effective way to involve a university in a research joint venture is as a subcontractor as opposed to as a research partner.

strongly agree..strongly disagree **mean = 2.80**

7 6 5 4 3 2 1

Statement 7:
There is more "red tape" associated with having a university as a research partner in a joint venture as opposed to as a subcontractor.

strongly agree..strongly disagree **mean = 4.80**

7 6 5 4 3 2 1

Statement 8:
University involvement as a research participant in this project provided a window on the various uses of the technology being developed that non-university members of the joint venture would not likely have recognized.

strongly agree..strongly disagree **mean = 4.40**

7 6 5 4 3 2 1

Statement 9:
This research project has experienced difficulties acquiring and assimilating basic knowledge necessary for the project's progress.

strongly agree…………………………………………………...strongly disagree **mean = 2.40**
7 6 5 4 3 2 1

Statement 10:
Potential new applications of the technology being developed have been recognized over the course of the project.

strongly agree…………………………………………………...strongly disagree **mean = 6.20**
7 6 5 4 3 2 1

Statement 11:
At this stage of the research, it appears that the technology will be developed and commercialized sooner than expected when the project began.

strongly agree…………………………………………………...strongly disagree **mean = 3.00**
7 6 5 4 3 2 1

Please complete the following statements.

Statement 12:
The number of conceptual research problems encountered in this project has been _____ (please select one response—more than / less than / about the same as) expected when the project began.

More than = 3, about the same = 2, less than = 1; mean = 2.20

Statement 13:
The number of equipment-related research problems encountered in this project has been _____ (please select one response—more than / less than / about the same as) expected when the project began.

More than = 3, about the same = 2, less than = 1; mean = 2.20

Statement 14:
The number of personnel-related research problems encountered in this project has been _____ (please select one response—more than / less than / about the same as) expected when the project began.

More than = 3, about the same = 2, less than = 1; mean = 1.80

Statement 15:
To date, approximately ___ percent of the research time devoted to this project has, in retrospect, been unproductive.

mean = 12.0%

Statement 16:
To date, approximately ___ percent of the financial resources devoted to this project has, in retrospect, been unproductive.

mean = 10.0%

Statement 17:
We were unsuccessful in attracting certain universities to participate in this research project as research partners. These universities included:

And the primary reason that we were unable to attract them into the joint venture was:

Statement 18:
We were unsuccessful in attracting certain universities to participate in this research project as subcontractors. These universities included:

And the primary reason that we were unable to attract them into the joint venture was:

Please return by facsimile as soon as possible your completed questionnaire to **Professor Albert Link.** Again, thank you for your participation in this project.

Appendix B5. Survey instrument for single applicants with no university involvement.

UNIVERSITIES AS RESEARCH PARTNERS:
A Survey Conducted for the Advanced Technology Program at NIST
by
Professor Bronwyn Hall — University of California at Berkeley
Professor Albert Link — University of North Carolina at Greensboro
Professor John Scott — Dartmouth College

Thank you for agreeing to participate in this ATP-sponsored survey. The primary purpose of this survey is to explore why your ATP-funded project was undertaken in the absence of any university research assistance. All specific information from this survey will remain confidential; only summary findings will be incorporated into a final report to ATP.

Please respond to each of the following background questions using the response format noted in each question.

Question 1:
Prior to this ATP-funded project, my organization has __________ (please select one response—frequently/infrequently/never) been involved with a university in a research project.

Frequently = 3, infrequently = 2, never = 1; mean = 2.11

Question 2:
Did you consider having a university participate in this project as a research partner?

_____YES _____NO

Yes = 0, No = 1; mean = 0.78

If YES to Question 2, what criteria did you use to identify the university research partner?
1.
2.
3.

If YES to Question 2, briefly explain why the partnership did not come about.

If NO to Question 2, were there barriers that prevented identification of potential university partners, and if so what were they?

Question 3:
Were intellectual property issues an important reason for not including a university as a research partner in this study?

_____YES _____NO
Yes = 0, No = 1; mean = 0.22

If YES to Question 3, briefly explain what these issues were.

Question 4:
Were intellectual property issues an important reason for not including another company as a research partner in this study?

_____YES ____NO
Yes = 0, No = 1; mean = 0.44

If YES to Question 3, briefly explain what these issues were.

Please respond to the following statements by circling a response scale ranging from 7 = strongly agree to 1 = strongly disagree. If you do not have an opinion, do not respond to the statement.

Statement 1:
This research project is of too small a scale to warrant another company as a research partner.

strongly agree...strongly disagree **mean = 2.83**
7 6 5 4 3 2 1

Statement 2:
This research project is of too small a scale to warrant a university as a research partner.

strongly agree...strongly disagree **mean = 3.06**
7 6 5 4 3 2 1

Statement 3:
This research project concerns proprietary research so another company as a research partner would not be warranted.

strongly agree...strongly disagree **mean = 5.44**
7 6 5 4 3 2 1

Statement 4:
This research project concerns proprietary research so a university as a research partner would not be warranted.

strongly agree..strongly disagree **mean = 4.67**
7 6 5 4 3 2 1

Statement 5:
There was insufficient time during the preparation of the research proposal to identify an appropriate company to be a research partner.

strongly agree..strongly disagree **mean = 4.88**
7 6 5 4 3 2 1

Statement 6:
There was insufficient time during the preparation of the research proposal to identify an appropriate university to be a research partner.

strongly agree..strongly disagree **mean = 5.06**
7 6 5 4 3 2 1

Statement 7:
This research project has experienced difficulties acquiring and assimilating basic knowledge necessary for the project's progress.

strongly agree..strongly disagree **mean = 2.61**
7 6 5 4 3 2 1

Statement 8:
Potential new applications of the technology being developed have been recognized over the course of the project.

strongly agree..strongly disagree **mean = 5.56**
7 6 5 4 3 2 1

Statement 9:
At this stage of the research, it appears that the technology will be developed and commercialized sooner than expected when the project began.

strongly agree..strongly disagree **mean = 4.67**
7 6 5 4 3 2 1

Please complete the following statements using one of the response phrases.

Statement 10:
The number of conceptual research problems encountered in this project has been _____ (please select one response—more than / less than / about the same as) expected when the project began.

More than = 3, about the same = 2, less than = 1; mean = 2.44

Statement 11:
The number of equipment-related research problems encountered in this project has been _____ (please select one response—more than / less than / about the same as) expected when the project began.

More than = 3, about the same = 2, less than = 1; mean = 2.22

Statement 12:
The number of personnel-related research problems encountered in this project has been _____ (please select one response—more than / less than / about the same as) expected when the project began.

More than = 3, about the same = 2, less than = 1; mean = 2.50

Statement 13:
To date, approximately ___ percent of the research time devoted to this project has, in retrospect, been unproductive.

mean = 13.8%

Statement 14:
To date, approximately ___ percent of the financial resources devoted to this project has, in retrospect, been unproductive.

mean = 6.5%

Please return by facsimile as soon as possible your completed questionnaire to **Professor Albert Link.** Again, thank you for your participation in this project.

Appendix B6. Survey instrument for single applicants with university involvement as subcontractors

UNIVERSITIES AS RESEARCH PARTNERS:
A Survey Conducted for the Advanced Technology Program at NIST
by
Professor Bronwyn Hall — University of California at Berkeley
Professor Albert Link — University of North Carolina at Greensboro
Professor John Scott — Dartmouth College

Thank you for agreeing to participate in this ATP-sponsored survey. The primary purpose of this survey is to explore the role of university subcontractors in your ATP-funded project compared to for-profit companies. All specific information from this survey will remain confidential; only summary findings will be incorporated into a final report to ATP.

Please respond to each of the following background questions using the response format noted in each question.

Question 1:
Prior to this ATP-funded project, my organization has __________ (please select one response—frequently/infrequently/never) been involved with a university as a subcontractor in a research project.

Frequently = 3, infrequently = 2, never = 1; mean = 2.56

Question 2:
The university subcontractors in this ATP-project were selected because of (please rank the items below from 1=most important to least important; no ties please):
__ geographic proximity to research members of the joint venture
__ access to specialized equipment
__ access to eminent researchers **[this was the dominant response]**
__ overall research reputation
__ other (please explain and rank)

Question 3:
Did you consider a for-profit subcontractor to participate in this study but chose a university subcontractor instead?

_____YES _____NO
Yes = 0, No = 1; mean = 0.86

If YES, briefly explain why.

If NO, briefly explain why.

Question 4:
Were intellectual property issues an important reason for including a university as a subcontractor rather than as a research partner?

_____YES _____NO
Yes = 0, No = 1; mean = 0.78

If YES, briefly explain why.

Question 5:
Does your collaborative arrangement with the university subcontractor entail the sharing of future revenues associated with the development and commercialization of technology from this project?

_____YES _____NO
Yes = 0, No = 1; mean = 0.67

If YES, would you describe, in general terms, this arrangement? For example, does the arrangement involve sharing licensing fees? Royalties? Profits? Can you divulge what these percentages are using a range of values rather than a specific percentage? How well does this arrangement work from the perspective of your company?

Please respond to the following statements using a response scale ranging from 7 = strongly agree to 1 = strongly disagree. If you do not have an opinion, please respond with "n/a."

Statement 1:
University subcontractors are perceived to be easier to work with than for-profit subcontractors.

strongly agree...strongly disagree **mean = 3.33**
7 6 5 4 3 2 1

Statement 2:
University subcontractors are perceived to be less expensive than for-profit subcontractors.

strongly agree...strongly disagree **mean = 4.78**
7 6 5 4 3 2 1

Statement 3:
Based on my experience thus far in this project, I would consider a university subcontractor again for a similar research project.

strongly agree...strongly disagree **mean = 6.11**
7 6 5 4 3 2 1

Statement 4:
This research project has experienced difficulties acquiring and assimilating basic knowledge necessary for the project's progress.

strongly agree…………………………………………….....strongly disagree **mean = 3.00**
7 6 5 4 3 2 1

Statement 5:
Potential new applications of the technology being developed have been recognized over the course of the project.

strongly agree…………………………………………….....strongly disagree **mean = 5.78**
7 6 5 4 3 2 1

Statement 6:
At this stage of the research, it appears that the technology will be developed and commercialized sooner than expected when the project began.

strongly agree…………………………………………….....strongly disagree **mean = 3.56**
7 6 5 4 3 2 1

Please complete the following statements.

Statement 7:
The number of conceptual research problems encountered in this project has been _____ (please select one response—more than/less than/about the same as) expected when the project began.

More than = 3, about the same = 2, less than = 1; mean = 2.44

Statement 8:
The number of equipment-related research problems encountered in this project has been _____ (please select one response—more than / less than / about the same as) expected when the project began.

More than = 3, about the same = 2, less than = 1; mean = 2.00

Statement 9:
The number of personnel-related research problems encountered in this project has been _____ (please select one response—more than/less than/about the same as) expected when the project began.

More than = 3, about the same = 2, less than = 1; mean = 2.44

Statement 10:
To date, approximately ___ percent of the research time devoted to this project has, in retrospect, been unproductive.
mean = 11.1%

Statement 11:
To date, approximately ___ percent of the financial resources devoted to this project has, in retrospect, been unproductive.
mean = 9.4%

Please return by facsimile as soon as possible your completed questionnaire to **Professor Albert Link.** Again, thank you for your participation in this project.

ABOUT THE ADVANCED TECHNOLOGY PROGRAM

The Advanced Technology Program (ATP) is a partnership between government and private industry to conduct high-risk research to develop enabling technologies that promise significant commercial payoffs and widespread benefits for the economy. The ATP provides a mechanism for industry to extend its technological reach and push the envelope beyond what it otherwise would attempt.

Promising future technologies are the domain of ATP:

- Enabling technologies that are essential to the development of future new and substantially improved projects, processes, and services across diverse application areas.
- Technologies for which there are challenging technical issues standing in the way of success.
- Technologies whose development often involves complex "systems" problems requiring a collaborative effort by multiple organizations.
- Technologies that will go undeveloped and/or proceed too slowly to be competitive in global markets without ATP.

The ATP funds technical research, but it does not fund product development—that is the domain of the company partners. The ATP is industry driven, and that keeps it grounded in real-world needs. For-profit companies conceive, propose, co-fund, and execute all of the projects cost-shared by ATP.

Smaller firms working on single-company projects pay a minimum of all the indirect costs associated with the project. Large, "*Fortune* 500" companies participating as a single company pay at least 60 percent of total project costs. Joint ventures pay at least half of total project costs. Single-company projects can last up to three years; joint ventures can last as long as five years. Companies of all sizes participate in ATP-funded projects. To date, more than half of ATP awards have gone to individual small businesses or to joint ventures led by a small business.

Each project has specific goals, funding allocations, and completion dates established at the outset. Projects are monitored and can be terminated for cause before completion. All projects are selected in rigorous competitions that use peer review to identify those that score highest against technical and economic criteria.

Contact ATP for more information:

- On the Internet: http://www.atp.nist.gov
- By e-mail: atp@nist.gov
- By phone: 1-800-ATP-FUND (1-800-287-3863)
- By writing: Advanced Technology Program, National Institute of Standards and Technology, 100 Bureau Drive, Mail Stop 4701, Gaithersburg, MD 20899-4701

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