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Winning an Award from the Advanced Technology Program: Pursuing R&D Strategies in the Public Interest and Benefiting From a Halo Effect

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Winning an Award from the Advanced Technology Program: Pursuing R&D Strategies in the Public Interest and Benefiting from a Halo Effect

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Abstract

This paper addresses two questions: (1) how attributes of a firm's R&D strategy relate to the goals of the Advanced Technology Program and affect the chances of winning an award from the program; and (2) how winning an award affects a firm's success in raising additional funds for the proposed research project. Using data from a 1999 survey of the firms that applied for ATP funding in 1998, we find that award-winners are more likely to behave in ways that enhance the transfer of knowledge to, and the take up of technology by, other firms. Compared to non-winning applicants, award winning firms exhibit a greater willingness to share their research findings with other firms and are more embedded in a network of linkages to other firms. The award-winning group is also more likely to include projects and firms that open up new pathways to innovation. We also find award-winning firms have greater success in attracting additional funding for their ATP projects from other sources. Hence, ATP increases spending on risky R&D projects by other actors in the U.S. innovation system.

KEY WORDS: R&D strategy; public-private partnership; Advanced Technology Program; program evaluation.

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Executive Summary

The public interest is served when research and development (R&D) activities lead to the development of technical advances that enhance the quality of life of the nation's citizenry and that help to sustain high productivity economic growth. However, important opportunities for companies to make technical advances are likely to go unexplored for the following reasons:

- R&D projects on the technological frontier are risky and the probability of successfully overcoming certain scientific and technical barriers may be low.
- An individual firm may not have the capabilities required to develop the technology. Complex new technologies may require firms to collaborate and share information; however, the cost of establishing R&D partnerships and making them work productively may discourage firms from undertaking an R&D project.
- A firm may not undertake an R&D project because there are difficulties in appropriating the resulting benefits, e.g., the resulting knowledge may flow to others who benefit without sharing the costs, or other firms may capture a significant portion of business profits resulting from that R&D.

Public-private R&D partnerships can address these problems by encouraging firms to undertake problematic but promising projects.

The Advanced Technology Program (ATP) is such a public-private partnership program that was established in 1990 under the Technology Administration of the U.S. Department of Commerce. The goal of the program is to provide cost-sharing awards to firms for early stage R&D activities by U.S. firms that advance knowledge in a particular technical field *and*, if successful, are likely to achieve broad economic benefits that would not occur otherwise.

This report has two purposes. First, we examine the characteristics of projects and firms selected by ATP for funding. Our objective is to determine the behavioral patterns and strategies that distinguish award-winning firms from other applicants. We test specific hypotheses about project characteristics and firm practices by which award-winning firms are expected to integrate public and private objectives in their R&D strategies. We then consider whether ATP funding makes a difference to firms in attracting additional resources to carry out high-risk, potentially high-payoff R&D.

Our research provides new information and insights on the attributes of firms that won an ATP award in 1998. Specifically, we surveyed 1998 applicant firms in order to develop a set of indicators that measure the receptivity of an applicant to other firms' use of its research results, the extent of the firm's connections to the technical and financial resources of other organizations in R&D activities, and the potential for the proposed project to generate new pathways for disseminating innovation. Using these measures as indicators for the ways in which the R&D strategies of firms may align with the broad public interests that public private partnership programs (like the ATP) may serve, we ask:

- Compared to non-winners, do the firms that win an ATP award have R&D strategies with greater potential to open new pathways to innovation, contribute to the knowledge and technologies developed by other firms, and achieve commercial/economic impacts from their projects?

When information about a company's R&D activity comes from a credible source, such as a government agency with a reputation for scientific integrity and programmatic expectations for economic impacts, other public and private organizations will likely use that information in their investment and funding decisions. Thus, an ATP award may provide a certification function that validates a technology and signals to other investors that a technology is worth consideration.

The second issue we consider in this paper is whether ATP funding makes a difference to firms in attracting resources to carry out their high-risk, potentially high-payoff R&D. We address this question in two parts.

- Are the proposed projects pursued by firms in the absence of an ATP public-private cost-sharing partnership?
- Does the ATP award stimulate additional funding by other private and public sources?

In the Pursuit of Public Interest: The Distinguishing Features of Award-winning R&D Strategies

Our key finding is that the firms selected by the ATP are especially well positioned to deliver public benefits from their R&D activities. Award winners exhibit a greater inclination to engage in behaviors that facilitate the spread of knowledge, open up new pathways, and sustain connections among firms important to the development of innovations and ultimate successful commercialization. Specifically, for the 1998 applicants, we find that the R&D strategies of ATP award winners are distinguishable from all other applicants by having:

- a more extensive set of business linkages that facilitate the diffusion of knowledge and the commercialization process;
- a tendency towards openness in communications about research with other firms and institutions;
- research projects that are new to the firm;
- and projects that entail the formation of new R&D collaborations with other organizations.

Does ATP Funding Make Any Difference?

Do firms carry out proposed projects without ATP funding?

To the extent that the ATP attracts proposals for high risk projects, we would not expect projects to proceed without support from the ATP, or some other external funding source. On the other hand, if the ATP attracted proposals that companies planned to fund anyway, we would expect a high proportion of non-winning firms to pursue projects they had proposed to the ATP when we interviewed them one year later.

- For the most part, the ATP appears to attract the type of projects that require support from an outside source in order for the firm to be willing (and able) to proceed with its R&D plans. Most (63%) of our comparison group of non-winners did not proceed with any aspect of the R&D project proposed to the ATP. Moreover, of those that began work on the project without ATP support, in most instances (76%) the project was pursued at a smaller scale than the company originally proposed to the ATP.
- We conclude that ATP funding makes a difference by supporting R&D projects that would either not go forward or only be pursued at a lower scale of effort.

Does the ATP award stimulate additional funding of high-risk R&D projects by other public and private sources?

To the extent that winning an ATP award is perceived to certify the quality of the project and the firm, other public and private sources of funding will be more favorable disposed to supporting ATP award winners over other firms that request funding. This reputation effect from the award is termed a "halo effect." We assess the impact of the ATP award on other funding sources, by controlling for firm- and project-specific factors that may influence a firm's success in attracting funding from sources outside the firm.

- We find that, all else being equal, a firm that wins an ATP award is more successful in raising funds for the project from non-ATP sources.

Conclusions

The ATP is picking high-quality, high-risk R&D projects proposed by firms with R&D strategies that readily accommodate the goals of the program and serve the broader public purpose of such partnership programs in alleviating problems that inhibit technical advance, thus enhancing the overall efficiency of the U.S. innovation system. Our examination of a comparison group of projects also shows that in the absence of the type of public-private partnership provided by the ATP, a majority of firms are not likely to proceed with these projects on their own. Lastly, we show that the ATP award has benefit that is recognized by the investment community. By their actions, other funding sources demonstrate that they believe the ATP selection process identifies quality research projects and companies. Thus, the award confers a "halo" effect that prompts other funding sources to invest in these projects, stimulating additional investment in risky R&D projects.

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1. Introduction

Through a number of different mechanisms, the federal government provides R&D funding to universities and colleges, government-owned laboratories, and for-profit enterprises.[1] When the government funds R&D projects that are carried out by for-profit enterprises, there is always a question about whether and how the public interest is served. After all, private firms are expected to fund research when there is a technical opportunity with promising profit potential. The public interest is served when private firms' R&D leads to technical advances that enhance the quality of life of the nation's citizenry and that help to sustain high productivity economic growth. To the extent that private firms fund promising research, there is an alignment of public and private interests. However, important opportunities for companies to make technical advances are likely to go unexplored for the following reasons:

- R&D projects on the technological frontier are risky and the probability of successfully overcoming certain scientific and technical barriers may be low.
- An individual firm may not have the capabilities required to develop a technology. Complex new technologies may require firms to collaborate and share information; however, the cost of establishing research and development (R&D) partnerships and making them work productively may discourage firms from undertaking an R&D project.
- A firm may not undertake an R&D project because there are difficulties in appropriating the resulting benefits, e.g., the resulting knowledge may flow to others who benefit without sharing the costs, or other firms may capture a significant portion of business profits resulting from that R&D.

[1] For a recent discussion of new directions in the federal government's R&D programs, see Kelley (1997).

A public-private R&D partnership is a policy instrument that may be designed to address these problems. A government program offering cost-sharing partnerships with the private sector can provide a catalyst for private firms to undertake high-risk research which will have broad-based knowledge benefits for other firms and other industries. Government programs can also provide a neutral forum for competitors to work together on mutually beneficial research.[2] In reducing the transaction costs of establishing new R&D partnerships to the firm, government funding provides the opportunity to open up new paths to innovation. Another public benefit from government funding and the establishment of R&D collaborations may be the more rapid diffusion of knowledge about scientific advances of economic relevance to the private sector. In sum, government funding may reduce the scientific and technical risk sufficiently to bring the project within an acceptable rate of return for private-sector investment.[3]

Since 1990, the Advanced Technology Program (ATP), an example of a public-private R&D partnership, has funded U.S. based companies on a cost-sharing basis for conducting pre-competitive research and development of technologies with the potential for commercial applications. The ultimate long-term goal of the program is to achieve greater productivity growth in the economy through the promotion of technical advances that become incorporated in industrial processes, new products, and services.[4] In the long run, the economic benefits to consumers and other firms using and further developing these technologies are expected to be substantially greater than the profits realized by the initial innovating firm that received an ATP award.

This paper addresses two issues. In the first part, we focus on identifying the distinctive features of R&D strategies that are awarded by the ATP. The second issue of concern is whether ATP funding makes a difference to firms in attracting resources to carry out high-risk, potentially high-payoff R&D.

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[2] SEMATECH is an example of a successful public-private partnership program that has generated productive and profitable research collaborations among firms in the semiconductor industry (National Research Council (1996: footnote 19).

[3] According to Griliches (1992), the general argument for government funding of R&D activities is that the subsidy provides an incentive to firms to undertake risky R&D projects when the public rate of return exceeds the private rate of return. For-profit enterprises typically use some pre-determined benchmark rate of return (i.e., the hurdle rate). Only when the private expected rate of return for an R&D project exceeds the hurdle rate is a firm willing to undertake it. By reducing the firm's costs of undertaking risky R&D projects, government funding increases the expected rate of return for the firm, and thus increasing the willingness of the firm to pursue this type of research.

[4] For a discussion of the legislation and policy issues that led to the establishment of the ATP, see Hill (1998). For a formal presentation of the economic rationale underlying the ATP, see Jaffe (1996).

With respect to the first research question, we measure the receptivity of an applicant to other firms' use of its research results, the extent of the firm's connections to the technical and financial resources of other organizations in planning and carrying out its R&D-specific activities, and the potential for the proposed project to generate new pathways to innovation. Using these measures as indicators for the ways in which firms may incorporate public interests in their R&D strategies, we ask:

- Compared to non-winners, do the firms that win an ATP award have R&D strategies with greater potential to open new pathways to innovation and contribute to the knowledge and technologies developed by other firms?

Government funding is expected to spur additional private investment in R&D activities.[5] In the early stages of a technology's development, the value of the research is often difficult to assess. Moreover, the lack of information about the capabilities of other firms inhibits collaborative R&D efforts among firms. Hence, there is greater risk and likely under-investment in early stage R&D.

When information about a company's R&D activity comes from a credible source, such as a government agency with a reputation for scientific integrity and programmatic expectations for economic impacts, other public and private organizations will likely take note of that information in making their investment and funding decisions. An ATP award may serve a certification function in providing validation for a technology and signaling to other investors and funders that a technology is worthy of consideration. We address this question in two parts.

- Do non-winners in ATP funding competitions continue to pursue their proposed research projects without ATP funding?
- Are ATP award winners more likely to attract funding for their proposed R&D effort from other sources subsequent to winning an ATP award?

The failure of non-winners to pursue the R&D projects at the same level of effort proposed to the ATP indicates either the unwillingness or inability of these firms to completely fund the research with their own resources. Since all applicants to the ATP are proposing early stage R&D projects, the extent to which non-winners fail to pursue these projects without ATP funding provides an indication of what is likely to happen in the absence of the program. Moreover, comparing the relative success in fund-raising of ATP award winners and non-winning applicants allows us to assess the impact of the award in stimulating additional investment by other sources of R&D funds.

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[5] Previous research suggests that how the government provides funding to the private sector is important. David, Hall, and Toole (2000) indicate that the private sector is less likely to increase its R&D spending when government funding comes through contract R&D programs in which follow-on funding contracts for R&D or procurement is likely.

2. Background on the Advanced Technology Program

Since the program began operation in 1990, ATP has held annual competitions, soliciting proposals from all industries and – over the period 1994 to 1998 – for targeted technical problem areas. As of the close of 1999, when the data collection phase of this study ended, the ATP had provided funding to 468 industry-proposed R&D projects. Of the 1,067 participating organizations in ATP funded projects from 1990 through 1999, 71% were involved in joint venture projects with two or more firms. Moreover, although only 34% of ATP-funded projects were submitted as formal joint ventures, when all subcontractors are counted, fully 84% of all projects involve two or more organizations in a collaborative R&D effort.[6] Hence, even though there is no explicit mandate to support firms' initiatives in R&D collaborations, projects funded by the ATP tend to be joint projects with another firm or a university as a partner.

ATP depends on the initiative of industry to define the goals for the proposed research projects and to specify the organizational arrangements (e.g., with and without collaborators, joint ventures or more restricted contract relations with other organizations, etc.) that best meet those goals. All proposals submitted to the program for review are required to address the same set of issues. Applicants are provided a guide to use in preparing proposals. The guide includes information on the evaluation criteria that the ATP employs in selecting awardees.

To merit funding, the project must have both scientific and economic potential:

> "The research must be challenging, with high technical risk... aimed at overcoming an important problem(s) or exploiting a promising opportunity...[and] must have a strong potential for advancing the state of the art and contributing significantly to the U.S. scientific and technical knowledge base.
>
> The proposed technology must have a strong potential to generate substantial benefits to the nation that extend significantly beyond the direct returns to the proposing organization(s). The proposal must explain why ATP support is needed and what difference ATP funding is expected to make. The pathways to economic benefit...includ[e] the proposer's plan for getting the technology into commercial use, as well as additional routes that might be taken to achieve broader diffusion of the technology.."
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> (Chapter 1, p. 7-8, *Advanced Technology Program Proposal Preparation Kit*, 1999).

[6] Universities have been involved in 57% of all ATP projects, most often as subcontractors to participating companies.

Both technical experts and specialists in business and economic analysis of R&D projects evaluate every proposal. The selection process involves an assessment of the technical difficulties and promise of the project, its economic potential, and the need for public funding.

The selection process is highly competitive. Between 1990 and 1999, only 12 percent of proposed projects were funded. These award-winning projects included 16% of the 6,668 participating organizations (excluding subcontractors) identified on the proposals submitted to the program during this period.

3. Data Description

The 1998 ATP competition was held during the summer of 1998. The award winners were announced in October. There were a total of 822 organizations represented in 502 proposed projects. Our primary interest is the 741 for-profit enterprises that applied to ATP in 1998. This group of firms constitutes our sampling frame.

TABLE 1: PERCENT DISTRIBUTION OF APPLICANTS BY AWARD STATUS AND FIRM SIZE

	Award Status		
	Award Winners	Non-Winners	All Applicants
Large Firms (500 or more employees)	48%	27%	31%
Small Firms (Less than 500 employees)	52%	73%	69%
Number of Firms	147	594	741
Percent of All 1998 Applicant Firms	(20%)	(80%)	

Source: Survey of 1998 ATP Applicants.

ATP funded 79 proposals involving 161 organizations as principal participants (i.e., excluding subcontractors). There were 147 for-profit enterprises involved as principal organizations in these award-winning projects. Table 1 shows the distribution of firms by award status and firm size. Only 20 percent of applicant firms were awarded any ATP funds in the 1998 competitions. Small firms, with fewer than 500 employees, constituted 69 percent of all firms that applied to ATP that year. Even though firms in this size category were only 52% of ATP award recipients, they accounted for 83% of all awards made to individual companies in 1998.[7]

[7] There were also 27 joint venture (JV) projects funded in 1998. These JV projects include 65% of all winning firms and 87% of the winners with more than 500 employees.

We designed and pre-tested a survey instrument that was reviewed and approved by the Office of Management and Budget.[8] The purpose of the survey was to collect information from the applicant firms on the preparation of the ATP proposals, the involvement of other organizations (formally or informally) in the ATP proposed project, aspects of the firm's R&D strategy, and the applicants' perceptions of the ATP selection process.[9] In addition, we asked about the current status of the proposed project and the firm's experiences with other R&D funding sources before and after the ATP application.

The survey was designed to determine whether firms that win an ATP award, compared with non-winners, have R&D strategies that are more consistent with the broad program goals of ATP. That is, do the R&D strategies of winners have greater potential to open new pathways to innovation, to make contributions to the knowledge and technologies developed by other firms, and to achieve commercial/economic impacts from their efforts? The survey questions were consistent with broad program goals, but were not explicit representations of specific ATP project selection criteria. Although some strategies may be more appropriate than others for achieving certain program objectives, the program does not require specific R&D strategies or practices of the firms it selects for funding.

We directed the questionnaire to the person identified as the technical lead for the proposed project. If this person was no longer with the company, we asked for the individual who was most knowledgeable about the proposal and the company's R&D activities in the technical area identified in the proposal. The survey data were collected over a six-month period (June-December 1999). All interviews were conducted by telephone and averaged 20-30 minutes per completed interview.

Prior to calling a respondent to conduct the interview, we followed standard survey method procedures, sending a letter to each individual in the selected sample explaining the purpose of the survey, identifying the ATP as the sponsor of the study, and asking the designated respondent to cooperate in the survey. This letter also contained a statement of confidentiality and guarantee that responses to survey questions would remain anonymous. In addition, our mailing included a letter from the contractor that identified the organizations responsible for carrying out the survey (Johns Hopkins University and the University of Baltimore), provided contact information, and included a selection of questions that the respondent might find helpful to have in advance of the telephone interview.

[8] OMB granted approval (no. 0693-0027) for Johns Hopkins University to conduct the survey on March 24, 1999.

[9] A copy of the questionnaire is available from the authors upon request.

Our sample consisted of all the firms that received awards in 1998, plus a random sample of 50% of the non-winners. Thus, we contacted 297 non-winners and 147 awardees one year after the 1998 ATP selection process. As Table 2 indicates, we achieved an overall effective response rate of 61 percent, completing interview from 119 award winners and 122 non-winners. In the sample of non-winners, we discovered 23 cases where the proposing company was no longer in business, and another 26 cases where the person responsible for preparing the ATP proposal was no longer employed at the company and the company was not pursuing any aspect of the R&D proposed to ATP. We adjusted our response rate for non-respondents accordingly.

TABLE 2: SAMPLE SIZE AND SURVEY RESPONSE RATE BY AWARD STATUS

	Award Winners	Non-Winners	All Applicants
Total Population	147	594	741
Total Sample	147	297	444
Adjusted Sample	147	248	395
Number of Respondents	119	122	241
Response Rate	81%	49%	61%

Source: Survey of 1998 ATP Applicants.

The survey results were matched with company and project-specific data from other sources. First, we used independent sources, such as the CorpTech Database and Hoovers Online Company and Industry Network to verify survey responses concerning employment, financing, and the founding date of the company.[10] Second, we matched each record with information from ATP administrative records on the technology area of the proposal, the results of the ATP proposal review process, and the firm's prior history of applications and awards.

[10] See http://www.corptech.com/ and http://www.hoovers.com/

4. The Alignment of Public and Private Interests in the R&D Strategies of Firms

The ATP evaluates the quality of the research and the technical plan of each project it considers for funding and funds projects that are considered to be of high quality and to have commercial and economic potential. Obviously, a high quality research project is more likely to generate knowledge that will advance the state of the art in a particular technical field.

We hypothesized that there are four aspects of an R&D strategy that indicate an award-winning approach that best accommodates the public and private interests of the program. These are: the extent of a firm's linkages to other organizations, attitudes indicating the firm's receptivity to the use of its research results by others outside the firm, its willingness to form new R&D partnerships with other firms, and willingness to start R&D in new technical areas that are not currently part of the firm's existing R&D portfolio.

Each of these attributes is important to achieving the objectives of the program and to overcoming the difficulties that may be inhibiting technical advance. For example, a firm's approach to sharing information about its research and the extent of its linkages to other organizations in carrying out R&D affect how quickly knowledge about the firm's ATP-supported R&D project may spread to other firms and how rapidly the technology developed with ATP funds may be taken up by other firms. We do not expect all projects and funded firms to exhibit the same R&D strategy. Rather, we expect to find a higher incidence of these attributes to be evident among the set of award-winning firms and projects as a whole.

4.1 The Importance of Inter-Organizational Networks to Knowledge Diffusion and Commercialization of New Technologies

For knowledge to contribute to a scientific or technical field, it must flow *out* of the enterprise to members of the external scientific and engineering community. Hence, whether the R&D activity of a firm advances knowledge in a scientific or technical field depends on the opportunities for interchange between the firm's employees and their scientific and engineering peers outside the firm. A firm's network of ties to other organizations provides multiple pathways through which knowledge about innovative activity reaches other actors in the U.S. innovation system.[11] These include other for-profit enterprises and universities that are themselves involved in developing or using new technologies. The more embedded a firm is in a network of such inter-organization ties, the more quickly the knowledge generated by the firm is expected to be absorbed by other organizations in the system.

[11] For a discussion of the importance of organizational networks to innovation in biotechnology, see Powell, Koput, and Smith-Doer (1996). For a related discussion of the importance of social networks among scientists and engineers, see Liebeskind, Oliver, Zucker, and Brewer (1996). For a discussion of the influence of the defense industrial network on the take up of information technologies in manufacturing, see Kelley and Cook (1998).

Universities are an important source of new knowledge that may be applied to a broad range of industry problems.[12] A firm may enhance its R&D capabilities by hiring university graduates, collaborating with university faculty and technical staff, using specialized equipment at the university's laboratory facilities, or contracting for rights to use the intellectual property developed by university researchers. These connections to a university also serve as potential pathways for knowledge flows *from* the firm to the university-based research community. The more ways that a firm is linked to university resources and programs, the greater the potential for knowledge flows in both directions.

Although the potential commercial uses for a technology are an important consideration in ATP's selection of award-winning projects, the ATP does not fund product development or market research. As a consequence, a firm needs additional resources from non-ATP sources, including internal resources or those of other firms, in order to realize its commercialization plans. To yield much of an economic impact from the type of early stage research projects supported by the ATP, it will also frequently be necessary for other firms to undertake the development of related technologies. Hence, connections to other firms, both in the planning and development of the project and as sources of financial and technical support to the proposer, are especially important to the success of the company's commercialization plans. Moreover, the more embedded a firm is in such a network of relations with other enterprises, the more likely the research will be taken up and used by other enterprises. Thus, the greater the type and number of these connections a firm has to other for-profit enterprises, the greater the potential an R&D project will achieve success in commercialization of technology *and* contribute to the knowledge base of relevant actors in the U.S. innovation system.

From the survey data, we constructed two indices to measure the extent of a firm's linkages to these two important classes of organizations in the U.S. innovation system – universities and other for-profit enterprises. Both indices were constructed from a set of responses to questions from the survey. Index items included the various ways the applicant firm may have used the resources of other organizations to prepare the ATP proposal. In addition, we included information provided by the respondent concerning the sources of technical and financial assistance received by the applicant firm in the two years prior to the ATP application.

Table 3 identifies 12 different ways that our survey asked about an applicant firm's use of university resources. Included are measures of the involvement of a university as a partner and as a resource for the ATP project and connections to university resources that are not specific to the ATP project. We used a simple count of the presence of these connections to construct an additive scale measuring the strength and diversity of connections of the firm to the university-based research community.

[12] For a recent discussion of the role of universities in the U.S. innovation system, see: Rosenberg and Nelson (1994). For a discussion of the role of universities in ATP-funded R&D projects, see: Hall, Link, Scott (2000).

TABLE 3: QUESTIONNAIRE ITEMS IN UNIVERSITY LINKAGES INDEX

For ATP project and proposal:

1. Did your company first learn about ATP from someone at a university?
2. Did a university help you identify the research partner you consider to be the most important for the project you proposed to ATP?
3. In preparing the technical plan portion of your proposal, did you get assistance from someone at a university?
4. In preparing the business plan portion of your proposal, did you get assistance from someone at a university?
5. [If technical lead on the ATP project has been employed with the company less than 5 years], was this person previously employed at a university?

Other ties to university resources:

6. Does your company have any contracts or licensing agreements for intellectual property at universities?

In the two years prior to your ATP application have you used assistance from a university program

7. to address a technical problem?
8. to prepare a business or marketing plan?
9. to recruit R&D employees?
10. In the two years prior to your ATP application have you formed an alliance with a university to address your needs for equipment and facilities?
11. In the two years prior to your ATP application have any of your R&D personnel attended training or technical programs sponsored by a university?
12. In the two years prior to your ATP application, for your R&D or technology development activities, has your company received funds from a university program?

Note: University Linkages *Index* = $\sum$ Number of Connections (Number of 'yes' answers to these questions)

Source: Survey of 1998 ATP Applicants.

Table 4 shows the 19 questionnaire items we used to construct the business linkages index. Included are the applicant's connections to other firms in preparing the proposal for ATP, as a collaborator on the project, and more generally, in providing technical and financial resources to the applicant in the two preceding years. The same method of scale construction was used for this index.

Table 5 shows the average scores on these two indices for the ATP applicants we surveyed. Both ATP award winners and non-winners alike are similarly connected to universities, with an average score of 5.5. Looking at the differences in scores between award winners and non-winners on the business linkages index, we observe that, on average, award winners have a more extensive set of ties to other businesses than do non-winning applicants. This difference in means is statistically significant at probability level of .05. We interpret this difference to indicate that award-winning firms are better positioned than their non-winning counterparts to have their technologies taken up by other firms and to realize commercial success through a more developed network of ties to other firms.

4.2 Attitudes Towards Information Sharing and Knowledge Transfers to Other Firms

Firms employ different strategies to manage knowledge assets.[13] A common strategy is secrecy, i.e., a concerted effort to restrict access and to limit dissemination of information about the firm's R&D activities to other organizations.[14] Such efforts are costly. A major weakness of this strategy is that it isolates the firm from opportunities to augment its knowledge assets through exchanges of information. By contrast, firms may pursue a knowledge acquisition strategy that emphasizes learning about technical advances outside the firm, trading information with other firms, and forming linkages to other institutions.

[13] By knowledge assets, we mean to include proprietary technologies and know-how. Knowledge assets may be intangible or embodied in specific products. A firm may employ its knowledge assets to make innovative new products or improve its process technologies. However, some firms specialize in knowledge creation and derive revenues (profits) from licensing their technologies and from contracts (with other firms and government agencies) to provide R&D services. For a discussion of this new type of firm and the market for technologies, see: Arora, Fosfuri, and Gambardella (2000). For a general discussion of knowledge as a strategic asset of the firm, see: Winter (1987) and Liebeskind (1996).

[14] For a discussion of the importance of secrecy in R&D strategies, see: Cohen, Nelson, and Walsh (2000) and Levin, Klevorick, Nelson and Winter (1987). See Liebeskind (1997) about the costs and effectiveness of secrecy as a strategy for protecting a firm's knowledge assets.

TABLE 4: QUESTIONNAIRE ITEMS IN BUSINESS LINKAGES INDEX

For ATP project and proposal:

1. Did your company first learn about ATP from someone at another company, a consulting firm, or a venture capital firm?

In preparing the technical plan portion of your proposal, did you get assistance from

2. someone at another company?
3. a consulting firm?

In preparing the business plan portion of your proposal, did you get assistance from

4. someone at another company?
5. a consulting firm?
6. [If technical lead on the ATP project has been employed with the company less than 5 years], was this person previously employed at another company?
7. Did someone at a venture capital firm help you identify the research partner you consider to be the most important for the project you proposed to ATP?

Other Business Ties:

In the two years prior to your ATP application have you had assistance in addressing a technical problem from

8. another company?
9. a private consulting firm?
10. a private venture capital firm?

In the two years prior to your ATP application have you had assistance in preparing a business or marketing plan from

11. a private consulting firm?
12. a private venture capital firm?

In the two years prior to your ATP application, has your company received financing for your R&D or technology development activities from

13. another company?
14. a private venture capital fund?
15. an individual (angel) investor?

In the two years prior to your ATP application, to address your needs for equipment and facilities, has your company used

16. an alliance with another company?
17. secured bank financing?
18. private investor or angel financing?
19. venture capital financing?

Note: Business Linkages *Index* = $\sum$ Number of Connections (number of 'yes' answers to these questions)

Source: Survey of 1998 ATP Applicants.

TABLE 5: RESOURCE LINKAGES TO UNIVERSITIES AND TO OTHER BUSINESSES BY ATP AWARD STATUS

	Award Status		
	Award Winners	Non-Winners	All Applicants*
Mean Number of Business-University Linkages	5.4	5.5	5.5
Standard Deviation	1.6	1.4	1.5
Mean Number of Business Linkages**	4.5	3.7	4.0
Standard Deviation	3.8	3.1	3.5

Notes:
* Means for all applicants are weighted to reflect the proportions of winners and non-winners in the overall population.
** t-statistic for difference between means is significant at < 0.05 level.

Source: Survey of 1998 ATP Applicants.

The more open that a firm is to learn about the research of others the more vulnerable it becomes to other organizations capturing the benefit from its own R&D investments. This may produce a public benefit by reducing the amount of duplication of R&D efforts.[15] From a policy perspective, reducing the amount of duplication by firms enhances the overall efficiency of the U.S. innovation system. Moreover, firms willing to share information about their R&D activities play an important role in accelerating the diffusion of economically valuable knowledge in the U.S. innovation system. In this case, a public-private cost-sharing partnership such as the ATP provides a mechanism for aligning the firm's private interests in acquiring new knowledge with the public interest in efficiency and in generating knowledge that has value to multiple actors in the system.

[15] For a discussion of the importance of knowledge diffusion to industry and the role of government in supporting R&D collaborations to generate it, see: Ouchi and Bolton (1988).

In our survey we asked questions designed to assess a company's openness to allowing other firms to learn about and benefit from its research activities. As indicated in Table 6, we used three different questionnaire items to construct a measure of a company's tendency towards openness or secrecy in conducting its own R&D and willingness to communicate with other firms about its research findings. The possible scores ranged from 0 to 3. Only if two of the three questions contributed to a positive score on this scale (value =2 or 3), did we consider the firm to exhibit a strong tendency towards openness, allowing other firms to learn about and benefit from its R&D activities. For a tendency towards openness, a respondent had to tell us that two of the following three statements about the company's strategy for managing its knowledge assets: the firm usually makes its research findings available to other firms; the firm does not consider keeping its R&D knowledge from spreading to other firms to be important to its long run success; and the firm is willing to continue to carry out R&D that it knows to be beneficial to other firms (i.e., where it will only be able to capture part of the benefits from its own research efforts). If none or one of these statements apply, we consider the firm to have a tendency towards secrecy in order to prevent other firms from learning about and benefiting from its R&D activities.

Table 6 shows that, as expected, most firms applying to ATP exhibit a tendency towards secrecy. Less than one-fourth of all applicants have a high acceptance of knowledge transfers to other organizations and are willing to share information about their R&D activities with other firms. However, we find a much higher proportion of award-winning firms exhibiting a tendency towards openness (30 percent), compared to non-winning applicants (19 percent). The higher rate of participation of such firms in ATP-funded projects suggests that the public interest is being served by enabling R&D activities that are more likely to generate knowledge which benefits both the participating firm and other firms not directly involved in the project.

4.3 Creating New Pathways to Innovation

R&D collaboration is widely recognized as important to a firm's R&D strategy for learning about technical advances in other organizations.[16] But establishing new collaborative ties to other firms is difficult.[17] An important role for government in public-private partnerships is to foster the formation of new R&D collaborations by reducing the costs to the firm of establishing these relationships. Government involvement in public-private partnerships also helps forge new innovation pathways by supporting R&D projects that represent ventures by firms into new technical areas that have not been previously explored.

[16] For recent research on the advantages of collaboration, see: Doz (1996), Hamel (1991), Inkpen (1995), Khanna, Gulati, and Nohria (1998). On R&D partnerships per se, see Hagedoorn, Link, and Vonortas (2000).

[17] See: Harrigan (1988) and Kogut (1989).

TABLE 6: TENDENCY TOWARDS OPENNESS OR SECRECY

	Award Status		
	Award Winners	Non-Winners	All Applicants*
Percent of Firms scoring 2 or 3 on scale measuring *Tendency to openness in attitudes about revealing information on own research to other firms* †	31%	19%	23%

$\chi^2 = 4.636$. Statistically significant at p. $<$ 0.05 with 1 degree of freedom.

Notes:

† Values of this scale range from 0 to 3, where 0 indicates a strong tendency towards secrecy and 3 means a high degree of openness, i.e., a willingness to share information and to do little to impede other firms from learning about the results of its internal research program.

Questionnaire Items in *Tendency to openness in attitudes about revealing information on own research to other firms*

To what extent do you intend to make your research results available to other firms and industries?	1= almost always or sometimes; 0= rarely or never
Do you think that keeping your company's R&D knowledge from spreading to other firms is important to your firm's long run success?	1= no; 0= yes
Would you ever consider *not* engaging in new R&D activity because you believe another firm may benefit from it?	1 = no; 0 = yes

*Percentages are weighted to reflect the proportion of winners and non-winners in the overall population.

Source: Survey of 1998 ATP Applicants.

4.4 Creating New Pathways to Innovation

Our survey provides information on both these mechanisms for generating new innovation pathways. With respect to R&D collaboration, we asked each respondent to tell us if the firm was partnering with other organizations on the project proposed to ATP, and whether the most important collaborator was a new partner. In regard to pursuing new technical areas, we infer that the R&D project proposed to ATP represented a new direction, i.e., a departure from the rest of the firm's research portfolio, if the respondent told us that the technical area of the project had not been part of the firm's R&D plans during the previous two-year period. If the respondent indicated that this was a first-time collaboration with its most important R&D partner, we concluded that the firm was intending to use the ATP funded project to underwrite the costs of establishing a new collaborative relationship with another organization. If the project had not been included in its R&D portfolio in previous years, we inferred that the firm was intending to use ATP funding to help underwrite the risk of embarking on a research endeavor in technical areas new to the firm.

Table 7 shows the percent of firms reporting that the proposed ATP project involved another organization as a research partner, and the percentages of new partnerships and new technical areas. Seventy-nine percent of the 1998 applicants in our sample included other organizations in their proposals. There is no difference between award-winners and non-winners in their propensity to partner with another organization on ATP-proposed projects. However, the percent of firms identifying their most important research partner as a new collaborator is much higher for award winners (59%) than non-winners (42%). Moreover, the projects that won an ATP award were far more likely to be characterized by the respondent as breaking new ground for the firm. Forty-seven percent of award winners indicated that the proposed ATP project represented a new direction for the firm, whereas only 19 percent of the non-winning applicants characterized the project thusly. These differences suggest that the ATP's cost-sharing partnership with industry is indeed underwriting the efforts of firms to form new R&D collaborations and to initiate risky projects in new technical areas.

TABLE 7: INDICATORS OF THE CREATION OF NEW PATHWAYS TO INNOVATION

New Partnerships

Percent of 1998 Applicants who included other organizations in the ATP proposal 79%

If Yes, was this a new partnership?	
Award Winners	59%
Non Winners	42%
All Applicants*	48%
χ^2	5.502 [a]

New Technical Area

Percent of Applicants proposing a project that was not part of the company's R&D plan (in a technical area new to the company)

Award Winners	47%
Non Winners	19%
All Applicants*	28%
χ^2	21.418 [b]

Notes:
*Percentages are weighted to reflect the proportion of winners and non-winners in the overall population.
[a] χ^2 is statistically significant at $p. < 0.05$.
[b] χ^2 is statistically significant at $p. < 0.01$.

Source: Survey of 1998 ATP Applicants.

5. *In Pursuit of the Public Interest: The Distinguishing Features of Award-winning R&D Strategies*

5.1 Methodology and Specification Issues

In the previous section, we identified behaviors and strategies that stimulate and strengthen interactions among firms, which in turn help to improve the efficiency of the innovation system. We also showed that ATP award winners are more apt to have these attributes than their non-winning counterparts in the 1998 applicant pool. We employ a multivariate regression technique to control for other factors that we expect to increase a firm's chances of winning an award. All models are specified as a logistic regression, with the same binary dependent variable, ATP award status, which is coded=1, if the firm won an ATP award in 1998 and =0 if the firm was an unsuccessful applicant that year. We employ the maximum likelihood method for estimating the effect of each factor on the likelihood of winning an award. The regression results are displayed in Table 8.[18]

We specified three models. Our basic model (column 1 of Table 8) includes two sets of indicators. The first group of variables (labeled *Extent of R&D Networks and Information Sharing*) measures how well-positioned and open the firm is to having its research results quickly taken up by other organizations. The second group of variables (labeled *New Pathways*) measures attributes of R&D projects that we identify as being related to the formation of new pathways to innovation. The other two regression model specifications (columns 2 and 3 of Table 8) add variables to the basic model to control for other factors we expect to be related to winning an award.

5.2 Control Variables

We include three categories of variables as controls for other factors that may influence a firm's chances of winning an ATP award other than those behaviors and strategies we have hypothesized to be important to the success of public-private partnerships in spurring innovation that firms are unlikely to undertake on their own. Two classes of control variables – *Experience with the ATP* and the primary *Technology Area of the Proposed Project* – are added in our second model (column 2 of Table 8). In model 3, we employ ATP reviewer assessments of the proposed project as a control for quality (column 3 of Table 8). The scores that reviewers give to each proposal serve as proxies for the overall quality of the proposal and firm, including the technical challenges and risks of the R&D, the economic potential of the technology, and the firm capabilities needed to carry out the project and to pursue commercialization.

[18] Means and standard deviations for all regression variables are included in Appendix Table 1.

TABLE 8: LOGISTIC REGRESSION MODELS EXPLAINING WINNING AN ATP AWARD IN 1998

	(1) Basic Model	(2) With Controls for Experience & Technical Area	(3) With All Controls, including Proposal Quality Ratings
Extent of R&D Networks & Information Sharing Strategy			
University Linkages	-0.0565	-0.0584	-0.0906
	(0.0812)	(0.0899)	(0.1096)
Business Linkages	0.1418**	0.1245**	0.1642**
Tendency Towards Openness in Research Communications	0.6477**	0.9313**	0.8341**
	(0.2463)	(0.2827)	(0.3165)
New Pathways			
Important New R&D Partner on Project	0.5556**	0.7103**	0.9184**
	(0.2142)	(0.2555)	(0.2995)
New Technical Area for Firm	1.6901**	1.7130**	1.4505**
	(0.2371)	(0.2678)	(0.3125)
Control Variables:			
Experience with the ATP			
First-Time Application to ATP		-0.0750	0.2439
		(0.2664)	(0.3097)
No. of Previous ATP Awards		0.0621	0.0254
		(0.0778)	(0.0848)
Proposal Effort ($'s)		0.0028	0.0029
		(0.0184)	(0.0020)
Technology Area of Proposed Project			
Advanced Materials		0.7072	1.3288
		(0.6123)	(0.7287)
Biotech		1.2707*	2.0047*
		(0.6494)	(0.8041)
Electronics		1.4252**	2.0083**
		(0.6187)	(0.7599)
Manufacturing		-0.1351	-0.0835
		(0.8787)	(1.0258)
Research Quality, Economic Significance & Strength of Business Plan			
Maximum Score on Reviewers' Rating of Technical Plan			0.9531**
			(0.1755)
Maximum Score on Reviewers' Rating of Business Plan & Economic Potential			0.5839**
			(0.1295)
Constant	-2.3352**	-3.4149**	-17.1314**
	(0.4601)	(0.8357)	(2.3695)
-2 Log Likelihood	530.447	449.316	345.910
χ^2	84.889**	96.234**	195.363**
	(df = 5)	(df=12)	(df=14)

Notes: In all regressions, the number of observations is 239, and the data are unweighted.
** Statistically significant at probability level < 0.01.
* Statistically significant at probability level < 0.05.

Source: Survey of 1998 ATP Applicants.

Experience with the ATP

The ATP holds annual competitions. No restrictions prevent a firm from re-submitting a previously unsuccessful proposal in a subsequent competition. A firm that has won awards in previous years can also propose new projects in subsequent competitions. However, the experienced applicant's proposal is evaluated by the same criteria as that of a first-time applicant and all re-submissions are evaluated anew, often by a different set of reviewers. Still we might expect a firm to derive an advantage from having applied to the program in the past, if only due to a greater familiarity with the proposal format and objectives. Although a firm's success in previous competitions carries no weight in subsequent competitions, it does indicate a capability to generate good ideas and research plans that the ATP considers worthy of support.

We asked respondents if their firm had previously applied to the ATP and verified this information against program records. Hence, we include *First-Time Application to ATP* (coded =1, if the 1998 competition was the first time a firm had applied to ATP for funding; = 0, if the firm had applied for funding in any previous year). From program records, we also compiled a count of the number of times a firm has participated in winning projects since the start of the program. If a firm derives an advantage from having greater familiarity with the ATP selection process, we may expect a history of prior successes to increase a firm's chances of winning an award in a new competition, all else being equal. We include the *Number of Previous ATP Awards* as another control variable. Further, to the extent that a winning proposal reflects skill in grantsmanship (i.e., rather than the quality of the ideas and plans), we include a control variable for the amount of effort a firm spends in proposal preparation and writing. Our measure, *Proposal Effort*, reflects the total dollars spent by each firm on the application, including the cost of staff time, consulting fees and the cost of materials and travel.[19]

Technology Area

A firm's willingness to share information and its propensity to form linkages to universities and other businesses may be more common in certain research areas.[20] Introducing controls for the main *Technology Area of The Proposed Project* allows us to assess whether aspects of a firm's R&D strategy identified in our basic model are merely the reflection of the prevailing practices of firms in selected technical areas. Drawing on ATP program records, we coded each proposed project into one of five technology categories:

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[19] From all these sources, the total cost of the ATP application varied considerably, with a median proposal preparation cost of$15,000, and a range from $2,000 to $300,000 per firm.

[20] In particular, bio-technology firms are known to have extensive linkages to other firms and to universities. For a discussion of the extensive networks of biotechnology firms, see Powell et al. (1996). For a discussion of the importance of public-private partnerships, especially between biotechnology firms and universities, see: Kogut and Gittelman (2000), and Zucker and Darby (1996).

Advanced Materials, Biotechnology, Electronics, Information Technology and Software, and Manufacturing technology. We include four of the five categories in our specification (the omitted category, which becomes the baseline for comparison, is Information Technology and Software).

Proposal Quality

All proposals submitted to the ATP receive at least one independent review by a technical specialist as to the quality of the research, technical difficulty and risk, the potential for advancing the state of the art in a specific technical field, and the capabilities of the firm and its R&D partners to carry out the project. In addition, every proposal receives at least one review by a business specialist as to the technology's commercial viability and potential economic impact. In 1998, each reviewer scored the quality of the proposal on a scale ranging from 0 (lowest quality) to 10 (highest quality). Our indicator for the technical quality of a project is the maximum score a project received from any technical reviewer. The maximum score given by business reviewers to the proposal is our measure for ATP's assessment of the quality or merit of the potential commercial/economic benefits from the project.[21] Both these variables (*Maximum Score on Reviewers' Rating of Technical Plan* and *Maximum Score on Reviewers' Rating of Business Plan & Economic Potential*) are added to the model that includes other control variables. The regression results from this specification are displayed in column 3 of Table 8. By adding measures to control for proposal quality, we are able to estimate the impact of the firm's R&D strategy on the chances of winning an award from the ATP.

5.3 Discussion of Findings

Our findings are robust across specifications. The following attributes distinguish the R&D strategies of award-winners from all other applicants:

- A tendency towards openness in communications about research with other firms and institutions;
- A more extensive set of business linkages, and,
- Riskier research projects that are new to the firm and entail the formation of new R&D partnerships between organizations.

[21] A proposal may have from 1 to 3 (or more) reviews in either the business or technical assessment process. Winning proposals are likely to have consistently high ratings by reviewers. Non-winning projects have more variability in reviewers' scores. Average scores of highly rated non-winning proposals are lower than the winners, as a group. For this reason, we used the maximum score of each review type in constructing our indicators for proposal quality.

Our key finding is that selected firms and projects are especially well-positioned to deliver public benefits from their R&D activities. Award winners exhibit a greater inclination to engage in behaviors that facilitate the spread of knowledge, open up new pathways, and sustain connections among firms important to the development of innovations and ultimate commercialization.[22]

Needless to say, we expected to find high ratings by ATP's technical and business/economic reviewers to be predictive of winning an award, all else being equal. That is exactly what we find. On both quality dimensions, the higher the maximum rating the proposal received by reviewers, the greater the chances of winning an award. Even after having included the ATP's ratings of the technical quality and economic potential of a proposal, we still find that the four attributes – openness to knowledge leakages, extent of linkages to other firms, and "newness" of the project and the R&D partnership to the firm – remain statistically significant and distinguish award-winning firms from non-winners, as a group.

[22] The chances of winning an ATP award are not significantly improved if the firm has applied to ATP in the past. Nor does a prior history of success affect the outcomes for a firm in a subsequent round of ATP competitions. The amount that a firm spends in preparing a proposal also has no bearing on a successful outcome from the ATP selection process.

6. How ATP Funding Makes A Difference: Evidence from a Comparison Group Analysis

Thus far we have shown that the R&D strategies of award-winning firms indicate an integration of both public and private interests that the program is intended to serve. While strongly suggestive, our analysis has not directly addressed the question: Does ATP funding make a difference? Although award-winning firms have attested to the importance of ATP support,[23] more objective indicators of what may have happened had these firms not received an award can be made through comparisons of award-winners to similarly situated firms and projects that did not receive any funding from the program. Our chosen comparison group is the pool of projects and firms that applied for funding to ATP at the same time but were not awarded any funding.

Many R&D projects that a firm may consider undertaking are not comparable to those that a firm would propose for a public-private partnership. The R&D projects proposed by non-winning applicants are all potential candidates for a public-private partnership. In applying to ATP, these firms are, in effect, self-selecting projects that they perceive to be in need of (or would benefit from) public funding. However correct or incorrect the perceptions of the appropriateness of the project for public funding may be, we can be assured that *the pool excludes projects that firms strongly prefer to do completely on their own*. Because these projects were proposed to the ATP at the same time and under the same rules as the award-winning projects*, the stage of the R&D, the scale, and the starting times are also comparable*. Moreover, to some degree, *non-winning applicants have R&D strategies that exhibit the same characteristics that distinguish award winners and reflect the intersection of public and private interests of central importance to the program*.

Consider, for example, just one indicator of the extent to which non-winning applicants propose projects to the ATP that are potentially risky and problematic for the firm to carry out on its own. Over 40% of the 1998 non-winning applicants we surveyed had proposed projects that involved first-time collaborations with another organization. Because of the well-known difficulties of establishing trust and cooperation in dealing with another firm for the first time, we expect that many of the projects involving first-time collaborators will not proceed on their own, in the absence of ATP funding and the presence of a government agency as a neutral party. Even though award-winning projects are of higher quality than the average non-winning proposal, so few projects proposed to ATP actually get funding (only 12% in 1998) that it also seems reasonable to assume that there are still many more good candidates in the pool that do not get any ATP funding.

[23] Previous research by Powell (1999) indicates that award-winning firms believe that ATP funding makes a difference. The vast majority reports that ATP funding increased the scope and the technical challenges the firm was willing to undertake (Appendix A, p. 56).

For the reasons identified above, we consider the pool of non-winning applicants to be an appropriate comparison group that is close to ideal in certain key respects. With this comparison group, we are able to consider how likely it is that the type of R&D projects proposed to ATP proceeds without funding from the program and to assess the short-run effects of the ATP award. In this section of the paper, we address the following two questions:

- How often do non-winners proceed with the proposed project as planned, and,
- compared to award winners, how successful are non-winners in attracting other sources of funding for the projects that were proposed to the ATP?

6.1 Do Non-Winners Pursue R&D Projects Proposed to the ATP?

The ATP may reject a proposal for any number of reasons. The project may be poorly conceived, and hence judged to be less promising than other projects. The firm may have a promising technology but lack an adequate business plan for carrying the technology forward. If both the technology and business potential are very promising but the firm has adequate resources from other funding sources (within or outside the firm), then ATP is more likely to choose to award its scarce resources to firms that have greater need.

As we indicated in our introduction, firms are *unlikely* to pursue high risk projects on the technological frontier, projects that require a firm to form a new collaborative effort with another organization, or projects in technical areas where the innovating firm has difficulty in capturing much of the benefit from the research, i.e., where it is easy for other firms to benefit without having to share the costs of the research. To the extent that the ATP attracts proposals from industry with these characteristics, it is less likely that the rejected projects will proceed without support from the ATP or some other funding source external to the firm. On the other hand, if the ATP attracts proposals that companies planned to fund anyway, we would expect to find a high proportion of non-winning firms pursue the projects they had proposed to the ATP when we interviewed them one year later.[24] As Table 9 indicates, that is not the case.

[24] We attempted several specifications in an effort to explain which firms continued with the ATP project without funding from the program. However, we did not find any consistent predictors. To develop a better understanding of the factors distinguishing firms that pursued these unfunded projects, we are undertaking case study investigations of a selection of such firms.

TABLE 9: THE EXTENT TO WHICH NON-WINNERS PURSUE THE PROPOSED R&D PROJECT WITHOUT ATP FUNDING

Did not proceed with the project, at any scale	63%
Began project on a *much smaller scale* than proposed to ATP	17%
Began project on a *somewhat smaller scale* than proposed to ATP	12%
Began project at about the *same scale* as proposed to ATP	5%
Began project a *somewhat larger scale* than proposed to ATP	3%
Began project on a *much larger scale* than proposed to ATP	1%
Number of Cases	168

Note: Three respondents were unable or refused to answer this question.

Source: Survey of 1998 ATP Applicants.

More than three-fifths of the non-winners (63%) have not proceeded with any aspect of the R&D project that they proposed to ATP. This number includes 49 non-winners that we discovered had gone out of business in the past year. Also included are the projects where the individual responsible for preparing the proposal no longer worked for the company and there was no one whom we could identify who knew about the proposal or any continuation of that work in the same technical area.[25] In addition, there were another 66 non-winners who indicated that, in the past year, their company had not proceeded with any aspect of the project proposed to ATP.

[25] In most respects, the projects for firms that either went out of business or where the technical lead person was no longer employed at the firm were similar to the other non-awardees. We found one important difference. The average evaluator's rating of the defunct firms' business plans was lower than all other applicants (e.g., 6.7 compared to an average score of 8.3 for winners and 7.2 for other non-winners).

Thirty-eight percent of the non-awardees began work on the proposed project at some level of effort. However, in most instances (76%), the project was pursued at a *smaller* scale than the company had proposed to the ATP. Only five percent of the firms that received no funding from ATP were proceeding at the scale that they had originally proposed the previous year, with four percent of the non-winners proceeding with a larger scale effort than had been proposed to ATP. These results suggest that, for the most part, ATP is attracting the type of projects that fit the criteria for a public-private partnership and that require support from an outside source in order for the firm to be willing (and able) to proceed with the R&D. Furthermore, that so few projects in this comparison group proceeded without any ATP funding suggests that ATP funding is making a difference in supporting promising R&D projects that would not otherwise go forward, or would only be pursued by the private sector at a lower scale of effort.

6.2 Subsequent Success in Attracting Funds From Non-ATP Sources

In addition to a firm's own resources, other external sources may provide support to the type of R&D projects that the ATP is considering funding. These sources include other businesses that may derive a benefit from the research, private venture capital firms, public venture capital funds and technology programs established by state governments, and the research programs of other federal agencies. Table 10 shows the percentages of applicant firms that sought additional funding for the same project from such non-ATP sources and the percentages that actually succeeded in attracting funding from these sources.[26]

Overall, 40 percent of the firms that applied to ATP for funding in 1998 also applied to other funding sources in the year following their ATP application. Obviously, firms winning ATP awards were less likely than non-winners to seek additional funding for their award-winning projects from non-ATP sources. Even though only 25% of award winners pursued other funding sources for their projects, they were more than twice as likely as non-winners to successfully raise funds from these sources.

[26] Award winners may use external funding from non-federal government sources to meet the cost-sharing requirement of the ATP. In addition, award winners may use non-ATP funds to expand the scope of work or scale of effort proposed to the ATP.

There are several possible explanations for the fund-raising success of ATP awardees. Award-winning firms may be better at raising funds than the average non-winner. Just as the ATP reviewers determined, award-winning firms may be more stable as businesses and hence, less risky an investment. The high proportion of ATP single-company awards going to small firms may attract the attention of venture capital firms (especially in certain technical areas)[27] and other organizations specializing in funding small firms. Or, since the ATP award reflects a competitive selection process at an agency with a scientific reputation, it may generally be perceived by other funding sources as providing information not otherwise available about the quality of the firm and project.

TABLE 10: PERCENTAGE OF FIRMS THAT APPLIED TO OTHER FUNDING SOURCES TO SUPPORT THEIR R&D ACTIVITIES AND THEIR SUCCESS RATES BY ATP AWARD STATUS

	Award Status		
	Award Winners	Non Winners	All Applicants
Percent of All Firms in Award Category that Applied to Other Funding Sources	25%	47%	40%
Percent of Those Firms Seeking Funding That Succeeded in Attracting Additional Investment for their R&D Activities	73%	33%	46%

Note: Percentages are weighted to reflect the proportions of winners and non-winners in the overall population.

Source: Survey of 1998 ATP Applicants.

[27] For a discussion of the concentration of venture capital funding in certain technical areas, see Gans and Stern (2000).

7. ATP Award Certifies Quality

The rigor of the ATP selection process may produce valuable information about R&D project quality. The award itself serves as an information signal that other agents may believe and are willing to act upon.[28] To the extent that the award attracts the attention of these agents and is perceived to certify the quality of the project and the firm, these organizations will be more disposed to favor ATP award winners over other firms that request funding. This reputation effect from the award is termed a "halo effect," whereby award-winners receive more favorable treatment from other agents compared to similar firms with similar R&D projects. In order to determine if the ATP serves such a certification function, we need to show that the selection process itself is widely viewed by award-winners and non-winners alike as being fair, rigorous, and rational. Our analysis also needs to take into account competing explanations for the favorable treatment afforded ATP award winners by external funding sources other than the ATP.

7.1 Certifying Quality: The Integrity and Rationality of ATP's Selection Process

The host agency of the ATP, the National Institute of Standards and Technology (NIST), is widely recognized to be an important source of technical information and expertise in a number of areas. For the ATP to benefit from the prestige of NIST, the selection process itself must be perceived as fair and rational (i.e., the award results should be explainable in relation to the criteria). Our survey provides evidence that the ATP selection and award process is indeed widely viewed as fair and rational.

The ATP emphasizes the impartiality of its treatment of proposals during the review and selection process. All proposals receive at least one technical review and one review of its commercial and economic potential. Each proposal is discussed and assessed by a panel of experts. The selecting official is then presented with the panel's recommendations. Debriefings are provided for non-awardees.

We asked award winners and non-winners alike about their perceptions of the selection process and whether the respondent believed that his/her company would consider applying to ATP in the future. Tables 11 and 12 present the responses to these questions by the Award Status of the respondent.

[28] On this point, see Narayanan, Kelm, and Lander (2000).

TABLE 11: OVERALL, REGARDLESS OF THE OUTCOME FOR YOUR PROPOSAL, DID THE ATP REVIEW AND SELECTION PROCESS APPEAR FAIR?

	Award Status		
	Award Winners	Non-Winners	All Applicants
Percent Responding 'Yes'	95%	67%	76%

Note: Percentages are weighted to reflect the proportions of winners and non-winners in the overall population.

Source: Survey of 1998 ATP Applicants.

As we would expect, Table 11 shows that a high percent (95%) of those that won an ATP award perceived the selection and review process to be fair. However, among non-winners, a substantial majority (67%) *also* considered the review and selection process to be fair. These responses suggest that ATP has a reputation for fairness that is widely recognized. As further evidence, consider the responses to the question about the respondent company's plans to apply to ATP in the future shown in Table 12. Although there is a higher negative response from non-winners, a majority (59%) is very positive about the prospect of applying to ATP again.[29]

[29] Note that the percent of winners and non-winners that are undecided is about the same (15% of winners and 12% of non-winners).

TABLE 12: TO YOUR KNOWLEDGE, DOES YOUR COMPANY PLAN TO APPLY TO THE ATP IN THE FUTURE?

	Award Status		
	Award Winners	Non- Winners	All Applicants
Definitely/Very likely	82%	59%	67%
Undecided	15%	12%	13%
Not very likely/Definitely not	4%	29%	21%

Note: Percentages are weighted to reflect the true proportions of winners and non-winners in the overall population.

Source: Survey of 1998 ATP Applicants.

When a proposal fails to win an award, the ATP provides the opportunity for the non-winning firm to discuss with panel representatives both the strengths and weaknesses that were identified in the proposal during the review process. Once a company, or group of companies, has been notified that the project was not selected for funding, management may request to schedule a telephone debriefing session within a few weeks of the decision. Although there are usually two representatives from the ATP's expert panels (a business and a technical expert), any number of individuals from the proposing companies may participate in the debriefing.

Table 13 shows that a 63% majority of non-winners who responded to our survey indicated that they had participated in a debriefing in 1998. We included an assessment of the value of the feedback they received from their discussions with ATP staff during the session. In general, most non-awardees (69%) found the debriefing either to be very helpful (32%) or reasonably helpful (37%). These responses suggest that most non-winners perceived the ATP staff's explanation for rejecting the proposal to be rational and to provide useful guidance for improving the firm's technical and/or business planning.

TABLE 13: PERCENT OF NON-WINNERS THAT PARTICIPATED IN A DEBRIEFING AND RESPONDENTS' ASSESSMENT OF ATP'S HELPFULNESS TO THE COMPANY

Percent of Non-Winners who participated in a debriefing with ATP		63%
How helpful did you find the debriefing session to be?		Percent of Firms Participating in a Debriefing
	very helpful	32%
	reasonably helpful	37%
	not sure	3%
	not particularly helpful	19%
	not at all helpful	9%

Source: Survey of 1998 ATP Applicants.

7.2 Controlling for Firm and Project-Specific Factors Affecting a Firm's Success in Raising R&D Funds from External Sources

In order to determine whether the ATP award has the hypothesized halo effect, we need to take into account other factors related to winning an ATP award that may also influence the effectiveness of the firm in attracting other funding. All else being equal, a firm that has had a history of success in R&D fund-raising from non-ATP sources is more likely to succeed in attracting additional funding from these external sources. With less internal resources to draw upon, small firms may more aggressively pursue funding from external sources. There are also a greater number of government and private sector sources that devote resources exclusively to small entrepreneurial firms.[30] Stable organizations with a relatively low risk of business failure may also be considered by other firms to be good candidates for investment. To take into account these factors, we need to specify a multivariate regression model.

[30] For one, all federal agencies that contract with the private sector for R&D are required to set aside a small percentage of their budgets for the Small Business Innovation Research Program (SBIR). In recent years, annual spending by all federal agencies on the SBIR program has exceeded $1 billion.

We estimated three regression models (shown in Table 14). The dependent variable in all three models is the log of the sum of funds that our respondents reported receiving for the ATP project from all non-ATP sources in the year following their application to the program. We use information on the subset of firms (n=92) that report an attempt to pursue funding for the project from other external sources. Firms either receive additional funding, or they do not. Because the distribution of data is bounded at zero, and may not be negative, the data is a truncated sample, which leads to bias in the OLS regression results. To adjust for this, we employ the Tobit technique, which provides unbiased estimates of the model's parameters.[31]

Model 1 includes firm-specific factors that we expect to influence success in attracting outside funding. Our specification of these factors controls for whether or not the firm qualifies as a small business and hence is eligible for funding from the SBIR and other programs that target small entrepreneurial firms. The age of the firm is also included as a proxy for the risk of business failure since young firms have a high failure rate. Our basic model also takes into account the amount of external funding the firm received from non-ATP sources in the two years prior to its ATP application. The better the firm's funding track record, the more successful the firm is likely to be in raising funds for the project in the current period.

We include the maximum rating by the ATP reviewers of the project. From our previous analyses, we know that these ratings are contributing factors but by no means the only important predictors of winning an award. Although only highly rated projects win ATP awards, there is also considerable variability in the ratings given non-winning proposals, with some receiving ratings as high as award-winning proposals. To the extent that these quality differences are discernible by other funding sources, we expect higher rated projects to receive more funding than projects with low scores.

[31] For a more detailed explanation of limited dependent variables, see Kennedy (1994), pp. 228-241. For details on the tobit estimating procedure, see Hall (1984) and Tobin (1958). Means and standard deviations of all variables used in the regressions are included in Appendix Table 2.

TABLE 14: TOBIT REGRESSION MODELS TO EXPLAIN THE AMOUNT OF NEW FUNDING (LOG $1,000S) RAISED FROM NON-ATP SOURCES

	Model 1	Model 2	Model 3
ATP Award Winner		3.5847*	2.9078†
		(1.5883)	(1.4983)
Small Firm (< 500 employees)	6.039*	6.0203*	5.2955†
	(2.915)	(2.899)	(2.815)
Age of the Firm (years since birth)	0.0732	0.0829	0.0928†
	(0.0517)	(0.0515)	(0.0510)
Log ($1,000) Received from Other Sources, pre 1998	0.5416*	0.6101**	0.6590**
	(0.2441)	(0.2415)	(0.2434)
Maximum Score on Reviewers' Rating of Business	0.4075	0.1660	-0.1169
Plan & Economic Potential	(0.4218)	(0.4184)	(0.3992)
Maximum Score on Reviewers' Rating of Technical	0.0907	-0.1138	-0.0462
Plan	(0.3769)	(0.3728)	(0.3475)
Technology Area of Proposed Project			
Advanced Materials			-2.2290
			(2.9542)
Biotech			2.4825
			(3.3115)
Electronics			1.5659
			(2.9542)
Manufacturing			-3.7494
			(3.2703)
Constant	-11.8907**	-10.0351*	-7.6253
	(4.6727)	(4.5454)	(5.0766)
-2 Log Likelihood	-157.372	-154.756	-148.645
χ^2	12.26**	17.49**	29.71**

Notes: In all regressions, the number of observations = 92, and the data are unweighted.
** Statistically significant at probability level < 0.01.
* Statistically significant at probability level < 0.05.
† Statistically significant at probability level < 0.10.

Source: Survey of 1998 ATP Applicants.

In models 2 and 3, we include a variable that distinguishes ATP award winners from their non-winning counterparts. Model 3 adds a set of variables to account for the major technical areas of the R&D projects proposed to the ATP. These constitute additional controls for the popularity or attractiveness of particular technical areas to the institutions that are potential sources of support for the R&D activities of firms.

7.3 Discussion of Findings

Looking at firm and project specific factors alone (the results shown in model 1), we find that small firms attract more funding from non-ATP sources. Moreover, firms that have proven to be better fund-raisers in the past are able to attract more funds than firms that have a less successful track record. We also find that the quality of the project as rated by ATP reviewers does not influence the amount of funding a firm is able to raise for that project from other external sources. Only when we include controls for the technology area of the project (model 3), do we find the age of the firm to be a significant predictor of a firm's ability to raise funds from non-ATP sources.

Our analyses show that winning an ATP award significantly increases the amount of funding a firm is able to raise for the project from non-ATP sources. Although the effect of the ATP award is somewhat weakened by the inclusion of controls for technology area (model 3), the results of models 2 and 3 are consistent with one another. All else being equal, ATP award winners are more successful in raising funds for their projects from non-ATP sources than firms in our comparison group.

These results support our thesis that the NIST/ATP selection process produces valuable information about R&D project quality and provides an information signal that other agents find credible and are willing to act upon. Furthermore, the ATP selection signal has information content beyond that provided by technical and business reviewer ratings. Through their investment decisions, other funders, private and public, are showing, by their actions, that they believe the ATP award provides additional information about the quality of the project.

8. Conclusions

The mission of the Advanced Technology Program is to support those R&D activities of for-profit enterprises that offer the greatest promise for contributing to technical advance among various actors in the innovation system and for realizing broad-based economic value from that innovative activity. Compared to non-winning applicants, ATP award winners have greater linkages to other business, are more open in their research communications with other organizations, are more likely to initiate a new direction in R&D activities and are more likely to be engaged in establishing new R&D partnerships with other organizations. These findings suggest that the ATP is picking firms and projects that are better structured to achieve the goals of the program and to enhance the efficiency of the U.S. innovation system.

We also validate certain features of the program design. Our examination of a comparison group of projects shows that in the absence of ATP funding, a majority of firms do not proceed with these projects on their own. Of those that do proceed at all, the tendency is to scale back the project from the level of effort that was initially proposed to the ATP. This is strong evidence that the cost-sharing partnership feature of the program is indeed appropriately aimed at the types of R&D projects that would not go forward under industry sponsorship alone.

Finally, we show that the ATP award itself has added value recognized by the investment community. By their actions, other funding sources are showing that they believe the NIST/ATP selection process is able to identify quality. The award confers a "halo" effect that is valued by other funding sources as indicated by the increased amounts they are willing to invest in these projects. Since few R&D projects proposed to ATP actually proceed at a comparable level, we conclude that the ATP award stimulates additional investment in risky R&D projects that would otherwise not be funded by the firms themselves or by other funding sources.

9. References

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Appendix Tables

APPENDIX TABLE 1: MEANS AND STANDARD DEVIATIONS OF VARIABLES USED IN REGRESSION MODELS EXPLAINING WINNING AN ATP AWARD

(n=241)

	Mean	Std. Deviation
Dependent Variable:		
Winning an Award		
Award Status (1= winner; 0=non-winner)	0.49	0.50
Extent of R&D Networks & Information Sharing Strategy		
University Linkages Index (0, 12)	2.08	1.67
Business Linkages Index (0, 19)	4.10	3.49
Tendency Towards Openness in Research Communications (0, 1)	0.25	0.43
New Pathways		
Important New R&D Partner on Project (0, 1)	0.41	0.49
New-to-the-Firm Project Technical Area (0, 1)	0.33	0.47
Control Variables:		
Experience with the ATP		
First Application to ATP (0, 1)	0.50	0.50
Number of Prior ATP Awards (0, 12)	0.56	1.47
Proposal Preparation Cost ($'s)	27,786	36,870
Major Technology Area of Proposed Project		
Advanced Materials (0, 1)	0.33	0.47
Biotech (0, 1)	0.13	0.34
Electronics (0, 1)	0.41	0.49
Manufacturing (0, 1)	0.08	0.26
Assessment of Research Quality and the Economic Significance & Strength Of the Business Plan		
Maximum Reviewer Score on Technical Plan (1, 10)	8.27	1.95
Maximum Reviewer Score on Business Plan (0, 10)	7.95	1.98

Note: All data shown in the table are unweighted.

Source: Survey of 1998 ATP Applicants.

APPENDIX TABLE 2: MEANS AND STANDARD DEVIATIONS FOR VARIABLES USED IN REGRESSION MODELS EXPLAINING AMOUNT OF NEW R&D FUNDING FROM NON-ATP SOURCES

(N=92)

	Mean	Std. Deviation
Dependent Variable:		
New Funding received		
In the year after the ATP application		
Log ($1,000's)	2.90	3.06
ATP Award Status		
Award Winner = 1; Non Winner = 0	0.34	0.48
Control Variables:		
Previous Success in R&D Fund-Raising		
Log ($1,000's Received in previous 2 years)	4.22	2.94
Age of Firm	10.23	16.23
Number of years since Birth of the Firm		
Small Firm	0.85	0.36
(if ≤ 500 employees, firm size=1; if >500 employees, firm size = 0)		
Assessment of Research Quality And the Economic Significance & Strength Of the Business Plan		
Maximum Reviewer Score on Technical Plan (1, 10)	7.81	2.38
Maximum Reviewer Score on Business Plan (0, 10)	7.49	2.32
Major Technology Area of Proposed Project		
Advanced Materials (0, 1)	0.34	0.48
Biotech (0, 1)	0.12	0.32
Electronics (0, 1)	0.41	0.49
Manufacturing (0, 1)	0.13	0.34

Note: All data shown in the table are unweighted.

Source: Survey of 1998 ATP Applicants.

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 the 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 which will go undeveloped and/or proceed too slowly to be competitive in global markets without the 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 the ATP.

Smaller companies working on single-firm projects pay a minimum of all the indirect costs associated with the project. Large, "Fortune-500" companies participating as a single firm pay at least 60 percent of total project costs. Joint ventures pay at least half of total project costs. Single-firm 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 the 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 which use peer-review to identify those that score highest against technical and economic criteria.

Contact the ATP for more information:

- On the World Wide Web: 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, Stop 4701, Gaithersburg, MD 20899-4701.

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