Leveraging Research and Development: Assessing the Impact of the U.S. Advanced Technology Program

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ABSTRACT. This paper examines the factors that affect a firm's chances of winning an award from the Advanced Technology Program (ATP) and the subsequent impact of the award on a firm's success in raising additional funds for its research and development (R&D) activities. Analysis of data from a survey of 1998 ATP applicants shows that proposals with higher ratings by technical and business/economic experts have a greater chance of winning an award. Further, the projects and firms selected by ATP are more willing to share their research findings with other firms, and tend to be those that open up new pathways for innovation through combining technical areas or by forming new R&D partnerships. Most of the non-winners have not proceeded with any aspect of the R&D project proposed to ATP and, of those that have, most did so at a smaller scale. Furthermore, the ATP award has prestige value for the winning firms; the halo effect from the award increases the success of these firms in attracting additional funding from other sources. Our conclusion is that the ATP is leveraging activities that have a strong potential for broad-based economic benefit.

1. Introduction

Through a number of different agencies, the U.S. federal government provides research funding to universities and colleges, government-owned laboratories, and for-profit enterprises. Support for basic research at universities is widely accepted and the relationship to technical progress is well established. A common question regarding the public funding of research conducted by private firms is whether the public interest, with regard to technical advance and economic growth, are being promoted. After all, a private firm is expected to fund its own research when it perceives a technical opportunity with reasonable profit expectations.

In some cases, however, private firms may not pursue promising technical opportunities for the following reasons:

- R&D scientific and technical frontiers are risky and the chances of failure are high.[1]
- An individual firm may not have the capabilities required to develop the technology. Complex new technologies may require collaboration and information sharing; however, the cost of establishing research and development partnerships and making them work productively may provide disincentives to undertaking the project.
- Private incentives may not be sufficient to induce a firm to undertake the project in the face of difficulties in appropriating the resulting benefits, i.e. (the resulting knowledge may flow to others who may benefit from the R&D without sharing the cost).[2]

Public-private R&D partnerships provide a policy instrument that may alleviate these concerns and encourage private-sector investment. A government R&D partnership may provide a catalyst for private firms to undertake research which will have broad-based knowledge benefits for other firms and other industries. Government programs may provide a neutral forum for competitors to work together on mutually beneficial research (NRC 1996: footnote 19).[3] In addition,

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government funding may reduce the cost to the firm of establishing working relationships with R&D collaborators and provide an incentive for firms to undertake such joint efforts. R&D collaborations provide the opportunity for a firm to acquire knowledge and complementary technical expertise that it would otherwise be difficult to obtain. Moreover, these cooperative arrangements facilitate the diffusion of economically relevant knowledge within the private sector, thus further leveraging the public investment. Finally, government R&D funds may reduce the firm's scientific and technical risk sufficiently to bring the project within an acceptable rate of return for private-sector investment (Griliches, 1992).[4]

Recently, governments around the world have encouraged public-private partnerships (NRC, 1996).[5] The long-term goal of these programs is to achieve greater productivity growth in an economy through the creation of knowledge that may become incorporated in industrial processes, products and services (Kelley, 1997). The logic for public investment is that, in the long run, the economic benefits to consumers, other firms and the national economy will exceed the private returns realized by the firm that initially received the research award. In the United States, the Advanced Technology Program (ATP) provides an example of a government R&D program that attempts to encourage broadly applicable technical advance. Since 1990, the ATP has provided selective cost-sharing awards for early stage industry-defined research projects with broad-based economic potential (Hill, 1998).[6]

1.1. *Rationale for public-private R&D partnering*

The mission of the ATP thus depends upon its success in selecting projects with attributes that indicate a high potential to generate substantial economic benefits. Of course, there is no way of guaranteeing, in advance, whether an R&D project actually will result in successful commercialization or if the knowledge created will be valued by other organizations. The ATP's review and selection process aims to identify high quality research projects proposed by industry that have clearly delineated pathways through which the projects may achieve broad-based economic benefits. High ratings on the technical and economic dimensions by the ATP's reviewers are a pre-requisite for winning an award.

In addition to the assessment of the proposal itself, certain behaviors evident in a firm's R&D strategy may provide an indication of how readily the knowledge generated by the government funded R&D project may diffuse to and benefit other organizations.[7] In particular, a firm that is connected to other businesses for assistance in planning and carrying out its R&D, or has extensive linkages to the university research community, may offer more opportunity for other organizations to learn about the technical advances from the funded project (e.g. Doz, 1996; Hamel, 1991; Inkpen, 1995; Khanna et al., 1998; Powell et al., 1996).[8] Moreover, some firms attempt to guard access to their research results, while others see an advantage in sharing knowledge and are more willing to disseminate their research findings to other firms.[9] Clearly, when a firm openly shares information, the results of its research become known more quickly.

Since the ATP wants to encourage the diffusion of new knowledge by industry, it may favor projects where firms are attempting to forge new ties in new collaborative R&D efforts, or projects proposed by firms that are embedded in networks, or of company R&D and commercial linkages and firms that are more willing to share the knowledge that their R&D creates. The first research question we address in this paper concerns how these differences in R&D strategies of firms are related to winning an ATP award.

- Compared to non-winners, do firms that win an ATP award have R&D strategies with greater potential for diffusing knowledge and incorporating technical advance into commercial applications?

To the extent that the ATP is selecting projects in firms with R&D strategies that are more accessible to other researchers and firms, the more likely it is that the knowledge generated by the project will be taken up and used. Projects with such attributes are more likely to yield economic benefits, all other things being equal, that extend beyond the firms directly engaged in the project.

1.2. *Leveraging private sector R&D investment*

Government funding may also spur additional private investment in R&D activities.[10] For those outside the firm, the value of R&D activities in the early stages of technology development is difficult to assess since there is greater risk and uncertainty.[11] As a result, private investors typically focus on later stage projects. In order to secure private investment, a technology must be at a proof of concept phase. Public funding is a means for supporting early stage technology development and moving the project to a point where private investors are more willing to fund.[12] Finally, at any given time, there are a large number of investment opportunities and it may be difficult for private investors to accurately evaluate potential investments. 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 as well as programmatic expectations of economic significance, the investment decisions of other organizations may be favorably affected. In light of a large number of potential investment opportunities, the announcement of the ATP award may provide information that certifies an awardee's R&D activities from the perspective of the investment community (Lerner, 1999).[13] Hence, our second research question focuses on how ATP's funding makes a difference to firms in carrying out the type of high-risk, potentially high payout R&D proposed to the program. We address this question in two parts.

- Do non-winners continue with the proposed research project without ATP funding?
- Does the ATP award induce additional investment by other organizations in the R&D project?

The next section provides an introduction to the ATP and its mission. Section 3 presents the data that we will use to answer our three research questions. Section 4 describes how we measure the potential of the project to provide broad-based economic benefits and addresses the first research question. Section 5 considers if non-awarded firms and projects proceeded and we conclude that the majority of the non-awardees did not pursue the research. Section 6 considers the third question on the ability of the ATP award to induce additional funding. We conclude that ATP appears to provide a certification function that increases the amount of funds that firms are able to raise subsequently.

2. Selecting R&D projects with broad-based benefits: Background on the advanced technology program

ATP depends on the initiative of industry to define the goals for the proposed research projects.[14] All 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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> (*Advanced Technology Program Proposal Preparation Kit*, 1999, pp. 7–8).

Independent technical experts and specialists in the business planning evaluate every proposal. The selection process involves an assessment of the project's contribution to technical advance, its economic potential, and the need for public funding. In any given year, fewer than 20 percent of proposed projects actually receive funding and the overall average is 12 percent for the competitions conducted between 1990 and 1999.

3. Study of the 1998 ATP applicants: Data description

To address our research questions about the ATP, we focus on the competition held during the summer of 1998. A total of 502 proposals were submitted. Because ATP guidelines encourage joint projects, 822 organizations applied in this

competition. Our primary interest is the 741 for-profit enterprises that applied to ATP in 1998.[15] This group of firms constitutes our sampling frame. The award winners were announced in October 1998.

ATP funded 80 proposals that involved 161 organizations, including 147 for-profit enterprises. Table I shows the distribution of firms by award status and firm size. About 20 percent of all applicant firms in 1998 received an ATP award. Small firms, employing fewer than 500 employees, constituted nearly 70 percent of all applicants. Although firms in this size category were only 52 percent of ATP award recipients, they accounted for 83 percent of all awards that were made to individual companies in that year. There were also 27 joint venture (JV) projects funded in 1998. These JV projects include 65 percent of all awardees and 87 percent of the firms with more than 500 employees.

To collect data on the 1998 applicants, we conducted a survey that asked about the applicant's perceptions of the process, about their firm's R&D strategies, and their experience with other funding sources in the year following their ATP application.[16] All interviews were completed over a six-month period (June–December 1999). Our respondent was the person identified as the technical lead for the proposed project. If this person was no longer with the company, we asked to speak to the individual who was most knowledgeable about the proposal and the company's R&D activities in the area identified in the proposal.[17] The telephone questionnaire required 20–30 minutes to complete.[18]

Our sample consisted of 100 percent of the winning firms and a simple random sample of 50 percent of the non-winners. Thus, we contacted 297 non-winners and 147 awardees one year after the 1998 ATP selection process. We completed interviews for 119 winners for an 81 percent response rate (119/147). For the non-winners, we discovered that within one year there were 49 cases that we could not interview, either because the company was no longer in business (23 cases) or because 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 (26 cases). We adjusted our response rate accordingly. We completed interviews for 122 non-winners, for a 50 percent response rate (122/(297-49)). This yields an overall effective response rate of 61 percent.

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.[19] 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.

4. Does the ATP favor firms that have greater potential for knowledge diffusion?

Our first research question requires considering projects and firm characteristics associated with greater economic potential. A project is expected to have greater economic potential if the firm embarks on a new technical problem or forms a new R&D collaboration. Although collaborations are widely recognized as an important R&D strategy (Doz, 1996; Hamel, 1991; Inkpen, 1995; Khanna et al., 1998; Powell et al., 1996), estab-

TABLE I
Distribution of applicants by award status and firm size

	Award status		
	Award winners	Non-winners	All applicants
Percent of firms ≥ 500 employees	48%	27%	31%
Percent of firms < 500 employees	52%	73%	69%
Number of firms	147	594	741
Percent of all applicants	20%	80%	100%

lishing a new relationship is difficult and costly for firms (Harrigan, 1988). Table II shows the percent of projects proposed to ATP in 1998 that involved two or more organizations as research partners, and the percent of new partnerships and new technical areas proposed by ATP award winners compared to non-winners. Seventy-nine percent of the 1998 ATP applicants in our sample included other organizations in their proposal. There is no difference between award-winners and non-winners in their propensity to have partners. However, the percent of award-winners identifying a new collaborator as their most important research partner, is significantly higher than occurs among non-winners (59 percent versus 42 percent). Another indication that award winners are more likely to open new pathways to innovation is their significantly greater tendency to propose a project in a technical area new to the firm (47 percent versus 19 percent).

One firm's R&D activities may have the potential to augment other firms' innovative capabilities but only if research results and knowledge are shared. Competitors' reluctance to collaborate and share research results may be likely. However, for certain complex technical areas, sharing information may be essential for the firm's technical advance. Moreover, an award winning firm's willingness to diffuse research results affords a greater opportunity for other firms to benefit from government-funded research.

TABLE II
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 $p < 0.01$.

As indicated in Table III, we used three statements about the company's approach to construct a measure of the firm's tendency towards either openness or secrecy in conducting its own R&D. The possible scores ranged from 0 to 3. We expected to find that most firms have a tendency to secrecy (Nelson, 1990; Liebeskind, 1997). Firms that answered yes to two of the three questions were considered to exhibit a tendency towards openness in their communications with other firms about their research. Overall, we find that only 23% of all applicants exhibited a tendency towards openness. However, compared to non-winning applicants, a significantly greater percentage of firms can be characterized as having a tendency towards openness in their research communications (31% compared to 19%).

The potential for contributing to scientific and technical advance is expected to be enhanced by a firm's linkages to universities and other institutions. For example, universities are an important source of new knowledge that may be applied to a broad range of industrial problems (Mowery and Rosenberg, 1989). In carrying out R&D a firm may draw upon its connections to university faculty, graduates, laboratory facilities, and intellectual property to augment its internal capabilities. These relationships are also potential pathways for reciprocal knowledge flows from the firm to the university-based research community and then perhaps on to other firms. We expect that the more connections that a firm has to university resources, the greater the potential for knowledge flows. As indicated in Table IV, we measured twelve different ways a firm may be linked to universities.[20] Included are universities as R&D partners in general and as resources for the ATP project specifically. The number of linkages serves as an index of the strength and diversity of connections to the university-based research community.

The ATP mandate stresses commercial and economic benefits as program goals; however, the program does not fund product development or

TABLE III
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%

Notes:
$\chi^2 = 4.636$. Statistically significant at $p < 0.05$ with 1 degree of freedom.
† 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.
* Percentage are weighted to reflect the proportion of winners and non-winners in the overall population.

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

market research. As a consequence, the potential of a technology to attract non-ATP resources for commercialization is critical. This could take the form of additional private capital attracted by the ATP awarded company, or might include resources provided by other companies who take up the technology and incorporate it into their commercial efforts. Connections to other firms, in the planning and development of the project, and more generally, as sources of financial and technical support, not only may be important to carry out the research but also may facilitate the eventual commercialization of the technology and the overall eventual impact of the project on the economy. We asked about applicant's connections to other firms in preparing the proposal for ATP, as potential collaborators on the project, and more generally, in providing technical and financial resources to the applicant in the two years prior to the application. We used the 19 questions shown in Table V to construct a business linkage index. A higher number of links to other businesses signals connection to a diversity of resources that are particularly important for companies seeking to commercialize their technologies.

Table VI shows the results of our comparisons of award-winners to all other applicants on these two indices. We find that there is no significant difference among firms in the extent of their linkages to universities. However, award-winners have a significantly greater number of linkages to other businesses.

The results of our survey show that the ATP tended to make awards to those companies who proposed projects involving the formation of important new partnerships. In addition, we find that award-winning projects are more likely to involve new areas of research for the firm. When compared to unsuccessful applicants, the firms receiving funding from ATP were more likely to have extensive linkages to other businesses and to profess a greater willingness to share information about their research findings with other firms. This indicates that the knowledge and technologies developed by the award-winning projects were more likely to be diffused quickly through the extensive linkages of the firms and their greater willingness to make their research results available to other firms and their greater tolerance of knowledge leakages. Surprisingly, we find no

TABLE IV
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).

statistical difference between winners and non-winners in the extent of their linkages to universities.[21] That suggests that the ATP is attracting firms with similar connections to the resources available from universities in our nation's innovation system. Given the types of projects that were proposed to the ATP, perhaps it is not surprising that we find that all applicants had similar links to universities.

In sum, the following attributes increase the likelihood of winning an ATP award:

- Riskier research projects that are new to the firm;
- Research projects that form new R&D partnerships between organizations;

TABLE V
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 to Business Linkages Index = $\sum$ Number of Connections (Number of 'yes' answers to these questions).

TABLE VI
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-to-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.

- Firms that demonstrate a tendency towards openness in communications about research with other firms and institutions; and,
- Firms that have a more extensive set of business-to-business linkages.

These attributes distinguish award-winners from other applicants.

5. One year later: What happened to non-winners and the R&D projects they proposed to the ATP?

Our second research question addresses the concern that firms may proceed with projects in the absence of government funding. During the review and selection process, the ATP attempts to determine whether or not the R&D activity that is being proposed is likely to be carried forward at the same speed and scale by the company without any assistance from the ATP. Hence, if ATP attracts proposals that companies would proceed with anyway at the same funding level, with the same timeframe and goals, we would expect to see a high proportion of non-winning projects proceeding during this period of time. However, as Table VII indicates, when we interviewed firms one year later, this was not the case.

If a project is believed to be of central importance to a firm that has already funded this type of R&D from its own resources, the ATP is likely to reject the proposal. Similarly, if a company has access to other funding sources (within or outside the firm), the ATP may choose to award its scarce resources to firms that lack access to such funding sources.

More than three-fifths of the non-winners (62 percent) have not proceeded with any aspect of the R&D project that they proposed to ATP. This number includes the non-winners that we discovered had gone out of business in the previous year. Also included are the projects where the persons 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.[22] In addition to these 49 cases, there were another 66 non-winners who indicated that, in the previous year, their company had not proceeded with any aspect of the project proposed to ATP.

Nearly 37 percent of the non-awardees began work on the proposed project at some level of effort. However, in most instances (77 percent), 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 same scale as they originally had proposed the previous year, while less than four percent of the non-winners were proceeding with a larger scale effort than had been proposed to ATP.

These results suggest that, for the most part, ATP is attracting applicants that need support in order to proceed with their R&D plans. A small minority of non-winners pursued its R&D plans at the same or an even greater scale than originally proposed to ATP. It seems reasonable to assume that the few non-winners who proceeded at the

TABLE VII
The extent to which non-winners pursue the ATP proposed R&D project without ATP funding

Did not proceed with the project, at any scale	62%
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%

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

same or greater scale than they had proposed to the ATP were rejected because the ATP saw no need to fund these projects: the projects were promising but the need for public funding was not apparent.

6. Halo effect: Does the ATP award increase R&D funding from other sources?

When an enterprise receives an R&D contract from a government agency the award may be a signal to non-government sources of funding, such as banks, venture capital firms and other potential investors, that the firm has a potential future stream of revenue from a reliable customer (the U.S. government). The ATP awards differ from the usual government R&D contracts to industry, and hence the economic information conveyed by the award is quite different. There is no promise of follow-on funding by the agency. The ATP seeks to fund R&D projects that have commercial applications, and there is no procurement connection – the ATP does not purchase the technology it helps to develop through its awards. In light of the unique features of the program, we assess the potential influence of an ATP award on the subsequent behavior of the investment community to arise from the information the award signifies about both the technical quality and economic potential of the project and firm.

For an ATP award to influence the subsequent decision of other sources of research funding implies that the announcement of the award itself provides valuable and credible information to the investment community. The host agency of the ATP is the National Institute of Standards and Technology (NIST), which is widely recognized to be an important and reliable source of technical information and expertise in a number of areas.

6.1. *Pursuing R&D funding from other sources: The impact of the ATP award*

The highly selective and competitive nature of the ATP award may signal potential investors about the quality of the firms' R&D project. As a result, other investors such as angels investors or venture capitalists, other businesses, as well as state governments and other federal agencies may invest in the firm. We expect the ATP awards to confer a halo effect to winning firms and projects, boosting the chances of a firm's success in attracting additional funding for its R&D activities.

To test for this effect, we considered the group of applicants that pursued other funding sources in the year following the ATP application. Table VIII compares the percentages of firms in the two award status categories that sought additional funding from other sources and the percentages that actually succeeded in attracting funding from these sources. Although a minority of all applicants sought funding from other sources, the percentage of ATP award winners seeking additional funding was much lower. On average, however, the ATP awardees who sought funding from other sources were much more successful in attracting funds than non-winners. We asked firms about the amount of funding that they received for the ATP-proposed research project from non-ATP sources, including private individuals, venture capitalists, other firms, state and local government programs, and other federal government agencies.

6.2. *The ATP halo effect*

Winning an ATP award significantly increases the firm's success in attracting additional funds from other sources for R&D activities. Our findings

TABLE VIII
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%	38%
Percent of those firms seeking funding that succeeded in attracting additional investment for their R&D activities	73%	33%	44%
$\chi^2 = 12.592$[a]			

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

support the inference that the ATP award confers a halo effect on winners making them more likely to attract other funding. Through their investment decisions, other funding sources, both private and public, demonstrate that they believe that the ATP award provides valuable additional information about the quality of the project. Thus, our results confirm that the ATP award appears to send a market signal that certifies that the firm and the technology are promising.

7. Conclusion: The potential of the ATP for small business

Growth theorists describe two roles for government R&D policy (Jovanovic, 2000). The first role is in funding the supply of R&D. Most research to date has focused on this topic. The second role for government is providing incentives for private sector R&D and generating a set of behavioral responses that would be expected to stimulate R&D, promote innovation and economic growth. We know the most about the supply of R&D resources. Less is known about the ways in which government programs provide incentives for activities that generate innovation and economic growth.

In this paper, we have shown how a government program is leveraging private sector R&D activities by selecting projects with greater potential for diffusing knowledge and for contributing to the development of new technologies for commercial use. In essence, the mission of the Advanced Technology Program is to support private sector R&D projects that offer potential for contributing to technical advance and for realizing economic value. Our findings suggest that the operation of the program is consistent with its mandate and objectives. While the program is selecting projects that are rated highly by independent technical and business experts, it awards technically risky, new projects proposed by firms that have strong external linkages to other institutions and exhibit a willingness to diffuse knowledge based on their research findings.

We conclude that ATP is selecting projects and firms that have greater potential for increasing the circulation of new knowledge and for having the business connections necessary to realize economic benefits from its activities. The extent of a firm's linkages to other enterprises and to the resources of universities indicate that a firm is well-positioned to both tap the capabilities of other actors in our nation's innovation system and be a conduit for carrying the knowledge generated by an ATP project to use by other firms. These types of connections are important to the overall operation of the entire U.S. innovation system. We also find that the ATP supports the formation of new linkages and the initiation of R&D projects that bridge different technical areas, opening up new pathways to innovation.

We provide evidence that the investment community values the ATP award. Among firms that

seek additional funding, we find that ATP award winners are more successful than non-winners. Since few R&D projects proposed to ATP actually proceed at a comparable level, we conclude that the ATP is stimulating additional investment in risky R&D projects that would otherwise not be funded by the firms themselves or other funding sources. For small businesses that naturally have a tendency to engage in high-risk research projects, form collaborative relationships in order to augment their internal resources, and require additional funding and legitimacy, the ATP program may provide an important vehicle for their growth and development.

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Notes

[1] Link et al. (forthcoming) note that the traditional distinctions between basic and applied research have become meaningless in the commercialization of complex technologies. Firms may identify research areas that require additional fundamental research.

[2] The profit incentive that motivates innovative activity by an individual firm also discourages information sharing and collaborative R&D activities between companies.

[3] An example of productive and profitable research undertaken by public-private partnerships is SEMATECH.

[4] The general argument for government funding of certain types of R&D activities, as articulated by Griliches (1992), is that such subsidies provide an incentive to firms to undertake high-risk R&D projects in which the public rate of return exceeds the private rate of return. This includes, for example, the case where an industry as a whole may benefit from the development of an enabling technology. Private firms typically use some pre-determined benchmark rate of return known as a hurdle rate. The project will only be acceptable if the expected rate of return is above that benchmark. By reducing the cost of the project to the firm, government funding will increase the expected rate of return and may make private companies willing to pursue them.

[5] See National Research Council (1996, pp. 12–40) for a review of international programs that encourage collaboration. For an introduction and review of the objectives of recent U.S. R&D programs, see Kelley (1997).

[6] For a discussion of the legislation and policy issues that led to the establishment of the ATP, see Hill (1998).

[7] Only when scientific and technical advances become known and are incorporated into new products and processes can ATP expect to see any economic benefits realized from the funded project.

[8] Studies of the strategies that managers use to learn about other organization's products, technologies, and business practices emphasize the importance of both formal linkages between firms and the informal network ties among engineers, scientists, and managers employed in different organizations. In general, this literature indicates that cooperation among firms is an important pathway for learning about technical advances in other organizations. More specifically, linkages that involve the sharing of resources, whether technical or financial, become important conduits for knowledge transfer among firms.

[9] Paradoxically, in order to gain direct and early access to the knowledge and technologies being developed in other organizations, a firm has to be willing to give some of its own accumulated knowledge and technologies to others (Liebeskind, 1996).

[10] Previous research suggests that the ways in which government provides funding to the private sector is important. David et al. (2000) indicate that the private sector is less likely to increase its own R&D spending when government R&D funding is provided through contract R&D programs in which there is potential for follow-on funding and technology procurement.

[11] See the remarks of David Morgenthaler of Morgenthaler Venture Capital (forthcoming).

[12] See Feldman et al. (2000) for an analysis of in-depth case studies that found this relationship. These case studies were used to design this statistical study that we report on here.

[13] Lerner (1999) suggests that the Small Business Innovation Research (SBIR) program award provides a certification function that informs private investors of a notable investment opportunity.

[14] The ATP is fundamentally different from other government R&D programs as the focus is industry-defined. This contrasts with the SBIR as a case in point.

[15] Private firms must lead ATP projects but there is frequent collaboration with not-for-profit organizations. In 1998 alone, there were 38 Universities, 29 non-profit organizations, seven government labs and seven foreign-owned U.S. subsidiaries included in projects proposed to the ATP.

[16] The survey instrument was reviewed and approved by the Office of Management and Budget and the JHU Committee on the Use of Human Subjects. OMB granted approval (no. 0693-0027) for Johns Hopkins University to conduct the survey on March 24, 1999.

[17] Prior to calling our respondents to conduct the interviews, we followed standard survey method procedures, sending a letter to all potential respondents in the selected sample to explain the purpose of the survey, identifying ATP as the sponsor of the study, and asking for cooperation. This letter also contained a statement of confidentiality and assurance that responses to any of the survey questions would remain

anonymous, and would not be publicly released in any form that would identify a specific individual or company. The letter included a list of questions that the respondent might find helpful to have in advance of the telephone interview. In addition, our mailing included an introductory letter from the ATP. The Schaefer Center for Survey Research at the University of Baltimore conducted the telephone interviews.

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

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

[20] See Feldman and Kelley (2001) for further discussion.

[21] The average applicant scored 5.5 on the university linkage index with no statistical difference between award winners and non-winners.

[22] In most respects, the projects for firms that either went out of business or where the Principal Investigator (P.I.) was no longer employed at the firm were similar to the other non-awardees. However, we found one important difference. When compared to the evaluation of their business plans, the defunct firms were rated as having stronger, on average, technical plans. This suggests that they were relatively weaker on the business front.

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