

Program Design Effects in the Advanced Technology Program: Joint Venture/Single Participant and University Role in Firm Success

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Executive Summary

The Advanced Technology Program (ATP) has significant and robust effects on innovation in firms. ATP participation and award, taken together, generally increase patents applied for (that are eventually granted) during the time they are receiving ATP support, compared to patenting by that same firm prior to and after the ATP award, controlling for firm size and industry. Interestingly, it appears that participation comes with some fixed costs, and only when the ATP award exceeds these fixed costs does company innovation increase. These results also hold for public companies (listed in COMPUSTAT), for which we can control for research and development (R&D) expenditures, implying that for public companies ATP support does not replace part of their own R&D effort. Further, when we add universities and other non-profit joint venture (JV) participants (as partners of firms), we again find that patenting increases during support by ATP. Fixed-effects estimates—controlling for unmeasured characteristics of each participant—provide strong, consistent support for all of the above results.

JV participants consistently appear to have lower fixed costs of entry into ATP, but also lower marginal impact per dollar of funding received compared to Single Participants. JVs or other alliances between firms are often thought to improve success through sharing of expertise, with the added network ties to firms and universities adding to social capital and leading to higher rates of innovation. We do find consistent support for JVs patenting significantly more during ATP compared to all ATP participants, even under fixed effects—except for public companies. However, at the same time many of the single participants are quite small with no or very few patents before ATP and hence show very large percentage increases.

University collaborations are also expected to have positive effects on innovation via the information they can provide to others. As expected, when universities are JV partners patents increase significantly during ATP participation, whether looking at all firms, public firms only, or all participants, but these results become non-significant in fixed effects estimates. However, our analysis design sets a high hurdle for significance: we first enter the effects of the overall JV and then estimate the incremental effect due to university JVs—and the JV effect measure is likewise an incremental effect above the main ATP effect.

Turning to the role of university subcontractors, whether with JVs or Single Participants, it shows a much less consistent pattern. The effects on patenting during ATP is sometimes strongly positive, sometimes not significant, sometimes significantly negative, and may shift in either direction or sign—or both—in fixed effects estimates. Perhaps other company-university collaborations outside of ATP—including past collaboration history with the same university-- need to be included as a comparison base, since firms with many such collaborations may be less affected by university subcontracts within ATP.

The headline result of our research is the strong ATP program effects on patents granted, along with additive JV effects. These ATP effects survive the tough tests of fixed effects estimation for all firms, public firms, and all organizations including university and other non-profit partners in JVs.

I. Introduction

It is commonly understood that research and development (R&D), being in part a public good, would be under-produced absent government support. There has been considerable controversy over whether industry R&D should be supported, much more controversy than over support of R&D in universities and research institutes. Direct investigation of the issues raised in the resulting debates lies beyond the scope of this paper (see Cohen and Noll 1991),¹ however these debates create pressure for government programs funding industry R&D to be accountable, to evaluate the impact of the program carefully and thoroughly. This paper is part of that effort.

The Advanced Technology Program (ATP), at the National Institute for Standards and Technology (NIST), is the focus of this paper. The ATP funds “enabling technologies which firms are not likely to pursue in a timely way without the ATP” (Furlani 1999:121). The role of the Advanced Technology Program (ATP) is to “bridge” the gap between demonstrating a promising but risky idea and garnering the organizational resources to commercialize a product, thereby increasing the commercial capture of advanced technology.² NIST made its first awards in 1990, with the first projects beginning work in 1991.

A necessary (but not sufficient) condition for the success of the Advanced Technology Program is that it contributes to the success of participant firms: If these firms do not profit from the new technology, others are unlikely to adopt it. Hence, we search for evidence of ATP’s overall impact on firm success as the first step in this process. Our second step, begun but not completed in this paper, is to investigate what underlies any impact on firm success that we uncover. Here, we investigate program design effects, focusing on Joint Ventures (JVs) versus Single Participants (SPs) and also on the role of universities.

ATP is administered by a single federal agency: the National Institute of Standards and

Technology (NIST), under the Technology Administration of the U.S. Department of Commerce. All projects have a common review structure and administrative requirements.³ ATP is the only major U.S. government program for technologically advanced R&D that includes a significant number of both joint venture and single participant projects.

For a number of reasons, including avoiding sample selection bias, we choose to evaluate ATP's effects across all participants in terms of overall change during ATP support in patent applications—for patents ever granted. Patents are a suitable measure, though of course not equally suitable, for all of ATP's participants: small, privately-held firms, larger public firms, universities, and other research organizations all patent. From 1988, when our panel begins, to 1997 when it ends, ATP participants account for over 40% of all utility patents granted to U.S. entities by the U.S. Patent and Trademark Office (USPTO). Indeed, innovation in “advanced technology” and patenting seem to go hand-in-hand for nearly all of the organizations participating in ATP, especially so for the firms.

A more fundamental reason for selecting a measure that is available for all organizations rests on our theoretical approach. ATP not only provides awards to participants, but it actively engages in institution-building, creating new structures that facilitate making innovations and capturing those inventions in technologically advanced commercial products. We will consider the ATP institution-building processes in more detail in the next section of this paper. This institutional shift causes a change in the participants' social embeddedness including network relations with other firms and universities (Granovetter 1985), especially so for JVs, though even Single Participants note the importance of subcontractors to reaching their project objectives. These social structure and social network expansion and change are best assessed in a before, during, and after “self-comparison” design. If we select a project-specific outcome measure, we

cannot have data before it starts nor after it stops. Note that the design roughly follows that for assessing the impact of an external shock, but in ATP there is a central endogenous component: Only those firms who apply to ATP get awards.⁴

Institutional context shifts imply changes in firms' social capital, where social capital is the "accumulated history in the form of social structure appropriable for productive use," here appropriable by firms or other organizations in pursuit of their interests (see Sandefur and Laumann 1998: 482 after Coleman 1990). Social capital can have informational benefits for the firm, specifically in ATP about the technologies all of the JV participants are using in the funded project and also about their underlying basic knowledge brought into the JV. Universities are often at the center of new discoveries and also the application of these discoveries, particularly discoveries that involve radical change from prior knowledge (see especially Zucker and Darby 1996 and 1998; Zucker, Darby and Brewer 1998; Darby and Zucker 1999; Liebeskind et al. 1996; also Jaffe 1989). Thus, for many ATP projects, university relationships are expected to often be the most valuable source of information. ATP companies, then, are expected to patent more when they include universities as JV partners or as subcontractors (following Kelley 1999).

In the next section of this paper, we develop the theoretical approach that underlies our analysis of

ATP, provide more detail on ATP program design especially as it applies to JVs, and further discuss our selection of a patent-based measure of company success. We then briefly review the methods used in our research, followed by our results. We end with implications and conclusions, and append a separate section on suggestions to the Economic Assessment Office (EAO) at NIST

based on our results and experience in assembling the necessary data.

II. ATP Program Design as Institution-Building

“Because social capital is appropriable social structure, changes in the social structure will affect both its existence and its value.” – Sandefur and Laumann 1998: 494.

In the Advanced Technology Program, Single Participants (SPs) in general face fewer significant changes in their operating context than participants in JVs . Resource flow from the ATP award occurs, and some social relationships may change through new or deeper interaction with subcontractors. In fact, in Powell (1997: 23-24) the seven quotes concerning obtaining assistance from universities were all from SPs. Thus, there are some changes in information sharing in SP projects, observably with subcontractors. However, there is less opportunity than in JV projects—fewer other organizations and a generally lower rate of interaction.

The lower rate of interaction stems at least in part from ATP’s institution-building process that requires a joint administrative structure for JV participants, but no equivalent structure for subcontractors (in either JV or SP projects). We expect the major impact in SPs to come from increased resources available through the ATP award.⁵ The context in which firms operate if they are members of JVs contains more significant operational changes. The other organizations—firms, universities, other non-profits—with whom each participant collaborates may shift and will certainly intensify, at least in frequency. These changes in social structure in which the firm operates embed each participant in a different, or at least more intense, set of network relationships.

ATP’s institution-building is quite specific about the “preferred” partners in a JV. ATP encourages a mix of JV partners that further ATP program objectives (ATP, 1999: 34): “Joint ventures should aim to include companies of diverse size, including smaller companies, and possibly other organizations, such as universities and national laboratories.”

II.A. JV Internal Governance Structure: Information Sharing

With the goal of improving JV project coordination and outcomes, ATP has designed collaborative social structure linking firms, universities, federal labs, and other non-profit participants in JVs. First, ATP has established incentives to encourage formation of JVs , including potentially higher award levels and more years of funding, and also has established ground rules for collaboration by creating a set of required governance structures for internal management of JVs. These rules are outlined in ATP's application materials (ATP, 1999).

ATP requires that JVs prepare a scheme for the distribution of intellectual property and provides a "Sample Intellectual Property Plan For Joint Venture Agreement" (ATP 1999: Appendix G-2, 69). Suggested arrangements allow for both sole ownership by a discovering partner and joint ownership if more than one discovering partner. In addition, cross-licensing agreements along with conditions of use (e.g., exclusive licenses or nonexclusive) are also outlined. Government walk-in rights are required for patents.

ATP specifies in some detail several structures that are **required** for internal governance of JVs: (1) A Management Committee must consist of one representative of each collaborating organization; (2) Proprietary information must be protected within the JV; and (3) Each member of the JV must grant to a single Administrator a Power of Attorney regarding the NIST Cooperative Agreement (Sample Joint Venture Agreement, ATP 1999: Appendix G-1, 65-68).

While driven by practical concerns in management of collaborative R&D, ATP's program design for JVs tends to relax the boundaries of participants' organizations. ATP specifically opens up the boundaries where the ATP project impinges in order to encourage joint governance and reasonable access by all JV members to intellectual property created within the JV. "Spillovers" or transfers, especially of knowledge, to other JV members occur within this enlarged

"information envelope" that protects the information—to some extent—from further dissemination (Zucker, Darby, Brewer and Peng 1996; internal task routines may also be difficult to understand from outside the organization, see (Nelson and Winter 1982: 123-124).

Enlarging the effective organizational boundary to encompass the new research collaborations has two main effects that cause more information sharing to occur: (1) JVs make the knowledge created by one participant organization more observable to the other participants, because internal task routines that would often be unobservable across organizational boundaries becomes transparent through the joint work among scientists, engineers, and other technically trained workers; and (2) Boundary enlargement may define a new "common," at least one area of mutual benefit around the shared ATP project, since the ATP project is likely to continue to draw resources from the government if the course of the research appears promising.

II.B. Changes in Social Capital in ATP: Effects on Firm Success

Our argument is a simple one: JV participants, because of ATP's active institution-building (and subsequent reinforcing oversight by Project Managers), operate in—or are "embedded in"—a different social context, with new social structure active, as they enter a new JV in ATP. By becoming embedded in the new structure, JV participants increase their available stock of social capital and derive an information (or knowledge) benefit from it. We argue therefore that firms not only have more resources during ATP, but also have changed social relationships (more, more intense, different collaborators) that may provide additional or at least different social capital that adds value above the characteristics of the firm itself and the project resources from ATP (Coleman, 1988 and 1990; Burt, 1997). Many of the early JVs involved firms that had never worked together before and had formed specifically to apply for ATP funding (Silber, 1996: 23).

Not surprising, we expect this information benefit to be greater when there is a university partner in the JV, since universities generate the largest part of the science and technology knowledge stock. This information benefit, derived from additional social capital provided by the JV network of relationships, translates into expected increases in applications filed—for patents ever granted—during JV funding by ATP. We further expect that JVs receive a boost in intellectual property returns relative to Single Participants because of the increased information sharing in JVs.

Comments by ATP participants in JVs support our argument. As one JV member notes (Powell, 1997:22): “Excellent collaborative environment and complementary technical capabilities have improved the quality of technical output and effectiveness of the team. There has been tremendous synergy between the companies that are collaborating on this project. Each company brings a particular expertise that the others don’t have and which would be difficult to develop. Each party is an enabler for the others.” Another JV participant states (Powell, 1997:23): “Exposed to new ideas, technologies that would otherwise not have been exposed to. Enabled us to leap forward with newer approaches into our architectural design.” A surprising 99 percent of those participants who found collaboration helped in achieving ATP project goals (78% of all participants) reported that the collaboration stimulated creative thinking, while 77 percent stated that they were able to use the collaboration to obtain R&D expertise (Powell, 1997: 20, Figure 1).

The new social relationships link each participant in the JV into wider social networks, including firms, universities, federal labs, and other organizations outside of the JV with which other JV partners have collaborated or are linked to in some other way. These contacts multiply access to social capital with its accompanying information advantage (see Granovetter, 1973 on

the strength of weak ties in social networks). As one JV member explained (Powell, 1997: 24): “In general, the collaboration has allowed us to contact new potential collaborators and markets. Some of these markets are for new equipment using our technology in ways we had not considered. Due to the success of the JV, the various members are investigating projects outside the ATP.”

II.C. Firm-Specific and Project-Specific Success: Patents

Institution-building by ATP and the resulting social capital and information advantage held by ATP participants, specifically in JVs but also in collaborations with universities, provides a model of the inputs into the innovation process in ATP projects. How do we best measure the impact?

Since we focus on changes in social capital as the unmeasured mediating variable operating in ATP, our theoretical approach requires an assessment based on changes in success, comparing before ATP, during ATP, and after ATP. Project specific variables, collected by the Office of Economic Assessment at NIST, are an important means of evaluation (see Long 1999; Powell 1997; Laidlaw 1997) but are not suitable for a test of our model since only the ATP period can be measured.

In this paper we study change in innovative, inventive activity by firms due to ATP. A major purpose of ATP is to increase commercial capture of advanced technology. Patents are arguably the single best measure of commercial capture of invention, conveying intellectual property rights.⁶ Figure 1 shows that patents are in fact commonly used to protect intellectual property created under ATP support: fully 75% of the organizations funded 1993-1995 report that patents are primary or secondary strategies they will employ, with only 13% reporting that patents are unlikely (Powell 1977: 40-41).

Data on ATP project-specific intellectual property, including patents and other kinds of innovations, are routinely collected by NIST's Office of Economic Assessment. In this paper, we begin the process of extending this assessment to see if ATP projects have a more general effect on formation of new intellectual property within the firm or non-profit, an "internal knowledge spillover." Our main indicator is whether overall rates of patent application by a firm or non-profit are increased after participation in ATP begins. Using a patent count measure from archival data provided to us by colleagues at the NBER (assembled from Derwent files by an NBER/Case Western team) and significantly augmented by the Center for International Science, Technology and Cultural Policy (CISTCP) at UCLA (through a proprietary joint venture), we find that the before and after patenting rates generally increase after ATP participation under a number of different program and participant variations.

ATP also collected information on patents that resulted directly from ATP support. We explore the validity of this measure in our results section, testing the relationship between overall patenting by the organization and patents reported to ATP. We find that there is a very strong positive relationship, but a very unstable one. Few patents are reported to ATP, only 40 from 1993-1996 or .07 percent of total patenting by ATP participant organizations during that period. This suggests participant firms report as few patents as possible to ATP so as to avoid giving the federal government rights to royalty-free use of the patents. Aghion and Tirole (1994) have emphasized the difficulty that firms have in writing contracts that effectively constrain researchers to disclose valuable inventions as resulting from their research, and the same incentives to avoid reporting are doubtless present here.

III. Methods

In this paper, we focus on the form of the relationships (JV vs. SP), and secondarily on an indicator of their content: University partner in a JV (present or absent) and university subcontractors (present or absent) in both JV and Single Participant projects. The university variables are qualitative proxies for information or knowledge.

Our first step is to set the unit of analysis. Generally, archival data on patents are available only for the organization as a whole and not for individual locations of multi-location firms. As a result, for analysis of whether participation in ATP had a positive effect on firms, we must move to the firm/organization as our basic unit of analysis. Figure 2 shows both the project and participant level for ATP ever active projects/participants in both JV and Single Participant projects.

III.A. Deflated Patents and Dollar Deflators

Our framework for analysis of ATP effects thus rests on measurement of changes in patent applications made by companies (for patents that are later granted) during the period they are active ATP participants and are receiving ATP funding.

The overall rate of patenting is affected by the value of patents and the ease of obtaining them (Griliches, 1992). In recent years Congress and the courts have strengthened patent rights and the U.S. Patent and Trademark Office has hired more patent examiners. As a result, both the rate of patent application and the speed with which patents are granted have increased. Thus, a simple before and after comparison is subject to criticism as reflecting trend increases rather than any real effect.

Accordingly, we developed a “deflated” patent-count measure, analogous to real GDP

which is obtained by dividing current dollar GDP by the GDP deflator (a kind of price index): patents-per-assignee deflator. The patents-per-assignee deflator is the ratio of total number of patents with a U.S. assignee at issue in a given year divided by the number of U.S. assignees in that year to the same calculated patents per assignee in 1996. Figure 3 reports data on the total number of U.S. patents with a U.S. assignee at issue and the calculated values of patents-per-assignee deflator.

We report the chain-type price index for gross domestic product that we used to deflate the ATP and JV award dollars, as well as R&D expenditures for public firms (Compustat).

III.B. Sampling Criteria and Panel Design

Patenting by ATP awardees are tracked both before and after they become ATP participants, as well as during ATP, allowing us to assess their patenting performance both with and without ATP support. Thus, ATP participants serve in a sense as their own comparison group.

Table 1A summarizes the criteria we used to select eligible participants. For our main analysis we selected firms only, because of the heterogeneity among non-profit ATP participants and the fact that all are in JVs. At the end of our results section, we briefly examine all organizations that are ATP participants to check for potential bias in our results. Second, the ATP participant must be involved in research and development, excluding joint venture participants that served only administrative functions. Third, we exclude participants involved in projects that were cancelled before completion. Fourth, the project must have started by the end of 1996, in order to have multiple years of ATP participation for participants entering late in the period. Fifth, we determined year of founding for each firm (universities and other non-profits were assumed to be “born” by 1988 since there is no reliable data available). Firms enter the panel

when founded or in 1988 if founded before that date in order to be able to distinguish whether no patenting in a given year meant that the organization did not yet exist or was in fact not patenting that year.

Sixth, still referring to Table 1A, we selected 1988 as the starting observation year for firms already founded to provide some pre-ATP observations even for firms entering in the first ATP cohort (1991) and end the panel in 1996 because we use the number of patents, by year of application, for patents already granted (the US Patent and Trademark office releases no information on patents applied for but not yet granted). By 1997, the count of patent applications becomes truncated because many have yet to emerge from the process given that our patents granted data ends June 30, 1999.

In Tables 1B through 1D, we present the panel design for three overlapping samples. In each case, in order to match into patent data, multiple establishments of the same firm are counted as one unit even though different locations of that firm may be participating at different times in ATP (each participation will be included in the model). The first sample (1B) is of all active firms that are ATP participants, showing the distribution of active periods in ATP by year. New entrants are due only to founding of a firm. Table 1C shows only those public companies active in each year. Finally, Table 1D shows all active organizations, including universities and other non-profits as well as firms. All active participants in ATP are included in this table, but refer back to Table 1A to review exclusion criteria and recall that the unit of analysis at the firm or organization level means the lack of one-to-one correspondence with ATP administrative records.

Refer to the Appendix for further details of design and methods, as well as a discussion of data sources. We now turn to the results of our analyses.

IV. Empirical Results: ATP's Effects on Firm Success

We divide our discussion of results into three parts, in each case beginning with descriptive statistics, then reporting OLS regression,⁷ and concluding with fixed effects estimation: (1) Firm participants; (2) Public firm participants, defined as appearing in Compustat; and (3) All organizational participants, including universities and other non-profits.

IV.A. Results for Company ATP Participants

Table 2 presents the descriptive statistics for firms in ATP. The industry definitions are taken from ATP because these firms are a mix of privately held companies and public companies. While public companies have SIC codes available, the privately held companies do not. These industry categories refer to the ATP project, so are not comparable to the more typical SIC codes.

The main effects of ATP participation on patents applied for (that are eventually granted) are estimated in equation 3.2 in Table 3. ATP participation and award, taken together, generally increase patenting during the time firms are receiving ATP support, compared to patenting by that same firm prior to and after the ATP award, controlling for firm size and industry. It appears that participation comes with some fixed costs, and only when the ATP award exceeds these fixed costs does company innovation increase. Figure 4 presents the results from equation 3.2, breaking out the separable effects for Single Participants (only), JVs (only), and those firms in both SP and JV projects. The change in patent applications (for patents eventually granted) are visually striking, especially for those firms in both types of projects.

JVs add significantly to the main ATP effect, with an additional increment for JVs with university partners (equations 3.3 and 3.4 in Table 3). JV participants appear to have lower fixed costs of entry into ATP, but also lower marginal impact per dollar of funding received compared

to Single Participants.

In equation 3.4, we also add university subcontractors to both JV and SP projects. The first is positive and significant, while the Single Participant subcontractors do not significantly boost patenting. Finally, we experiment with the ATP measure of patents reported to them as a direct result of the ATP project, and also add project application year to see if there is a planning effect. Both are strongly positive.

Fixed-effects estimates—controlling for unmeasured characteristics of each participant—provide strong, consistent support for the main ATP and JV participant effects, but the university and project application year lose significance. Patents reported to ATP proves to be highly unstable, reversing sign and remaining highly significant.

IV.B. Results for Public Company ATP Participants, Listed in COMPUSTAT

Table 5 presents the descriptive statistics for the public companies. We add one variable available in Compustat, R&D stock. The strong effects of ATP on patenting reflect those reported above in Table 3; for public companies, we can control for research and development (R&D) expenditures, implying that for public companies ATP support does not replace part of their own R&D effort. Figure 5, decomposing the effects in equation 6.2 (Table 6), again shows the strength of the ATP effect on patenting, except when public firms are only in Single Participant projects. Though the patents still increase when participating in ATP, the effect is much weaker than seen in Figure 4 for all firms.

The JV incremental effect is qualitatively similar to the results for all firms reported in Table 3. However, university collaborations—whether as JV partners or as subcontractors—do not increase patenting. Project application year is not significant, but “patents reported to ATP”

has a qualitatively similar effect as with all firms—strong and positive.

Looking now at the fixed effects estimation in Table 7, we see a more marked departure from the earlier all firm results. Here, just the main ATP effects are maintained. The Single Participant with university subcontractor is significantly negative, as is “patents reported to ATP.”

Public firms in JVs appear to have a less robust ATP effect on patents applied for—that are eventually granted.

IV.C. Results for All Organization Participants, Including Universities and Other Non-Profits

We present our results for all organizations in ATP in order to check our results above against the full sample of all ATP participants. We present the descriptive statistics in Table 8 and present a selected set of regressions, alternating OLS and fixed effects estimation across the table. The two new dummy variables, college and other non-profit, are never significant. Otherwise the results echo those in Tables 3 and 4 on all firms.

V. Conclusions and Implications

Positive effects of ATP on innovation rates in participating companies are both significant and robust in the analyses we report in this paper. Our measure of innovation—patent applications (for patents ever granted)—suggests that the effect of the ATP project spreads to effect the whole organization. These “internal spillovers” are the first stage in the broader effects that ATP needs to demonstrate in future research.

It was surprising to our research team to see how ATP organizations dominated U.S. patenting (over 40 percent from 1988 through 1996), suggesting that the very top, leading edge technology firms are getting involved as well as the top universities. These firms are not without competitors, so it would be strange indeed if other companies were not trying to develop related technologies—if we could turn the clock back, would we be content to stop all development of VCRs because Sony had developed Beta technology? What would the development path of that technology area look like now if the decision had been made to fund no more research and development in that area?

ATP appears to be an effective policy mechanism for encouraging companies to focus on advanced technology and to initiate new innovative activities and/or scale up existing efforts to develop pre-commercial advanced technology concepts into actual products. ATP’s focus on funding industry-initiated projects with “enabling, high risk technology with potential for broad economic impact” appears to generate strong benefits (Ruegg 1999:iii).

There is strong correspondence between our quantitative results and the qualitative results of the ATP Business Reporting System (Powell 1997). It is clear that ATP participants are generally enthusiastic supporters, and that they have very specific contributions to talk about when evaluating the program. The JV participants are the most likely to comment directly on knowledge

sharing and the potential for very rapid and even revolutionary development of advanced technologies—sometimes with those firms outside of ATP with the collaboration caused by the ATP project. We saw the same kind of enthusiasm in our focus groups with ATP Project Managers and a desire to support “good technology” in its many forms and stages. Exciting innovations are being developed, tested, and brought to market.

While there are some arguments for complete crowding out of private R&D expenditures by government grants (though we find evidence to the contrary for ATP), it is not surprising that ATP grants to private firms do in fact increase the success of R&D in the recipient firms. Our results show that these effects are in fact much more obvious for participant firms' total patenting than for the admitted direct results of the funded research projects.

This provides dramatic evidence of internal spillovers, downward reporting bias, or both. While internal spillovers may be unanticipated, they can in principle be captured and thus do not provide a strong argument per se for ATP or other government support of private R&D. However, the more people who share a secret -- or valuable tacit technological knowledge -- the harder it is to keep from outsiders and hence the greater the expectation of external spillovers. Identifying the extent of these externalities and understanding the processes that lead to more—or less—spillover is the goal for our next paper.

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ENDNOTES

¹ We will not review the rich and varied empirical literature on cost-benefit of state-supported R&D, various measures of impact of government R&D awards or subsidies on the business success of firms, and analyses of different kinds of mechanisms for support of industrial R&D by governments, including tax credits (for an excellent review of the latter, see Hall and van Reenen 1999; for a comparison of various government R&D policy tools, see Klette, Moen and Griliches 1999).

² The idea of ATP as a “bridge” emerged from qualitative field work conducted at NIST. In March 1999 the UCLA/ATP OEA team participated in focus group meetings with over a dozen different ATP project managers. Discussion ranged loosely around a set questions concerning how best to measure the effect of the ATP program, and what factors most often seemed to explained success or failure for particular projects and firms.

³ There have been a number of studies of the impact of the Small Business Innovation Research Program (SBIR) that has been in operation since the early 1980s, from xx to xx. Many of these studies examine the effects of SBIR awards as if it were a single program (XX). However, SBIR is actually a set of programs run by different federal agencies with a common focus on small businesses but with different administrative and review structures; the agencies also have different research foci that depend on their federal mission. In contrast, ATP is run under the same set of “ground rules,” though both joint ventures and special focused competitions tend to concentrate particular kinds of projects in a narrower range of industries. We do not investigate focused competitions here.

⁴ This source of endogeneity—arising from self-selection into ATP (though some in firms who fail to get an award will not like this terminology!)—is treated more directly in a related paper

(Zucker, Darby and Waguespack 2000). In this follow-on paper, we compare ATP awardees with a comparison group of later awardees, examined at least one year prior to receiving their first ATP award, as is the further self-selection into either joint venture (JV) or Single Participant (SP), with substantively similar results to those reported here.

⁵ There is also intense review by NIST before the award is made if the applicant is selected for an oral presentation at NIST, as well as interaction with NIST Program Managers, including significant technical oversight, after an award is made. We don't investigate these latter effects further, since we assume they are invariant across participants in ATP.

⁶ Trade secrets may be as good, but are both very difficult to identify and significantly less likely to have impact on ATP non-participants, while patents can be licensed and may also spillover to others through the incremental development of technology.

⁷ To handle zero patent observations, we also estimated tobit regressions. The results are substantively identical, though some of the industry categories and both the college and non-profit dummies became significant in tobit. Because of the small and substantively unimportant differences, we report OLS since we run fixed effects estimation also. Tobit results are available upon request to the authors.

Table 1A: Analysis Sampling Criteria.

ATP participants selected for analysis meet the following criteria:
1. Companies only first, then add Universities & non-profits.
2. Involved in ATP sponsored research and development.
3. Not involved in projects cancelled before completion.
4. Involved in a project that started work by 12/31/1995.
5. Observation years are from 1988 or the birth year of the organization, whichever is greatest, to 1996.
6. Patent data has a one-year lead, so patent observations are from 1989 to 1997.

Table 1B: ATP Active Companies by Panel Year—Total Patent Count

Year	1988	1989	1990	1991	1992	1993	1994	1995	1996
Total Organizations	232	245	260	274	285	349	349	350	350
New Entrants	232	13	15	14	11	64	0	1	0
Active in ATP	0	0	0	20	71	90	117	341	319
Inactive in ATP	232	245	260	254	214	259	232	9	31

Table 1C: ATP Active Public Companies by Panel Year*

Year	1988	1989	1990	1991	1992	1993	1994	1995	1996
Total Organizations	93	96	99	108	116	122	131	151	151
New Entrants	93	3	3	9	8	7	9	21	4
Firms Exiting**	0	0	0	0	0	1	0	1	4
Active in ATP	0	0	0	6	36	45	56	149	137
Inactive in ATP	93	96	99	102	80	77	75	2	14

*Public is defined as appearing in the COMPUSTAT files.

**These firms did not have R&D expenditures reported in COMPUSTAT for the indicated years.

Table 1D: ATP Active Organizations by Panel Year.

Year	1988	1989	1990	1991	1992	1993	1994	1995	1996
Total Organizations	294	307	322	336	347	411	411	412	412
New Entrants	294	13	15	14	11	64	0	1	0
Active in ATP	0	0	0	25	89	111	138	403	377
Inactive in ATP	294	307	322	311	258	300	273	9	35

Table 2: Descriptive Statistics for Company ATP Participants

Variable	Obs	Mean	S. D.	Min	Max
<u>PROJECT CHARACTERISTICS</u>					
ATP award (\$000s) ^a	2694	157.83	428.26	0.00	6856.37
ATP JV award (\$000s) ^a	2694	80.07	322.61	0.00	5697.77
Univ. collaboration ^b	2694	0.20	0.37	0.00	1.00
JV with University partner ^b	2694	0.08	0.26	0.00	1.00
JV with Univ. subcontractor ^b	2694	0.11	0.29	0.00	1.00
SP with Univ. subcontractor ^b	2694	0.07	0.24	0.00	1.00
Patents reported to ATP ^c	2694	0.02	0.19	0.00	4.29
Project application year ^b	2694	0.167	0.373	0.00	1.00
<u>PARTICIPATION INDICATORS</u>					
ATP participant ^b	2694	0.29	0.42	0.00	1.00
ATP JV participant ^b	2694	0.20	0.37	0.00	1.00
<u>COMPANY CHARACTERISTICS</u>					
Small ^d	2694	0.50	0.50	0.00	1.00
Medium ^d	2694	0.22	0.41	0.00	1.00
Large ^d	2694	0.22	0.41	0.00	1.00
Biotechnology ^b	2694	0.13	0.32	0.00	1.00
Chemicals/Chemical Processing ^b	2694	0.07	0.24	0.00	1.00
Electronics ^b	2694	0.14	0.32	0.00	1.00
Energy And Environment ^b	2694	0.04	0.18	0.00	1.00
Information/Computers/Communication/Entertainment System ^b	2694	0.23	0.41	0.00	1.00
Manufacturing (Discrete) ^b	2694	0.22	0.40	0.00	1.00
Materials ^b	2694	0.17	0.35	0.00	1.00
<u>DEPENDENT VARIABLE</u>					
Patent applications/US assignees deflator	2694	39.34	141.84	0.00	2053.00

^a continuous variable for company/year: sum of monthly awards for company this year.

^b (number of months during the year that the variable is true)/12; varies from 0 to 1.

^c continuous variable for company/year: reported patent count broken down into monthly increments for duration of project, then summed by year.

^d dummy variable for company: does not vary with year.

^e continuous variable for company/year.

Table 3: Patenting By ATP Company Participants – OLS Regression

Dependent Variable Specification Estimation	Patent application count for following year (for patents ultimately granted only), US patents/US assignees deflator				
	3.1 OLS	3.2 OLS	3.3 OLS	3.4 OLS	3.5 OLS
Constant	-46.900*** (10.960)	-44.224*** (10.525)	-42.573*** (10.361)	-41.947*** (10.370)	-44.285*** (10.326)
Small	-11.922* (5.790)	-13.766* (5.548)	-10.274 (5.481)	-9.764 (5.471)	-11.029* (5.445)
Large	159.124*** (7.034)	144.381*** (6.800)	138.635*** (6.723)	138.021*** (6.708)	135.541*** (6.690)
Biotechnology	59.909*** (12.408)	47.834*** (11.917)	50.438*** (11.736)	448.864*** (11.807)	47.098*** (11.749)
Electronics	104.819*** (12.181)	89.574*** (11.725)	88.106*** (11.542)	91.978*** (11.608)	90.234*** (11.549)
Energy And Environment	53.226*** (16.709)	43.935** (16.008)	49.270** (15.777)	49.265** (15.748)	48.444** (15.662)
Info./Comp./Comm./Ent. System	61.704*** (11.127)	54.338*** (10.672)	52.996*** (10.507)	51.355*** (10.562)	50.368*** (10.509)
Manufacturing (Discrete)	44.150*** (11.215)	44.301*** (10.752)	39.109*** (10.609)	36.383*** (10.623)	35.411** (10.566)
Materials	52.780*** (11.880)	47.937*** (11.378)	43.448*** (11.210)	43.213*** (11.204)	42.187*** (11.146)
ATP award (\$000s)		0.098*** (0.007)	0.203*** (0.016)	0.195*** (0.018)	0.188*** (0.079)
ATP participant		-26.015*** (6.613)	-139.564*** (13.766)	-140.321*** (14.269)	-130.439*** (14.299)
ATP JV participant			135.275*** (14.407)	98.424*** (15.321)	99.865*** (16.626)
ATP JV award (\$000s)			-0.139*** (0.020)	-0.133*** (0.021)	-0.136*** (0.021)
JV with University partner				32.094** (11.199)	32.924** (11.138)
JV with Univ. subcontractor				28.039* (11.344)	27.526* (11.283)
SP with Univ. subcontractor				8.612 (14.501)	.136 (14.591)
Project application year					27.051*** (6.057)
Patents reported to ATP					45.087*** (13.370)
Adjusted R-squared	0.232***	0.296***	0.318***	0.322***	0.330***
N	2694	2694	2694	2694	2694

Significance levels: *p ≤ .05, **p ≤ .01, ***p ≤ .001

Table 4: Patenting By ATP Company Participants – Fixed Effects

Dependent Variable	Patent application count for following year (for patents ultimately granted only), US patents/US assignees deflator			
	4.1	4.2	4.3	4.4
Specification Estimation	Fixed effects	Fixed effects	Fixed effects	Fixed effects
Constant	38.741*** (1.090)	38.696*** (1.086)	38.655*** (1.087)	38.111*** (1.155)
ATP award (\$000s)	0.018*** (0.003)	0.047*** (0.008)	0.043*** (0.009)	0.047*** (0.008)
ATP participant	-7.956** (2.777)	-27.088*** (6.271)	-28.498*** (6.508)	-33.194*** (6.431)
ATP JV participant		20.755** (6.786)	26.266*** (7.943)	31.224*** (7.834)
ATP JV award (\$000s)		-0.039*** (0.009)	-0.034*** (0.010)	-0.028** (0.010)
JV with University partner			.818 (5.429)	-0.214 (5.338)
JV with Univ. subcontractor			-8.419 (5.460)	-9.826 (5.369)
SP with Univ. subcontractor			6.289 (6.881)	14.360* (6.826)
Project application year				3.407 (2.405)
Patents reported to ATP				-63.741*** (7.011)
Adjusted R-squared	0.895***	0.896***	0.896***	0.900***
N	2694	2694	2694	2694

Significance levels: *p ≤ .05, **p ≤ .01, ***p ≤ .001

Table 5: Descriptive Statistics for Public Company ATP Participants, Listed in COMPUSTAT

Variable	Obs	Mean	S. D.	Min	Max
<i>PROJECT CHARACTERISTICS</i>					
ATP award (\$000s) ^a	1067.00	221.47	569.16	0.00	6856.37
ATP JV award (\$000s) ^a	1067.00	134.64	448.14	0.00	5697.77
Univ. collaboration ^b	1067.00	0.24	0.40	0.00	1.00
JV with University partner ^b	1067.00	0.12	0.31	0.00	1.00
JV with Univ. subcontractor ^b	1067.00	0.14	0.32	0.00	1.00
SP with Univ. subcontractor ^b	1067.00	0.08	0.25	0.00	1.00
Patents reported to ATP ^c	1067.00	0.03	0.27	0.00	4.29
Project application year ^b	1067.00	0.19	0.39	0.00	1.00
<i>PARTICIPATION INDICATORS</i>					
ATP participant ^b	1067.00	0.33	0.44	0.00	1.00
ATP JV participant ^b	1067.00	0.26	0.42	0.00	1.00
<i>COMPANY CHARACTERISTICS</i>					
Small ^d	1067.00	0.25	0.44	0.00	1.00
Medium ^d	1067.00	0.32	0.47	0.00	1.00
Large ^d	1067.00	0.43	0.49	0.00	1.00
Biotechnology ^b	1067.00	0.11	0.30	0.00	1.00
Chemicals/Chemical Processing ^b	1067.00	0.11	0.28	0.00	1.00
Electronics ^b	1067.00	0.14	0.30	0.00	1.00
Energy And Environment ^b	1067.00	0.05	0.19	0.00	1.00
Information/Computers/Communication/Entertainment System ^b	1067.00	0.21	0.39	0.00	1.00
Manufacturing (Discrete) ^b	1067.00	0.20	0.37	0.00	1.00
Materials ^b	1067.00	0.18	0.34	0.00	1.00
Cum. RD stock, 20% annual deprec ^e	1067.00	1477.17	3908.54	0.00	36025.15
<i>DEPENDENT VARIABLE</i>					
Patent applications/US assignees deflator	1067.00	87.37	206.93	0.00	2053.00

^a continuous variable for company/year: sum of monthly awards for company this year.

^b (number of months during the year that the variable is true)/12; varies from 0 to 1.

^c continuous variable for company/year: reported patent count broken down into monthly increments for duration of project, then summed by year.

^d dummy variable for company: does not vary with year.

^e continuous variable for company/year.

Table 6: Patenting By ATP Public Company Participants, Listed In COMPUSTAT – OLS Regression

Dependent Variable Specification Estimation	Patent application count for following year (for patents ultimately granted only), US patents/US assignees deflator				
	6.1 OLS	6.2 OLS	6.3 OLS	6.4 OLS	6.5 OLS
Constant	-54.429** (20.095)	-49.893* (19.678)	-46.840* (19.105)	-46.670* (19.203)	-46.657* (19.108)
Small	-15.162 (13.151)	-17.368 (12.890)	-11.420 (12.552)	-11.824 (12.607)	-13.156 (12.536)
Large	114.627*** (12.684)	111.265*** (12.378)	106.520*** (12.030)	106.550*** (12.046)	104.790*** (11.981)
Biotechnology	76.332*** (23.937)	67.637** (23.426)	75.997*** (22.923)	75.705*** (23.092)	76.009*** (22.964)
Electronics	169.847*** (23.601)	158.412*** (23.181)	153.416*** (22.511)	156.336*** (22.794)	155.499*** (22.666)
Energy And Environment	36.018 (29.922)	29.335 (29.229)	32.398 (28.562)	33.143 (28.660)	31.463 (28.503)
Info./Comp./Comm./Ent. System	72.303*** (20.324)	72.089*** (19.896)	69.777*** (19.314)	69.417*** (19.621)	68.622*** (19.514)
Manufacturing (Discrete)	-3.862 (20.639)	0.632 (20.150)	-2.570 (19.567)	-2.762 (19.681)	-3.537 (19.562)
Materials	55.502* (22.006)	51.141* (21.473)	43.160* (20.865)	42.820* (20.913)	41.843* (20.794)
R & D Stock (\$millions)	0.026*** (0.001)	0.024*** (0.001)	0.024*** (0.001)	0.024*** (0.001)	0.024*** (0.001)
ATP award (\$000s)		0.074*** (0.010)	0.242*** (0.023)	0.236*** (0.031)	0.237*** (0.030)
ATP participant		-37.344** (12.449)	-190.751*** (25.705)	-190.587*** (26.605)	-183.088*** (26.573)
ATP JV participant			167.298*** (26.321)	156.058*** (30.542)	151.836*** (30.466)
ATP JV award (\$000s)			-0.226*** (0.029)	-0.222*** (0.035)	-0.239*** (0.030)
JV with University partner				12.950 (19.357)	15.720 (19.265)
JV with Univ. subcontractor				12.040 (20.167)	9.842 (20.065)
SP with Univ. subcontractor				5.557 (30.890)	-13.046 (31.086)
Project application year					9.486 (11.705)
Patents reported to ATP					69.089** (18.250)
Adjusted R-squared	0.451***	0.478***	0.508***	0.507***	0.514***
N	1067	1067	1067	1067	1067

Significance levels: *p ≤ .05, **p ≤ .01, ***p ≤ .001

Table 7: Patenting By ATP Public Company Participants, Listed in COMPUSTAT – Fixed Effects

Dependent Variable	Patent application count for following year (for patents ultimately granted only), US patents/US assignees deflator			
	7.1	7.2	7.3	7.4
Specification	Fixed effects	Fixed effects	Fixed effects	Fixed effects
Estimation	Fixed effects	Fixed effects	Fixed effects	Fixed effects
Constant	88.828*** (4.013)	86.748*** (4.058)	87.158 (4.123)	87.517*** (4.064)
ATP award (\$000s)	0.026*** (0.005)	0.067*** (0.013)	0.090*** (0.017)	0.085*** (0.017)
ATP participant	-16.123** (6.161)	-41.180** (13.550)	-29.040* (14.289)	-32.263* (14.007)
R & D Stock (\$millions)	-0.001 (0.002)	0.000 (0.003)	-0.000 (0.003)	-0.001 (0.003)
ATP JV participant		25.478 (14.573)	14.939 (17.427)	19.853 (17.076)
ATP JV award (\$000s)		-0.058*** (0.017)	-0.077*** (0.020)	-0.056** (0.020)
JV with University partner			19.358 (11.634)	13.972 (11.414)
JV with Univ. subcontractor			-17.356 (11.511)	-17.045 (11.248)
SP with Univ. subcontractor			-41.618* (17.988)	-22.618 (17.807)
Project application year				4.907 (5.302)
Patents reported to ATP				-72.543*** (10.859)
Adjusted R-squared	0.905***	0.906***	0.907*	0.911***
N	1067	1067	1067	1067

Significance levels: *p ≤ .05, **p ≤ .01, ***p ≤ .001

Table 8: Descriptive Statistics for All Participant Organizations in ATP

Variable	Obs	Mean	S. D.	Min	Max
<i>PROJECT CHARACTERISTICS</i>					
ATP award money (\$000s) ^a	3252.00	145.45	404.49	0.00	6856.37
ATP JV award money (\$000s) ^a	3252.00	79.99	311.14	0.00	5697.77
Univ. collaboration ^b	3252.00	0.21	0.38	0.00	1.00
JV with Univ. partner ^b	3252.00	0.11	0.29	0.00	1.00
SA with Univ. subcontractor ^b	3252.00	0.06	0.23	0.00	1.00
JV with Univ. subcontractor ^b	3252.00	0.11	0.30	0.00	1.00
Patents reported to ATP ^c	3252.00	0.01	0.17	0.00	4.29
Project application year ^b	3252.00	0.16	0.37	0.00	1.00
<i>PARTICIPATION INDICATORS</i>					
ATP participant ^b	3252.00	0.28	0.42	0.00	1.00
ATP JV participant ^b	3252.00	0.21	0.38	0.00	1.00
<i>ORGANIZATION CHARACTERISTICS</i>					
Small ^d	3252.00	0.42	0.49	0.00	1.00
Medium ^d	3252.00	0.23	0.42	0.00	1.00
Large ^d	3252.00	0.18	0.39	0.00	1.00
Biotechnology ^b	3252.00	0.13	0.32	0.00	1.00
Chemicals/Chemical Processing ^b	3252.00	0.06	0.23	0.00	1.00
Electronics ^b	3252.00	0.13	0.30	0.00	1.00
Energy And Environment ^b	3252.00	0.03	0.17	0.00	1.00
Information/Computers/Communication/ Entertainment System ^b	3252.00	0.26	0.42	0.00	1.00
Manufacturing (Discrete) ^b	3252.00	0.23	0.40	0.00	1.00
Materials ^b	3252.00	0.15	0.34	0.00	1.00
College ^d	3252.00	0.83	0.28	0.00	1.00
Other Non-Profit ^d	3252.00	0.91	0.29	0.00	1.00
<i>DEPENDENT VARIABLE</i>					
PATS-US patents/US assignees deflator	3252.00	34.59	130.14	0.00	2053.00

^a continuous variable for org./year: sum of monthly awards for organization this year.

^b (number of months during the year that the variable is true)/12; varies from 0 to 1.

^c continuous variable for org./year: reported patent count broken down into monthly increments for duration of project, then summed by year.

^d dummy variable for organization: does not vary with year.

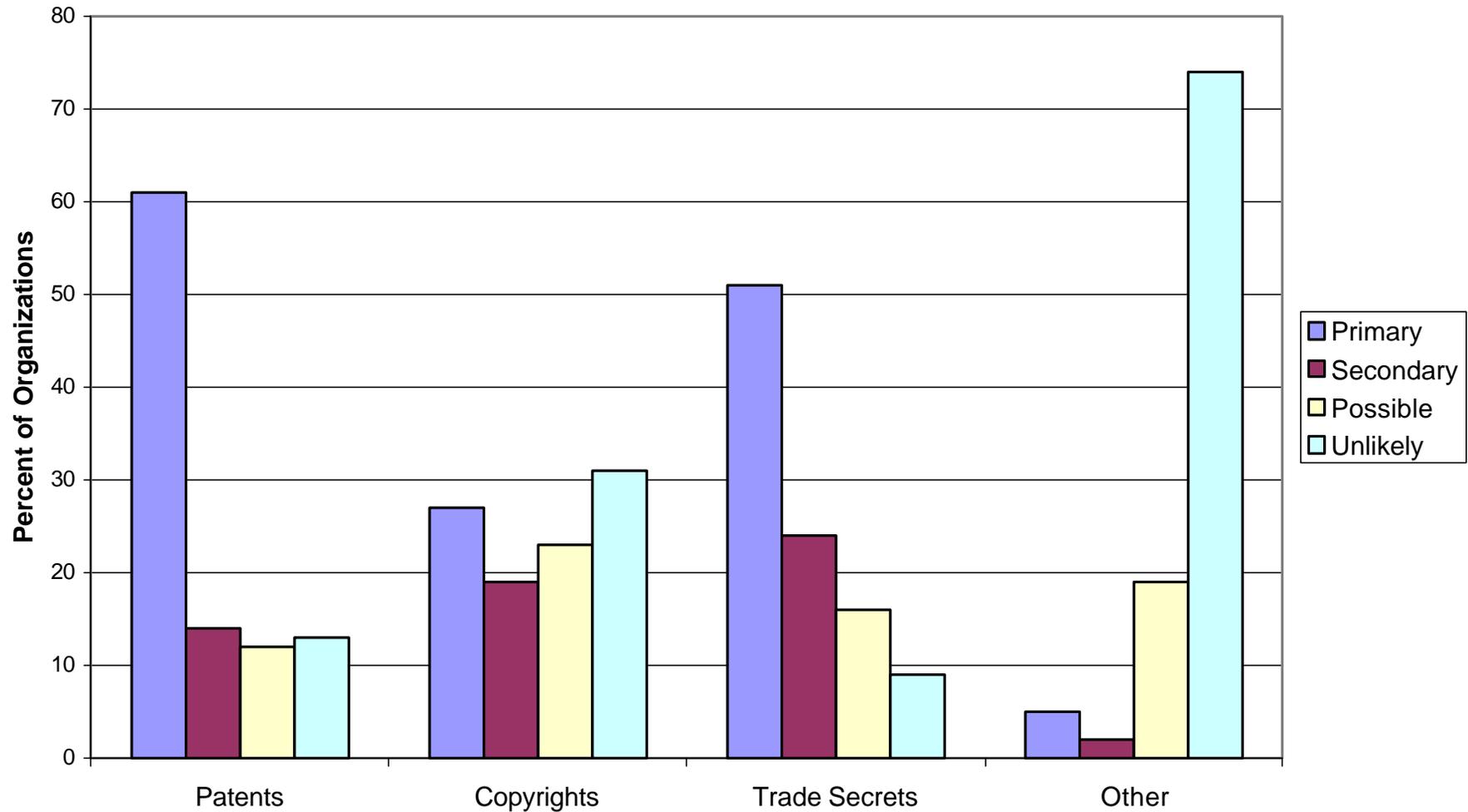
^e continuous variable for organization/year.

Table 9: Patenting By All ATP Organizational Participants – OLS Regression & Fixed Effects

Dependent Variable Specification Estimation	Patent application count for following year (for patents ultimately granted only), US patents/US assignees deflator					
	9.1 OLS	9.2 FIXED EFFECTS	9.3 OLS	9.4 FIXED EFFECTS	9.5 OLS	9.6 FIXED EFFECTS
Constant	-40.657*** (9.264)	34.006*** (0.904)	-39.782*** (9.285)	33.948*** (0.905)	-41.672*** (9.249)	33.507*** (0.960)
Small	-9.463 (5.004)		-9.033 (4.998)		-10.174* (4.976)	
Large	139.665*** (6.138)		139.320*** (6.129)		137.214*** (6.112)	
College	13.402 (7.710)		10.201 (7.796)		9.756 (7.757)	
Other Non-Profit	-5.798 (7.393)		-6.179 (7.389)		-5.965 (7.352)	
Biotechnology	47.476*** (10.291)		46.449*** (10.349)		45.122*** (10.302)	
Electronics	86.364*** (10.280)		88.958*** (10.336)		87.423*** (10.289)	
Energy And Environment	46.949*** (13.888)		46.541*** (13.878)		46.003*** (13.809)	
Info./Comp./Comm./Ent. System	49.052*** (9.236)		47.534*** (9.281)		46.666*** (9.238)	
Manufacturing (Discrete)	38.220*** (9.321)		36.515*** (9.328)		35.761*** (9.283)	
Materials	41.699*** (9.909)		41.532*** (9.909)		40.786*** (9.862)	
ATP award money (\$000s)	0.209*** (0.015)	0.047*** (0.007)	0.201*** (0.016)	0.043*** (0.008)	0.193*** (0.016)	0.048*** (0.008)
ATP participant	-142.300*** (12.407)	-26.900*** (5.667)	-145.369*** (12.889)	-28.276*** (5.885)	-135.572*** (12.932)	-33.655*** (5.825)
ATP JV participant	136.420*** (12.938)	22.024*** (6.067)	117.410*** (14.872)	26.570*** (7.040)	109.569*** (14.856)	32.217*** (6.954)
ATP JV award money (\$000s)	-0.150*** (0.018)	-0.039*** (0.008)	-0.144*** (0.019)	-0.034*** (0.009)	-0.146*** (0.019)	-0.031*** (0.009)
JV with University partner			25.346** (9.174)	2.291 (4.332)	26.273** (9.129)	1.264 (4.264)
SA with Univ. subcontractor			11.803 (13.206)	6.069 (6.253)	2.963 (13.295)	14.038* (6.206)
JV with Univ. subcontractor			17.109 (9.162)	-8.442 (4.392)	16.395 (9.120)	-9.754* (4.323)
Project Application Year					21.927*** (5.114)	2.795 (2.023)
Patents reported to ATP					48.896*** (12.192)	-62.741*** (6.386)
Adjusted R-squared	0.319***	0.896***	0.321***	0.896***	0.328***	.900***
N	3252	3252	3252	3252	3252	3252

Significance levels: *p ≤ .05, **p ≤ .01, ***p ≤ .001

Figure 1. Intellectual Property Strategies Planned



Source: Jeanne W. Powell, NISTIR 6098, Dec. 1997, p. 41, based on Business Progress Reports from 480 organizations funded 1993-1995.

Figure 2. Number of JV projects and firm participants, number of single participant projects, and cumulative number of unique ATP participant firms by year

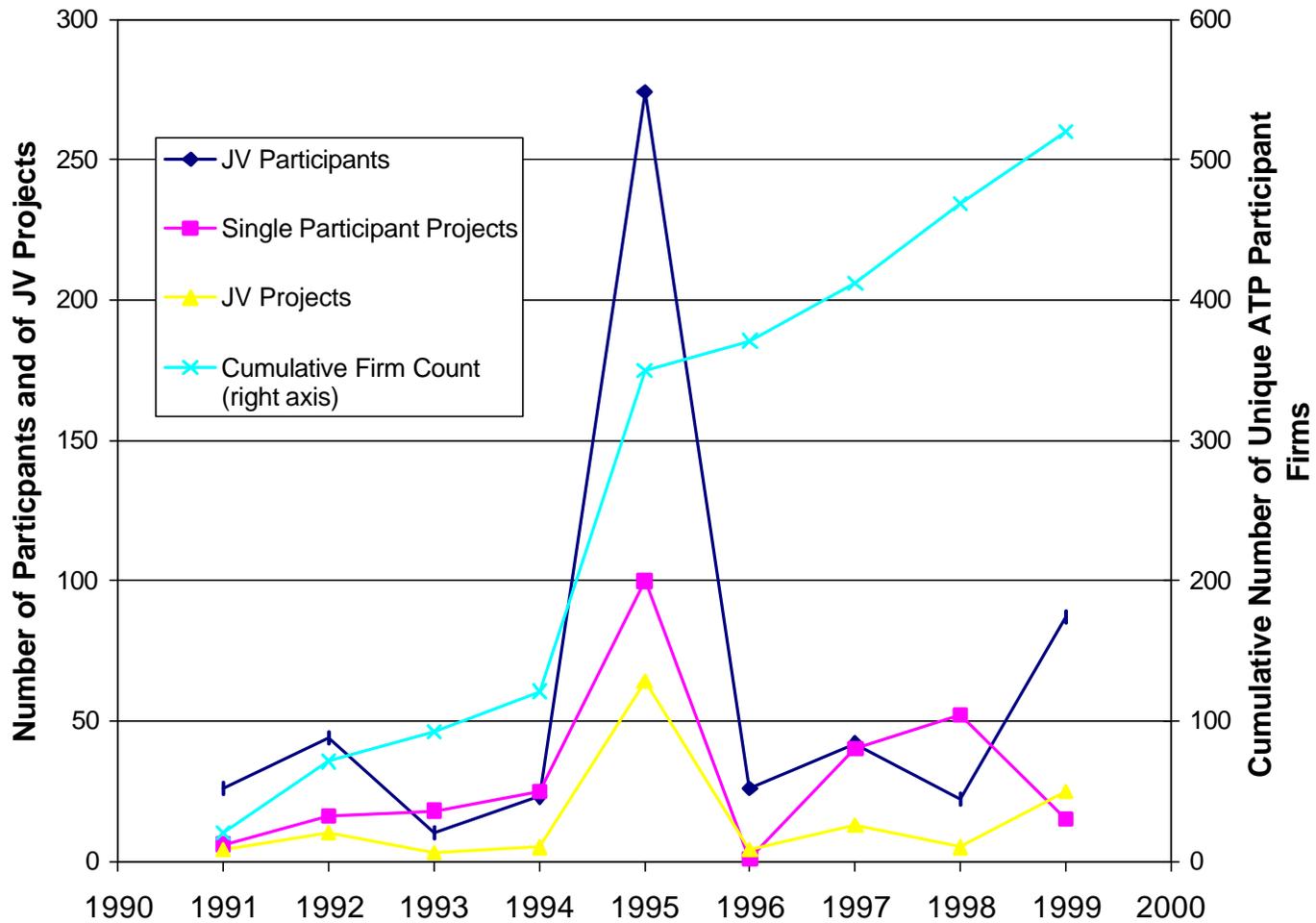


Figure 3. Yearly Counts for U.S. Assignees of Patents Granted and Deflated Patents Granted Dated by Application Year, 1988-1997

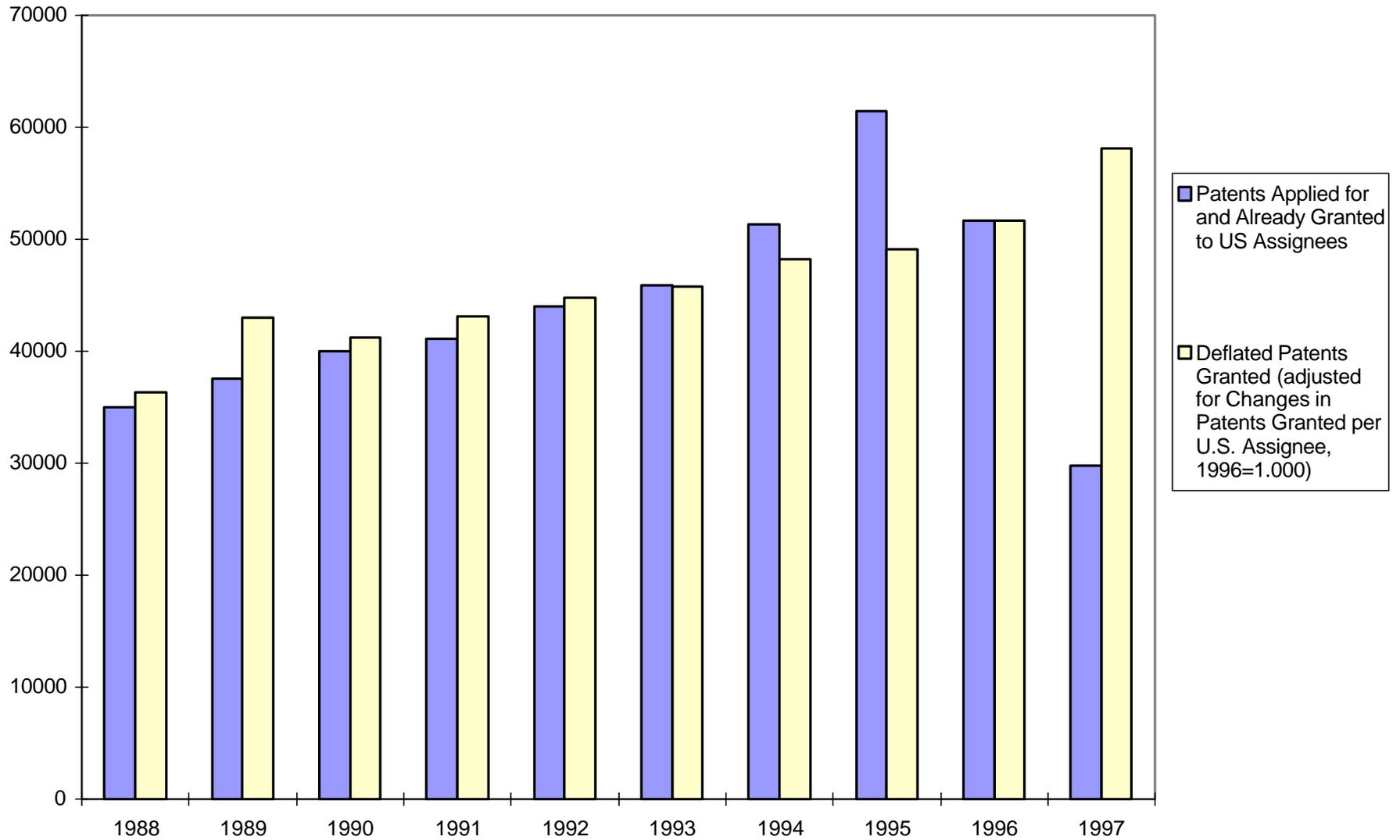
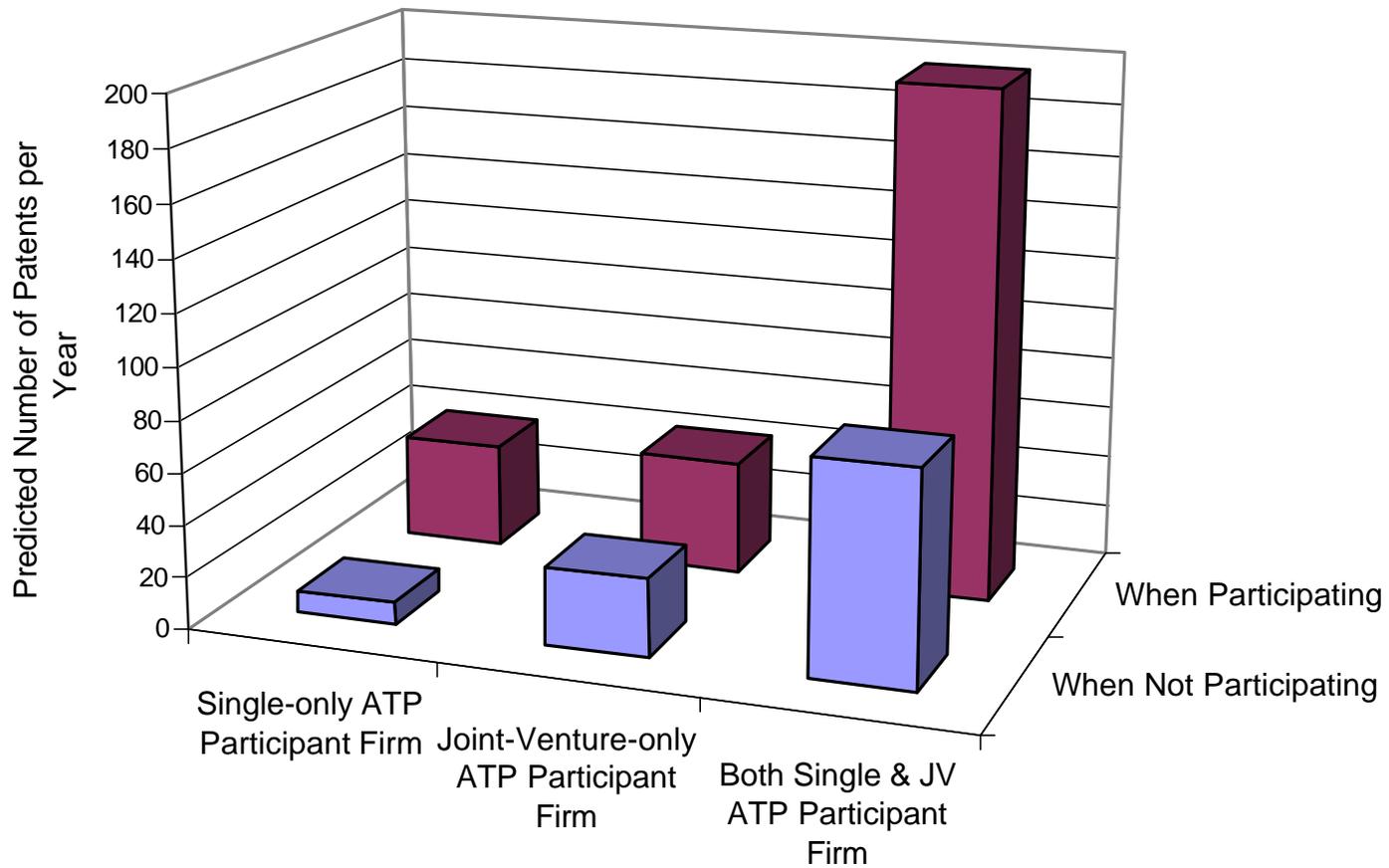
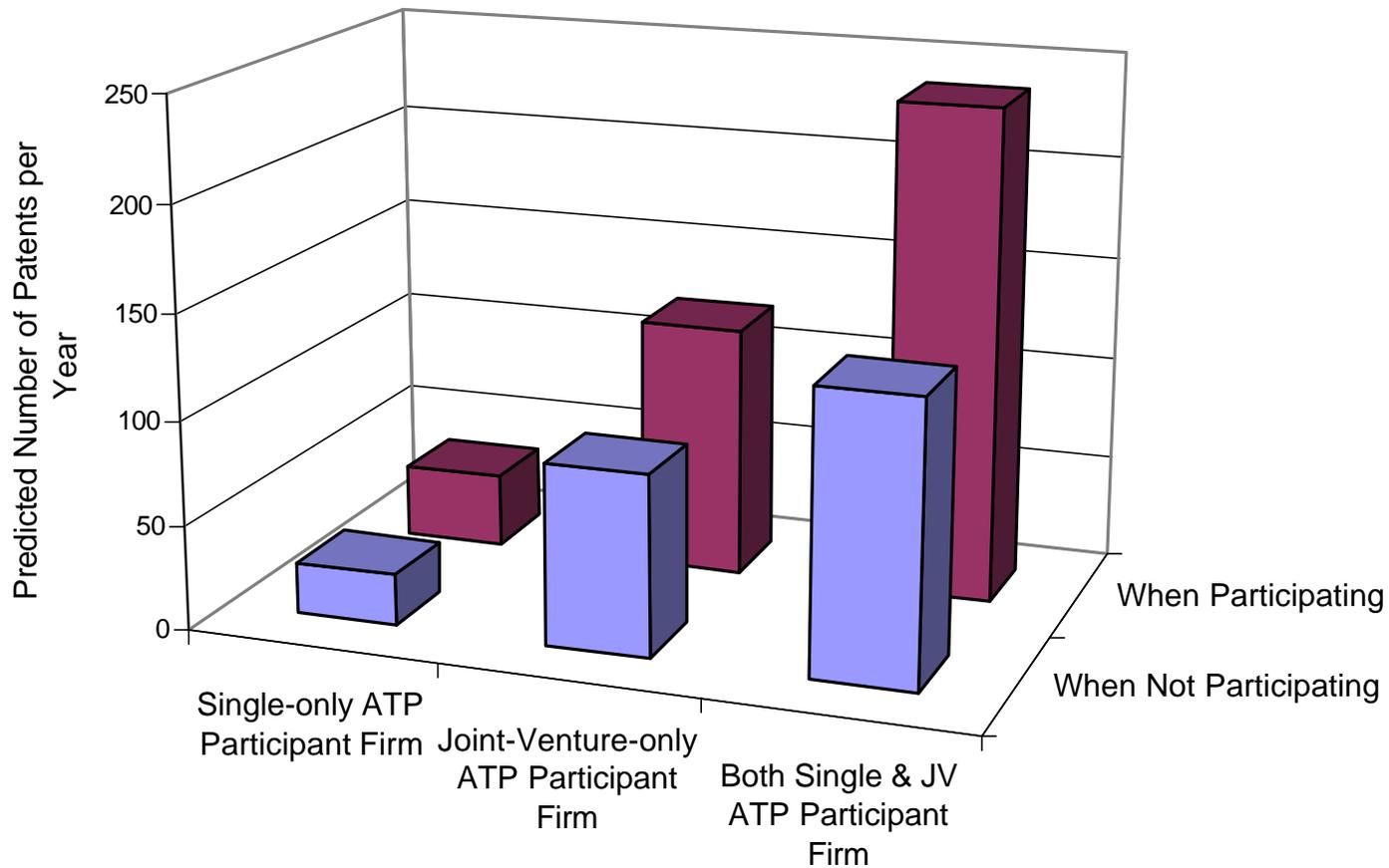


Figure 4. Expected Patenting By Firms During ATP Participation Versus When Not Participating in ATP - All Firms



These values are found by inserting for each participant type 0 or 1 for ATP participant, 0 or the mean award during full years of participation for ATP award, and type-specific mean values of the other independent variables in regression 3.2 (Table 3).

Figure 5. Expected Patenting By Firms During ATP Participation Versus When Not Participating in ATP - Only Publicly-Traded Firms



These values are found by inserting for each participant type 0 or 1 for ATP participant, 0 or the mean award during full years of participation for ATP award, and type-specific mean values of the other independent variables in regression 6.2 (Table 6).