WHAT DETERMINES THE SUCCESS OF STATES IN ATTRACTING SBIR AWARDS?*

Arno van der Vlist
Shelby Gerking
Henk Folmer

August 26, 2002

Abstract

This paper analyzes the interstate distribution of per capita awards made through the Small Business Innovation Research (SBIR) Program operated by the U.S federal government over the period 1983-93. The main finding is that after adjusting for population size, awards tend to be made to firms in centers of innovative activity, where knowledge is most easily created and spillovers between economic agents can occur most readily. State programs to assist prospective applicants for SBIR funding, on the other hand, appear to have had little effect in overcoming this seemingly powerful factor. Thus, the percentage distribution of per capita awards by state has remained roughly constant since the inception of the program. A possible implication of these results is that the SBIR program may exacerbate interstate differences in economic growth to the extent that growth of states is associated with their ability to create new knowledge.

WHAT DETERMINES THE SUCCESS OF STATES IN ATTRACTING SBIR AWARDS?

1. Introduction

Small Business Innovation Research (SBIR) awards support development of technology with commercial applications throughout the United States. This program is funded by a percentage set-aside from federal agency research budgets, now provides about $1.2 billion annually for research by U.S. small businesses, and has provided about $8.4 billion in small business research funding since its inception in 1982. Many states, noting that firms including Apple Computer, Compaq, and Intel have received support from federal programs, promote opportunities in the SBIR program and assist eligible companies with the application process as part of their economic and technology development programs.[1] Also, federal programs concerned with broadening the geographic base of U.S. science and engineering such as the National Science Foundation's Experimental Program to Stimulate Competitive Research (EPSCoR) have encouraged this type of support by states that historically have had comparatively little federal R&D activity. Yet, the SBIR program has been the subject of ongoing evaluation because of questions regarding its effectiveness in stimulating research and development in the private sector (see, for example, Wessner 2000) and because of concerns that awards historically have been concentrated in only a few states. For example, California and Massachusetts have consistently received about 40% of SBIR funding, while Plains and Rocky Mountain states such as Idaho, North Dakota, South Dakota, Montana, and Wyoming have received disproportionately much less support from this program.

This paper empirically examines public policies, programs, and state characteristics that may be expected to influence the geographic distribution of per capita SBIR awards and represents a contribution to the broader literatures regarding program evaluation and the effectiveness of state economic development efforts. A key finding is that public initiatives to attract funding through this program have had little impact on per capita awards received and, thus, on the interstate pattern of awards. Instead, a better explanation for the geographic distribution of per capita awards is that states with greater innovative activity, measured by the quality of higher education, and the fraction of the population employed in high-technology manufacturing and/or as scientists and engineers, have a competitive advantage in the program. In particular, more populous states win more SBIR awards than others, and more populous states with the above characteristics win still more. This outcome is consistent with the idea that research and development activity tends to agglomerate in order to benefit from the local pool of specialized labor, venture capital, and business services (Rees and Stafford 1986, Herzog and Schlottmann 1991). These considerations suggest that public policies aimed at changing the interstate distribution of research and development expenditures are unlikely to result in sweeping changes.

The remainder of this paper is organized into four sections. Section 2 describes the data used to estimate determinants of SBIR awards. Section 3 develops a fixed effects model for analyzing panel data on the extent to which public programs were effective in attracting SBIR awards over the period 1983-93. This time period was selected to take advantage of Berlund and Coburn’s (1995) special compilation of data on state technology programs. Section 4 builds on this analysis to estimate the extent to which variables related to innovation capacity are associated with state SBIR award levels over this same time period. Implications for regional growth and development are briefly explored in Section 5.

2. Data

The U.S. Small Business Administration, Office of Technology (1984-94) compiles data on number and dollar value of SBIR awards made in each state in each year by eleven federal agencies.[2] The Department of Defense, the federal agency with the largest research and development budget, makes about half of all awards. This study uses figures for the number and value of awards from both Phase 1 and Phase 2 of the program.[3] Nominal dollar values are converted to real ($1987) values using the GDP price deflator. As shown in Table 1, in 1983 all participating agencies combined made 688 awards with a real value of $51.7 million, whereas in 1993, 4016 awards were made totaling $567.5 million (in $1987). Thus, although the program has grown substantially over the years, it is not large in dollar terms. However, SBIR awards appear to play an important role in certifying firm quality to venture capitalists and other private investors (Lerner 1999).

Table 2 shows that SBIR awards have been disproportionately concentrated among firms in a few states. This geographic pattern of awards holds year in and year out and is only partly explained by state size. Ordinary least squares regressions of the mean number of awards (A_j) and mean real value of awards (in thousands of dollars) (V_j) by state between 1983-93 on mean state population (POP_j) over this same time period yields[4]

$$\underset{}{A_j} = \underset{(-0.95)}{-14.21} + \underset{(6.55)}{0.014}POP_j + e_j \qquad R^2 = 0.478 \qquad (1)$$

$$V_j = -1857.6 + 1.74POP_j + e_j \qquad R^2 = 0.458 \qquad (2)$$
$$\quad (-0.93) \quad (6.30)$$

Equations (1) and (2), show that while POP_j is positively and significantly (t-statistics are presented beneath coefficient estimates) related to A_j and V_j, it explains less than half of the variation in both variables. In other words, the interstate distribution of awards is not simply coincident with the interstate distribution of people; thus, additional factors appear to be at work in determining a state's success in attracting SBIR funding. Sections 3 and 4 identify some of these factors in a framework that accounts for persistence of award levels among states as well as the growth of the program over the sample period.

A portion of the remaining geographic variation in SBIR awards might be explained by the fact that states operated programs over the sample period to identify prospective applicants and to assist them with the proposal process. These programs, which have been linked to research and development activity by Bania, Calkins, and Dalenberg (1992) fall into three categories: (1) university-industry cooperative research relationships, (2) SBIR assistance, and (3) technology extension and deployment. University-industry cooperative research relationships are established to facilitate transfer of research results and personnel between academia and the private sector. By broadening communication between scientists and engineers, they may encourage innovation and therefore could lead to greater SBIR funding. State technology extension and deployment programs are aimed at encouraging the spread and application of the latest technology to aid economic development. These programs make technical information, including SBIR application materials, available through publications and computer databases. Also, staff members seek out potential adopters of existing technology and provide technical assistance. SBIR assistance programs make small businesses aware of opportunities for funding, provide help with proposal development, search for scientific and technical information, and facilitate contact with experts outside the firm. Rees (1991) and Berglund and Coburn (1995) provide a more complete description of these programs.

Information on the years in which each state operated these programs are taken from a survey conducted by Berglund and Coburn (1995, pp. 54-56), which covered the period 1983-93. Updating these data would be of interest, but is beyond the scope of this paper. Also, data on expenditures by these programs are not available for the sample period, so dummy variables were created to indicate whether or not a state operated a program in each of the three categories in each year.[5] The State of Washington did not provide information about its programs and was excluded from the analysis. In any event, data on program adoption show that the three types of programs were relatively rare in 1983, but by the end of the sample period were widely available. In 1983, 14% of states had university-industry cooperative research programs, 4% had SBIR assistance programs, and 10% had technology extension and deployment programs. By 1993, these percentages were 47%, 53%, and 65%, respectively. Additionally, no states had adopted all three programs until 1987, but by 1993, 18% of states had done so.

3. Fixed Effects Analysis

A fixed effects model is a natural way to analyze the connection between the three types of programs just discussed and per capita attraction of SBIR awards by state. Data on the number and real value of SBIR awards by state over the period 1983-93 form a balanced panel, in which heterogeneity among states and over time can be controlled. The model to be estimated is

$$AWARD_{jt} = \alpha + \mu_j + \lambda_t + \Sigma_k \beta_k X_{kjt} + \Sigma_k \gamma_k Z_{kj} + \varepsilon_{jt} \qquad (3)$$

In equation (3), $AWARD_{jt}$ is the natural logarithm of either the absolute number (*NUMBER*) or the real dollar value (*MONEY*) of SBIR awards (in thousands of 1987 dollars) received per thousand of population by state j in year t. Also, X_{kjt} denotes explanatory variables that vary over both states and time (such as those measuring state programs to attract SBIR funding) and Z_{kj} denotes explanatory variables that measure time invariant state characteristics. β_k and γ_k are coefficients to be estimated, μ_j and λ_t are unobserved state- and time-specific effects, and ε_{jt} is an error term. One-way fixed effects estimation includes only the state-specific effects (μ_j). Two-way fixed effects estimation includes both state- and time-specific effects. Simultaneity between SBIR funding and state programs to attract SBIR funding is a possible problem because program adoption may be influenced by the quantity of awards a state receives. However, this problem may not be serious for two reasons. First, as indicated previously, most states had adopted SBIR assistance programs by the end of the sample period. Second, the other two types of state programs have broader missions than simply to provide SBIR assistance (Berglund and Coburn 1995).[6]

Also in equation (3), dependent variables are transformed to natural logarithms because changes in explanatory variables are more likely to exert a constant percentage increase in per capita awards across states than a constant absolute increase.[7] Also, scaling both award measures by population controls for state size, which already has been demonstrated to partly determine absolute levels of funding through the SBIR program.

Notice that including the state dummies (m_j) in the regression will sweep out the Z_{kj}. Thus, effects of Z_{kj} on awards must be recovered in a separate analysis (see below).

The fixed effects approach was used to estimate equation (3) for three interrelated reasons. First, it is a simple way to control for, yet avoid enumerating, unique aspects of states, such as knowledge generation potential, as well as heterogeneity over time that might be attributable to a general increase in awareness of the SBIR program and to its expanding resources. Second, random effects specifications of equation (3), in which state- and time-specific effects are treated as error components, are rejected by Hausman (1978) tests in the two-way fixed effects case.[8] Third, conditional estimates of effects of state economic development programs on awards are thought to be of greater interest than corresponding unconditional effects that would be obtained from a random effects model. Coefficients of the state program variables in equation (3) are broadly interpreted as percentage changes in per capita awards, holding constant the net effects of state- and/or time-specific factors (depending on whether the one-way or two-way fixed effects model is estimated).

Explanatory variables included when estimating equation (3) (i.e., X) are limited to dummy variables indicating whether a state operates university-industry cooperative research programs, SBIR assistance programs, or technology extension and deployment programs. In the analysis described below, UI indicates whether a state had a university-industry cooperative research program, ASSISTANCE indicates whether a state had an SBIR assistance program, and EXTENSION indicates whether a state operated a technology extension and deployment program. Variables such as the education level of the workforce, the proportion of scientists and engineers in the population, the percentage of the workforce in high technology manufacturing, the number of Research 1 universities, and other factors possibly related to per capita awards are treated as part of Z_{jk}. This approach is taken for three reasons. First, these variables exhibit more variation between states than within states. Over the sample period, for a given state, they change slowly if at all over time and are most appropriately thought of as state characteristics that are swept out when m_j is included in equation (3). As noted previously, however, the role of these variables is explicitly considered in the analysis of mean per capita SBIR awards presented in the next section. Second, as a practical matter, these variables are not measured every year. Third, it is of interest to see whether the state program variables emerge as significant determinants of per capita awards when they have no competition from other X variables included in the analysis.[9]

Table 3 presents both one-way and two-way fixed effects estimates of equation (3) for *NUMBER* and *MONEY* together with means for the three explanatory variables.[10] Estimates are based on 539 observations (49 states x 11 years). State-specific variation in both equations is significantly different from zero at the 1% level.[11] Time-specific variation in both equations is significantly different from zero at the 1% level as well after removing state-specific and program effects.[12] Values of R^2 range from 0.644 to 0.923. Multicollinearity between the state economic development program variables does not appear to be a problem because the largest Pearson correlation between any two of the three variables is 0.31 and the condition number of the moment matrix for these variables is 2.49.

One-way fixed effects estimates suggest that the presence of university-industry cooperative research, SBIR assistance, and technology extension and deployment programs lead to substantially greater numbers and dollar values of per capita SBIR awards. Coefficients of the three program measures are positive and significantly different from zero at conventional levels in both the equations for *NUMBER* and *MONEY.* For example, these estimates indicate that maintaining an SBIR assistance program increases the per capita number of awards by about 31% and increases per capita value of awards by about 59%. Evaluated at sample means, these percentage increases imply absolute increases in the annual number and value of awards by about 16 and $3.58 million, respectively. Estimated effects of university-industry cooperative research programs are larger while those for technology extension programs are smaller. Thus, after controlling for net effects of state-specific variables such as knowledge generation capacity as well as other factors, it appears that state economic development programs are successful possibly either by encouraging more SBIR applications or by increasing applicant success rates.

A rather different picture, however, emerges from the two-way fixed effects estimates. These equations suggest that state programs have no influence on per capita SBIR awards. Coefficients of the three state program variables are negative and do not differ from zero at the 5% level under a two-tail test. There is a simple explanation for the contrasting implications from the one-way and two-way models. As previously noted, over the 1983-93 period states adopted technology development and assistance programs at a rapid pace. At the same time, as noted in Section 2, real resources distributed through the SBIR program increased by a factor of 10. The two-way fixed effects estimates control for the effect of SBIR program growth, while the one-way fixed effects estimates do not. Thus, the two-way fixed effects estimates are more appropriate for estimating the marginal contribution of the state programs holding the size of the SBIR program fixed over the sample period. According to these estimates, state programs had no effect on the per capita number of awards that states received. Indeed, it is possible that these programs increase the overall number of applicants to the SBIR program and lead to an improvement in the overall quality of proposals. Yet, there is no evidence that they alter the per capita number or value of awards. In consequence, Section 4 considers other possible explanations for the geographic distribution of SBIR awards.

4. Analysis of State-Specific Effects

If state economic development programs do not appreciably affect the per capita attraction of SBIR awards, then what factors might represent a better explanation? The answer here rests on further analysis the state-specific effects in equation (3). These effects, presumably influenced by the level of innovative activity in a state, can be recovered by manipulating equation (3) (see Henderson 1996 for details) to obtain equation (4).

$$W_j = c + \sum_k g_k Z_{kj} + v_j \qquad (4)$$

In equation (2), $W_j = \overline{AWARDS}_{j\cdot} - \sum_k b_k X_{kj\cdot}, \overline{AWARDS}_{j\cdot}$ denotes the time mean of either *NUMBER* or *MONEY* (expressed in logarithms per capita), $\overline{X}_{kj\cdot}$ denotes the time means of the state program variables, c is a constant equal to a plus the average of the $l_t, v_j = m_j + \overline{e}_{j\cdot}$, and the $\overline{e}_{j\cdot}$ are the time means of the residuals from the fixed effects estimates of equation (3). The dependent variable in equation (4), W_j, simply nets out the year-to-year effects of economic development programs on SBIR award levels from *NUMBER* and *MONEY*. The g_k coefficients in equation (4) are estimated by a least squares regression of W_j on the Z_{kj}. Notice, however, that in equation (4), the error term, v_j,is composite and would be expected to exhibit heteroskedasticity. In consequence, standard errors of the least squares estimates of g_k are corrected using the method proposed by White (1980). Also, to reduce potential endogeneity problems, variables in Z_{jk} are drawn to the extent possible from a year just prior to the start of the sample period.

Table 4 presents results from estimating equation (4). Five explanatory variables are used in the analysis to reflect different aspects of the level of innovative activity in a state. Similar variables have been used for this purpose in related studies (see, for example, Audretsch and Feldman 1996). *HIGH-TECH* denotes employment of workers per thousand of population in six manufacturing sectors classified as having the highest R&D intensity (Organization for Cooperation and Development 1995, see also the discussion of alternate classification schemes by Malecki 1997). These sectors are drugs, office and computing machines, communications equipment, electronic components and accessories, guided missiles and space vehicle parts, and engineering and scientific instruments.[13] Notice that the level of employment in these sectors also reflects the presence of industries oriented to national defense. Because of the U.S. Defense Department's prominent role in the SBIR program, *HIGH-TECH* is expected also to reflect the historical pattern of federal defense expenditures. *R&D* denotes research expenditures (in $000) at doctorate granting higher educational institutions in a state per thousand of population in 1982 (U.S. National Science Foundation 1984). *SCIENTISTS* denotes the number persons employed as scientists and engineers per thousand of population in 1980 (U.S. Bureau of the Census 1982). *RESEARCH 1* denotes the number of universities in a state, per thousand of population, classified as Carnegie Research 1 institutions in 1984 (Carnegie Foundation for the Advancement of Teaching 1987). *COLLEGE* denotes the percentage of persons with four or more years of college in each state's population in 1980 (U.S. Bureau of the Census 1982).

Means of explanatory variables are presented in the second column of Table 4 and regression results are presented in the third and fourth columns. Regressions use 49 observations as the state of Washington is again excluded. Multicollinearity does not appear to be a serious problem because the largest Pearson correlation coefficient among the set of explanatory variables is 0.56 and the condition number of the moment matrix is 9.8. Values of R^2 were 0.681 and 0.567 in the *NUMBER* and *MONEY* equations, respectively. Coefficients of explanatory variables are positive and jointly significantly different from zero at the 1% level.

In Table 4, coefficients of *HIGH-TECH*, *SCIENTISTS,* and, *RESEARCH 1* are positive and significantly different at the 5% percent level or lower under a 1-tail test in the equations for both *NUMBER* and *MONEY.* The coefficient of *COLLEGE* is positive and significantly different from zero at the 6% level under a 1-tail test in the *NUMBER* equation and not significantly different from zero at conventional levels in the equation for *MONEY.* The coefficient of *R&D* is not significantly different from zero at conventional levels in either equation. Thus, *R&D* and *COLLEGE*, while broadly measuring research capacity, do not appear to be indicators of where commercial technology is developed in the SBIR program. Coefficients are interpreted as the percentage change in per capita awards (*NUMBER* or *MONEY*) given a one-unit change in an explanatory variable. For example, if one more person per thousand of population is employed in a state's high-technology manufacturing sectors, the number of SBIR awards won per thousand of population would rise by 5.4% and the amount of money attracted would rise by 12.9%.

Table 5 presents calculations using mean values of relevant variables to further illustrate the magnitude of these effects. In particular, the table presents effects of increasing *HIGH-TECH*, *SCIENTISTS*, and *COLLEGE* by one unit. For the variables *HIGH-TECH* and *SCIENTISTS*, this means an increase of one such person in a state per thousand of population and for *COLLEGE*, it means increasing the fraction of persons with four or more years of college by one percentage point. Table 5 also shows the effect on both of these dependent variables of increasing the number of Research 1 universities in a state by one such university (not one such university per thousand persons). Elasticity estimates are presented as well, although a caveat regarding interpretation of these values is that *RESEARCH 1* is not a continuous variable.[14] Elasticity values are evaluated at the sample means of the relevant variables.

These calculations show, for example, that the 5.4% increase in the per capita number of awards occasioned by an increase in high technology employment by one person per thousand of population increases the absolute number of awards in a state with average population by about 3. The value of SBIR awards in a state with average population rises by about $778,000. Also, increasing the per capita number of scientists and engineers in a state appears to have a larger impact on SBIR funding than does increasing high technology manufacturing employment. In particular, the elasticities of both *NUMBER* and *MONEY* with respect to *SCIENTISTS* exceed those for *HIGH-TECH.* As previously noted, an increase in the percentage of college educated people in a state's population is associated with an increase in the number of awards. An additional

Research 1 university in a state increases the number of awards by 8.26 and increases the value of awards by $2.5 million. Overall, results presented in Tables 4 and 5 show that the number and value of SBIR awards are responsive to variables measuring innovative activity, after removing effects of population and publicly funded SBIR assistance programs.

5. Implications and Conclusions

This paper has analyzed the geographic distribution of awards made through the Small Business Innovation Research (SBIR) program. This analysis began with an attempt to explain this distribution by estimating a fixed effects model for state-level data on per capita awards for the period 1983-93. Measures of whether or not states had adopted university-industry cooperative research programs, SBIR assistance programs, or technology extension programs were used as independent variables. These variables did not perform well in the two-way fixed effects case. This outcome suggests that the effects of publicly funded assistance over the sample period cannot be distinguished from the effects of an expansion in the size of the SBIR program. On the other hand, variables measuring employment in high technology manufacturing, the percentage of population employed as scientists and engineers, and the number of Carnegie Research 1 universities in a state was positively and significantly associated with mean per capita state SBIR awards for the sample period. Thus, after adjusting for population size, awards tend to be made to firms in centers of innovative activity. State assistance programs do not appear to have been an effective tool in overcoming this seemingly powerful factor.

A possible implication of this result is that the SBIR program may confer an unintended economic advantage to U.S. states that already have more highly developed innovation capacity. The central argument here is this: Knowledge generation, the potential for knowledge spillovers between economic agents, and innovation capacity are associated with greater rates of local economic growth (Glaeser, Kallal, Scheinkman, and Schleifer 1992 and Henderson, Kuncoro, and Turner 1995). Also, knowledge generation and innovation capacity tends to be unevenly distributed over space and technical know-how is not readily transmitted between geographic locations (Jaffe, Trajtenberg, and Henderson 1993 and Anselin, Varga and Acs 1997). Thus, because SBIR resources are disproportionately allocated to commercial technology development in areas that already have the greatest capacity for innovation, the program would appear to exacerbate interstate disparities in economic growth rates. Additionally, states with a well-developed capacity for innovation that now receive the bulk of SBIR awards may wish to support further extensions of the program when it comes up for renewal in the U.S. Congress. On the other hand, states currently receiving few awards may have little to gain from further extensions of the program, unless they are willing to make infrastructure investments necessary to upgrade their capacity for innovation and knowledge creation.

ENDNOTES

[*] Authors affiliations are: Arno van der Vlist, Free University, Amsterdam, the Netherlands; Shelby Gerking, University of Wyoming, United States; Henk Folmer, Wageningen Agricultural University and Tilburg University, the Netherlands. van der Vlist's participation on this project was supported by a VSB-Scholarship from Fortis Bank and by the LEB-Fund at Wageningen Agricultural University. Gerking acknowledges the hospitality of CentER at Tilburg University where portions of this paper were completed, as well as visiting grant B46-386 from the Netherlands Organization for Scientific Research (NWO). We thank Julie Elston for helpful comments on an earlier draft.

[1] Another factor to consider along these lines is whether a state's political influence is used to intervene in the selection of awardees. Lerner (1999) contends that this possibility may not be important because of the small size of awards, the fact that awards are made by 11 different agencies, and the scoring systems used to rank applicants largely focus on the technological merit of proposals.

[2] It would also be of interest to analyze data on applications to the SBIR program to determine state success rates, but these data are available only for a few of the participating agencies in a few years spanned by our data.

[3] Phase 1 awards are made for research projects to evaluate the scientific and technical merit of an idea. Phase 2 awards are made for further development of selected Phase 1 projects that demonstrate greatest potential. The program also includes a third phase in which commercialization occurs. However, no SBIR funding may be used for Phase 3.

[4] Mean values of these variables were computed for each state over the 1983-93 period.

[5] The survey attempted to obtain FY1994 expenditures for each program category in each state. However, in many cases, states were unable to provide expenditure values because program activities were conducted by an economic development agency with a broader mission.

[6] Nevertheless, a complete analysis of simultaneity still would be worthwhile. This analysis, however, requires building a more complete model of the determinants of state technology program adoption. This broader framework is beyond the scope of this study and is left for further research.

[7] A few states in some years received no awards. As a consequence, the dependent variables, *NUMBER* and *MONEY,* were created after adding one to each observation. This procedure permitted the transformation to logarithms and preserved the interstate differences in awards seen in the raw data.

[8] Hausman (1978) test statistics on the one-way random effects estimates of the equations reported in Table 3 are 8.53 and 4.49 for *NUMBER* and *MONEY*, respectively. P-values for these statistics are 0.036 and 0.213. For the two-way random effects estimates, the corresponding test statistics are 17.94 and 15.85 for *NUMBER* and *MONEY,* respectively. P-values for these statistics are less than 0.01 in both cases.

[9] Notice that net effects of all state-specific variables are controlled by one-way fixed effects analysis and that net effects of all state- and time-specific effects are controlled by two-way fixed effects analysis. Consequently, an omitted variable problem may be less serious than it might at first appear.

[10] Variables measuring interactions between programs also were tried in specifications not reported here. These interaction variables were significant determinants of both the number and value of awards in the one-way fixed effects models; however, their coefficients never were significantly different from zero at conventional levels in the two-way models. Thus, to economize on space, only the most parsimonious specifications are reported. Also, another issue investigated turns on whether state programs might lead or lag SBIR funding. In the specifications tried, however, addition of time controls always destroyed the significance of the state program variables.

[11] In the one-way fixed effects estimates for *NUMBER*, the F-statistic for significance of the state-specific effects is F(48,489)=41.53 and the corresponding F-statistic in the one-way fixed effects *MONEY* equation is F(48,489)=15.50. In the one-way fixed effects equation for *NUMBER*, the F-statistic for testing the joint significance of the program variables after removing state-specific controls is F(3,488)=35.05. The corresponding F-statistic from the *MONEY* equation is F(3,488)=18.81.

[12] In the two-way fixed effects estimates of the *NUMBER* equation, the F-statistic for testing the joint significance of time controls after removing state and program effects is F(10,477)=52.44. The corresponding F-statistic in the *MONEY* equation is F(10,477)=28.738.

[13] These are sectors 283, 357, 366, 367, 376, 381 in the U.S. Bureau of the Census (1986).

[14] Calculations of effects of *RESEARCH 1* are based on the implicit assumption that all such universities are “perfectly divisible” in order to give partial derivatives with respect to this variable the usual interpretation.

REFERENCES

Anselin, Luc, A. Varga, and Zoltan Acs. 1997. Local geographic spillovers between university research and high technology innovations, *Journal of Urban Economics* 42: 422-48.

Audretsch, David B. and Mary Anne Feldman. 1996. R&D Spillovers and the geography of innovation and production. *American Economic Review*, 86: 630-40.

Bania, N., L. N. Calkins and D.R. Dalenberg. 1992. The effects of regional science and technology policy on the geographic distribution of industrial R&D laboratories. *Journal of Regional Science*, 32: 209-228.

Berglund, Daniel R. and Christopher M. Coburn. 1995. *Partnership: A Compendium of State and Federal Cooperative Technology Programs*. Columbus, Ohio: Battelle Press.

Carnegie Foundation for the Advancement of Teaching. 1987. *A Classification of Institutions of Higher Education, 1987 Edition*: Princeton, New Jersey: Carnegie Foundation.

Glaeser, Edward L., Hedi D. Kallal, Jose A. Scheinkman, and Andrei Schleifer. 1992. Growth in cities. *Journal of Political Economy*, 100: 1126-52.

Hausman, J. 1978. Specification tests in econometrics. *Econometrica*, 46: 1251-71.

Henderson, J. Vernon, A. Kunoro and M. Turner. 1995. Industrial development in cities. *Journal of Political Economy*, 103: 1067-85.

Henderson, J. Vernon. 1996. Effects of air quality regulation. *American Economic Review*. 86: 789-813.

Herzog, Henry W. and Alan M. Schlottmann. 1991. *Industry Location and Public Policy.* Knoxville: University of Tennessee Press.

Jaffe, Adam, Manuel Trajtenberg, and Rebecca Henderson. 1993. Geographic localization of knowledge spillovers as evidenced by patent citations. *Quarterly Journal of Economics*, 63: 577-98.

Lerner, Josh. 1999. The government as venture capitalist: the long-run impact of the SBIR program. *Journal of Business*, 72: 285-318.

Malecki, Edward J. 1997. *Technology and Economics Development: The Dynamics of Local, Regional, National Competitiveness*. 2nd edition. Edinburgh Gate: Addison Wesley Longman Ltd.

Organisation for Economic Co-operation and Development. 1995. *Industry and Technology: Scoreboard of Indicators 1995.* Paris: Organisation for Economic Co-operation and Development.

Rees, J. and H. Stafford. 1986. Theories of regional growth and industrial location: their relevance for understanding high-technology complexes. In: J. Rees (ed.), *Technology, Regions, and Policy.* New Jersey: Rowman.

Rees, J. 1991. State technology programs and industry experience in the United States. *Review of Urban and Regional Development Studies,* 3: 39-45.

U.S. Small Business Administration. Office of Technology. 1984-94. *Small Business Innovation Development Act: Geographical Distribution of Phase I and Phase II Awards.* Washington, D.C.: U.S. Small Business Administration.

U.S. Bureau of the Census. 1986. 1982 *Census of Manufactures: General Summary*. Washington, D.C.: U.S. Government Printing Office.

U.S. Bureau of the Census. 1982. *1980 Census of Population: General Summary*. Washington, D.C.: U.S. Government Printing Office.

U.S. National Science Foundation. 1984. *Academic Science/Engineering: R&D Funds, Fiscal Year 1982.* Washington, D.C.: National Science Foundation.

Wessner, C.W. 2000. *The Small Business Innovation Research Program: An Assessment of the Department of Defense Fast Track Initiative.* Washington D.C.: National Academy Press.

White, H. 1980. A heteroskedasticity-consistent covariance matrix estimator and a direct test for heteroskedasticity, *Econometrica*, 48: 817-38.

TABLE 1
NUMBER AND VALUE OF SBIR AWARDS
1983-93

Fiscal Year	Total Number of SBIR Awards	Total Current $-Value of SBIR Awards (in million $)	Total-Constant 1987 $-value (in million $)
1983	688	45	51.7
1984	1313	108	118.8
1985	1804	199	211.0
1986	2509	298	306.9
1987	2955	351	351
1988	2732	389	375.5
1989	2866	432	399.3
1990	3229	461	411.6
1991	3313	483	413.9
1992	3473	508	423.0
1993	4016	698	567.5

Sources: U.S. Small Business Administration, Office of Technology (1984-1994) and Berglund and Coburn (1995)

TABLE 2
DISTRIBUTION OF SBIR AWARDS BY STATE: 1983-93

State	Total Number of SBIR Awards	Share in Total Number of SBIR Awards (in %)	Total 1987 $-Value of SBIR Awards (in thousands)	Share in Total $-Value of SBIR Awards (in %)
Alabama	442	1.44	53121	1.6
Alaska	32	0.10	654.	0.0
Arizona	370	1.21	39573	1.2
Arkansas	47	0.15	3741	0.1
California	6774	22.07	803922	24.0
Colorado	1354	4.41	108702	3.2
Connecticut	894	2.91	103656	3.1
Delaware	87	0.28	9763	0.3
Florida	653	2.13	75903	2.3
Georgia	216	0.70	20872	0.6
Hawaii	84	0.27	10209	0.3
Idaho	29	0.09	2846	0.1
Illinois	498	1.62	58736	1.8
Indiana	177	0.58	20045	0.6
Iowa	66	0.22	5906	0.2
Kansas	57	0.19	4610	0.1
Kentucky	39	0.13	3727	0.1
Louisiana	105	0.34	8585	0.3
Maine	333	1.09	9888	0.3
Maryland	1652	5.38	175362	5.2
Massachusetts	4571	14.89	555506	16.6
Michigan	504	1.64	54805	1.6
Minnesota	412	1.34	42333	1.3
Mississippi	44	0.14	2609	0.1
Missouri	133	0.43	13438	0.4
Montana	55	0.18	4977	0.1
Nebraska	77	0.25	5935	0.2
Nevada	70	0.23	10927	0.3
New Hampshire	296	0.96	38076	1.1
New Jersey	849	2.77	96132	2.9
New Mexico	650	2.12	74231	2.2
New York	1365	4.45	137978	4.1
North Carolina	335	1.09	41757	1.2
North Dakota	86	0.28	1607	0.0
Ohio	903	2.94	80731	2.5
Oklahoma	103	0.34	10126	0.3
Oregon	380	1.24	39597	1.2
Pennsylvania	1161	3.78	130257	3.9
Rhode Island	87	0.28	8525	0.3
South Carolina	21	0.07	1392	0.0
South Dakota	7	0.02	484	0.0
Tennessee	357	1.16	41629	1.2
Texas	974	3.17	101106	3.0
Utah	506	1.65	52358	1.6
Vermont	172	0.56	6677	0.2
Virginia	1611	5.25	169035	5.0
Washington*	754	2.46	76188	2.3
West Virginia	19	0.06	5190	0.2
Wisconsin	157	0.51	17990	0.5
Wyoming	5	0.02	355	0.0

Source: U.S. Small Business Administration, Office of Technology (1984-1994) and Berglund and Coburn (1995).
*denotes state excluded from the regression analyses.

TABLE 3[a]

STATE PROGRAMS AND SBIR AWARDS

EXPLANATORY VARIABLE	MEAN	*NUMBER*		*MONEY*	
		ONE-WAY	TWO-WAY	ONE-WAY	TWO-WAY
CONSTANT	---	---	-5.189 (-161.66)	---	-0.865 (-8.69)
UI	0.32	0.407 (4.88)	-0.013 (-0.215)	0.680 (3.11)	-0.154 (-0.80)
ASSISTANCE	0.23	0.309 (4.24)	-0.038 (-0.67)	0.594 (3.10)	-0.042 (-0.24)
EXTENSION	0.33	0.281 (4.05)	-0.064 (-1.18)	0.334 (1.84)	-0.297 (-1.78)
SUMMARY STATISTICS					
NT		539	539	539	539
R^2		0.838	0.923	0.644	0.778

[a] t-statistics shown in parentheses beneath coefficient estimates

TABLE 4[a]

DETERMINANTS OF ADJUSTED MEAN AWARDS

EXPLANATORY VARIABLE	MEAN	*NUMBER*	*MONEY*
CONSTANT	---	-2.558 (-4.88)	-2.013 (-2.17)
HIGH-TECH	5.64	0.058 (2.88)	0.129 (3.06)
R & D	32.88	0.003 (0.44)	-0.006 (-0.55)
SCIENTISTS	8.40	0.103 (2.91)	0.150 (1.67)
RESEARCH 1	0.250 E-03	761.07 (2.32)	2000.9 (3.78)
COLLEGE	16.05	0.068 (1.62)	-0.020 (-0.26)
SUMMARY STATISTICS			
N		49	49
R^2		0.681	0.567

[a] t-statistics shown in parentheses beneath coefficient estimates

TABLE 5

EFFECTS OF CHANGES IN EXPLANTORY VARIABLES

EXPLANATORY VARIABLE	*NUMBER*		*MONEY*	
	ONE UNIT INCREASE	ELASTICITY	ONE-UNIT INCREASE	ELASTICITY
HIGH-TECH[b]	2.90	0.30	$778,000	0.73
R & D	---[a]	---[a]	---[a]	---[a]
SCIENTISTS[b]	5.47	0.82	$905,000	1.26
RESEARCH 1[c]	8.26	0.19	$2,467,000	0.50
COLLEGE	3.61	1.09	---[a]	---[a]

[a] coefficients of variable not significantly different from zero (see Table 4)

[b] one-unit increase represents a one-unit increase per thousand of population

[c] one-unit increase represents an increase of one Research 1 university