Firm Specialization in R&D Grants: Implications on SBIR Program Impacts

Technical Report · November 2015

DOI: 10.13140/RG.2.1.4835.2726

John Mann
Michigan State University

Steven R Miller
Michigan State University

Firm Specialization in R&D Grants: Implications on SBIR Program Impacts

November 2015

Working Paper Version

John Mann[1]
Assistant Professor
Department of Agriculture, Food and Resource Economics
Michigan State University
446 W. Circle Drive, Room 401A
East Lansing, MI, 48824-1039
mannjoh3@anr.msu.edu
Office: (517) 353-2129

Scott Loveridge[2]
Director, North Central Regional Center for Rural Development
Associate Director, National Agricultural and Rural Development Policy Center
Professor, Dept. of Ag., Food, and Resource Economics
Michigan State University
Justin S. Morrill Hall of Agriculture
446 West Circle Dr., Room 66
East Lansing, MI 48824
loverid2@anr.msu.edu
Office: (517) 432-9969

Steve Miller[3]
Assistant Professor
Department of Agriculture, Food and Resource Economics
Michigan State University
446 W. Circle Drive, Room 88
East Lansing, MI, 48824-1039
mill1707@msu.edu
Office: (517) 355-2153

Introduction

The Small Business Innovation Research (SBIR) program is a unique publically funded program that provides research dollars to US small businesses (500 or fewer employees) on a competitive basis to develop and commercialize new innovations. There are currently twelve agency managed programs[1] through which proposals are submitted, and each program has its own R&D and commercialization priorities. For example, many US Department of Defense (DOD) SBIR projects that successfully negotiated the "commercialization phase" of the program resulted in new government contracts, i.e., a very specialized product market (NRC, 2009). On the other hand, projects through other agency managed programs such as the National Science Foundation or US Department of Agriculture (USDA) have to rely on more traditional investing and financing networks to get products commercialized (e.g., angel or other venture capital) (Cleland, 2015). The SBIR program itself is financed through a set percentage (2.9% as of FY 2015) of "off-the-top" funding from each public agency funding science with an annual budget greater than $100 million.[2] From inception in 1982 through 2013, the program made 130,000 awards to 21,000 small businesses totaling $35 billion (SBIR, 2015b).

[1] Two programs are operated by the Department of Commerce, one for the National Institute of Standards and Technology and one for National Oceanic and Atmospheric Administration, and the Department of Defense program includes the branches of the military.
[2] This percentage will increase 1% per year until 2017 at which time the program will be up for congressional renewal (SBIR, 2015a).

The Technology Program Office of the US Small Business Administration administers the SBIR program and maintains the sbir.gov website where award data are publically available.[3] The data includes detailed information about all awards such as project descriptions, award phases and amounts, firm information, and the awarding agency. The SBIR data provides a unique resource regarding innovation activity that has been used in the economic literature to help inform about US entrepreneurship, especially about high tech small businesses. However, some study results regarding the impacts of SBIR dollars on economic indicators appear counterintuitive and there has been some disparity among reports. For example, Wallsten (2001), Goetz (2008), Link and Scott (2012) reported that their independent SBIR variables (e.g., award dollars or number of awards) had an inverse relationship with their dependent economic variables (e.g., employment or entrepreneurial activity). On the other hand, Lerner (1999) and Qian and Haynes (2014) reported positive effects. From the program evaluation perspective, this disparity in impact results potentially leaves policy makers unsure of the broad economic effectiveness of the SBIR program.

Some insight regarding these differences is provided by Van der Vlist, Gerking, and Folmer (2004) who considered the geographic distribution of awards across the US and found that awards and positive impacts tend cluster around innovation centers within states, which primarily occur in urban areas. Qian and Haynes (2014) also pointed out that the highest concentration of awards occurs in Northeast and West Coast states, while Southern and Central states have very low award concentrations. Additionally, Link and Scott (2009) determined that firms with multiple DOD SBIR awards over time (referred to as SBIR "mills") do not commercialize technologies as frequently as firms with a few or single phase I and II awards.

[3] As of the submission of this paper, the SBA was undergoing upgrades to its website and therefore SBIR data is not available in its entirety. It is the authors understanding that this is only temporary and that the full data will be available once all website updating is complete.

On the other hand, Connell (2009) has argued that these firms contribute good research and that regions with higher concentrations SBIR mills (such as Silicon Valley and Boston) account for significant economic impacts coming from R&D.

When all awards are combined into a single indicator, studies of SBIR impacts can generate unexpected results. For example, awards distributed to firms in innovation centers may have a different impact than those awarded to firms in regions with lower high tech firm densities. Additionally, since the SBIR program allows for firms to receive multiple awards, the impact of award dollars spread over many firms may be very different from the same amount allocated to a few, and the impacts (beyond technology communization rates) of award dollars distributed to firms that have received many SBIR awards may differ from that for firms receiving an SBIR award for the first time.[4] It may be that additional information about the nature of awards needs to also be considered when using award data in economic modeling.

In this paper, we look more specifically at the structure and characteristics of the SBIR program data itself, and consider the distribution of awards across states, agency managed programs, and firms. The motivation for this type of examination is to help better inform about the future use of program data in economic modeling and program evaluations. We also include an empirical analysis of award concentration among firms and across states and find evidence of an inverse relationship between state level award concentration and the per dollar awards to high tech firms.

SBIR Program Data

[4] There has been some concern expressed regarding firms receiving multiple SBIR awards, especially where the DOD is involved, and this has led a series of DOD SBIR program assessments by the National Research Council (NRC, 2009). These assessments are available through the National Academies Press at http://www.nap.edu/catalog/11989/an-assessment-of-the-sbir-program.

In 1983, 788 SBIR awards were made to 544 firms across eleven participating agencies.[5] From its onset, the SBIR program allowed for firms to receive more than one award per year. In its first year, this included only multiple phases I awards but in subsequent years this included multiple phase I and II awards.[6] Figure 1 shows the total number of awards, total firms, and first-time firms receiving awards from 1983-2013. We define first-time firms as a business that had not received an SBIR award in any prior year, but could have potentially receive multiple awards in their first award year. One characteristic of this figure is that the total number of awards and total number of firms receiving awards increased until about 2000. This was a function of increasing program budgets. However, the number of first-time firms receiving awards has remained steady since 1983. This means that on average the award ratio of first-time firms to total firms has declined over time. In the 1990s this average ratio was 32% and in the 2000s it was 27%. The total number of awards varies from year to year. Part of this variation, which also impacts the total award dollars, is due to changes in percentages set-aside after program reauthorization from congress; for example, from 4% to 2.6% in 2012, as well as changes in agency priorities (SBIR, 2015b; Van der Vlist, Gerking, and Folmer, 2004).

[Insert Figure 1 approximately here]

Changes in the distribution of award dollars by agency due to priority changes have also potentially impacted participating firms' commercialization activities. While the DOD has generally accounted for about half of all SBIR award dollars, Health and Human Services (HHS) increased its share of all SBIR award dollars from 20% in 1990 to 33% in 2013 while NASA's

---

[5] Our presentation of general information regarding SBIR data includes the years 1983-2014 (in some cases we only focus on 2000-2014), and all 50 states plus Washington, D.C.

[6] The SBIR funds two types of awards, called phases. Phase I awards usually do not exceed $150,000 and are intended to establish technical and commercial merit of the funded research and development. Phase II awards normally do not exceed $1 million and are intended to further develop promising research and development that received Phase I awards.

share decreased from 15% in 1990 to 5% in 2013 (Table 1) (SBIR, 2015b). These program changes reflect agency budget changes and an increasing share of SBIR dollars directed toward commercializing HHS priorities. For example, HHS allocated $89 million to the program in 1990 ($155 million in 2013 dollars) and $577 million in 2013 (SBIR, 2015b). This shift toward HHS priorities is also reflected in private sector venture capital during this period, as more venture capital was invested in health related innovations (PWC/NVCA, 2015). However, different industries do not respond the same to R&D expenditure, venture capital, and commercialization (Mowery, Nelson, and Martin, 2010). This implies that a shift in the types of R&D funding may impact regional economies in different ways. Additionally, this shift in research related to health priorities has also spilled over to other agency managed programs such USDA and NSF where more emphasis has been placed on health related topics within these other agency managed programs (Cleland, 2015).

[Insert Table 1 approximately here]

The distribution of awards among firms in different states also varies, and this may be due in part to the clustering effect described by Van der Vlist, Gerking, and Folmer (2004) and state and regional level resources available to firms (e.g., support to help firms apply for SBIR awards). Additionally, firms can acquire multiple awards if the program defined commercialization provisions of past projects are met (SBIR, 2015a).[7] For example, between 2000 and 2014 there were 19 states with at least one small business that received 100 or more SBIR awards (Table 2) (SBIR, 2015b). Five states had firms with 500 or more awards in the

[7] In phase I, firms can receive initial awards up to $150,000 (or up to $225,000 under special circumstances) and lasting for 6 months and multiple phase I awards to a single firm are also possible (SBIR, 2015a, 2015b). If the conditions set forth for phase I project awards are met, then firms qualify to compete for phase II awards, which is up to $1 million (or up to $1.5 million under special circumstances) for 2 years. Phase 3 is considered the commercialization phase and while no money allocation is given for this phase, firms must demonstrate commercialization success in this phase in order to qualify for future phase I and 2 awards.

fifteen year period, and one state, California, had a firm (Physical Optics Corporation) that received over 1000 awards. This same California firm received just over $300 million between the 2000 and 2014 or about 6% of the total value of all California SBIR awards and just over 1% of total awards to all firms in all states. Other states had firms that received much larger proportions of state totals. The highest occurred in West Virginia, in which one firm accounted for about 45% of all award dollars in the state over the fifteen year period. An important consideration regarding these observations is that the economic impact of a large amount of award dollars going to a single firm may be very different from an equivalent value of awards spread over many firms.

[Insert Table 2 approximately here]

While many of these multi-SBIR awarded firms are heavily involved in the DOD program, many of these firms have also received multiple awards from other agency managed programs. For example, about 40% of the firms have received 3 or more awards, whether phase I only or phase I and II (cumulative from 1983-2014) (SBIR, 2014). In Table 3, the proportion of firms that received multiple awards from a single agency are shown. About 43 of firms that received DOD awards have received 3 or more awards from DOD. However, a high proportion of firms that received DOE, HHS, and NASA awards have also received three or more awards from these same agencies (about 32%, 36%, and 39% respectively).

[Insert Table 3 approximately here]

At the same time, about 23% of firms have received awards from more than one agency managed program (Table 4).[8] For example, about 2% of firms have received awards from 5 or more agencies, and about 9% of firms have received awards from 3 or more agencies. In Table

[8] In this table, the two DOC managed programs are considered the same agency therefore the maximum number of programs is eleven and not twelve. Additionally, this data does not include the dismantled Department of Interior (DOI) and Nuclear Regulatory Commission (NRC) managed programs.

5, the correlation between the numbers of cumulative awards (1983-2014) to individual firms by agency is shown.[9] While the highest correlations occur between DOD/NASA (0.62) and DOD/DHS (0.52), there are other notable correlations between programs not including DOD, e.g., NSF/DOE (0.49), DHS/DOE (0.43), and NSF/EPA (0.37).

[Insert Table 4 approximately here]

[Insert Table 5 approximately here]

The number of firms receiving 5, 10, 25, and 50 or more awards from 2000 to 2014 is shown in Table 6. All states had at least two firms that received 5 or more awards, and Alaska is the only state that did not have at least one firm that received 10 or more awards. Interestingly, 34 states had at least one firm that received 50 or more awards. In California and Massachusetts, with regions generally regarded as innovation superstars, 42 and 34 firms received 50 or more awards, respectively. Given the employment cap for participating in the SBIR program, these observations imply that there may be incentives for some firms to restrict growth to remain eligible. More so, some of these multiple-award firms may not be commercially viable without being propped up by SBIR awards. Alternatively, those that surmount the learning curve of commercializing innovations through subsequent SBIR awards may be more efficient at generating successful ventures and giving rise to greater potential economic growth. Succinctly, a narrow distribution of awards to few firms may distort the economic impact of award dollars compared to a wide distribution to many firms and first-time awardees, though; it is unclear how this potential distortion may affect economic impact measures.

[Insert Table 6 approximately here]

Another way to characterize the way in which award dollars are distributed across firms is shown in Table 7. Here, the total value of the SBIR awards from 2000-2014 was divided into

[9] Again, the DOC data is combined into a single agency managed program.

four equal values. Then, firms were sorted from highest to lowest in absolute value of total awards during the period to determine how many firms accounted for each award quantile. The purpose of this table is to contrast the most successful and/or experienced firms with respect to SBIR dollar awards (about 1.1% of total firms—most extreme cases of multiple awarded firms) with the newest and/or least successful (about 82.3% of total firms). From 2000 to 2014, 151 firms (the most experienced and/or successful regarding award allocations) accounted for 25% of total SBIR awards (about $6.4 billion) with average total awards equal to about $42.2 million per firm and average total number of awards equal to about 130 per firm. This compares to the 10,982 newest to the program and/or least experienced firms in regards to the SBIR program (also accounting for about $6.4 billion in awards), with average total awards equal to about $0.58 million per firm and average total number of awards equal to about 2 per firm (includes phase I and phase II awards).

[Insert Table 7 approximately here]

One way to quantify concentration, in this case firm award concentration, is by constructing a Herfindahl–Hirschman Index (HHI) to demonstrate the concentrations of awards going to individual firms across agencies or states. To consider the difference in concentrations across the different agencies, we constructed agency level HHI by calculating firm shares in each agency for each year and then squaring and summing these Shares, i.e., $HHI_i = \sum_{j=1}^{N} Share_{ij}^2$, for agency i and firm j. In Table 8, the percent changes in selected agencies' HHI were then compared over two time horizons. As indicated by a decrease in the HHI scores, award concentrations declined between 1983 and 2013 in all agency programs, i.e., awards more broadly spread across more firms over time. The most significant declines in HHI scores were for the NSF (71% decrease in concentration) and HHS (69% decrease in concentration).[10] However, when only considering the last 14 years, from 2000 to 2013, some agency programs have experienced an increased award concentration, most notably the DOD (41% increase). It is important to point out that these changes in proportions are relative. For example, the DOD accounts for a substantial number of awards relative to all awards, while the USDA accounts for only a small number of total awards. Therefore, a small change in smaller programs such as the USDA would have large relative impacts on the proportions shown in Table 8 for that program.

[Insert Table 8 approximately here]

Empirical Analysis

In addition to examining the data distribution of SBIR awards across states, agencies and firms, we also wanted to consider the state level effect of award concentration on performance in terms of future allocation of SBIR award dollars. To do this, we constructed our dependent variable, *SBIR dollar awards per high tech firms,* by dividing total annual SBIR awards for a particular state and year by the number of high tech firms in that state and year. Here we use the NSF definition of high tech firms from their 2014 Science and Engineering (S&E) Indicators (NSF, 2014). Our primary independent variable of interest is *HHI for SBIR Awards*, constructed as described in the previous section above. We also included additional variables for non-SBIR public R&D, private R&D, venture capital, academic inputs, human capital, and firm dynamics, such that our input/predictor variables in our production model was similar to previous models, such as Van der Vlist, Gerking, and Folmer (2004) and Link and Scott (2012). This specification is unique in both the specification of the dependent variable and specification of the independent variable as the HHI for SBIR awards to account for the role of distribution of awards. Additional

[10] NSF has also made some recent program policy changes, which has resulted in an increase in the proportion of first-time awardees since about 2000 (Cleland, 2015).

independent variables were selected from the NSF S & E Indicators (NSF, 2014).[11] Summary statistics and Pearson correlations for our data are provided in Table 9 and Table 10.[12]

[Insert Table 9 approximately here]

[Insert Table 10 approximately here]

Our regression model is based on the following Cobb-Douglas production function:

$$\ln A_{it} = f(\ln x_{it}) + e_{it}$$

where $\ln A_{it}$ is a vector of the natural log of SBIR dollar awards per high tech firms for state i in year t (with a 2 year lag,[13] 2002-2010), $\ln x_{it}$ is a matrix of the natural log of the predictor variables (2000-2008), and $e_{it} \sim \mathrm{N}(0,1)$ is a vector of the error terms. We included both phase I and phase II award data in the model as experience with phase I can help obtain further phase I awards and because obtaining phase I awards are a necessary requirement for obtaining phase II awards. Further, the goal of the model is to predict award amounts based on award concentration within a state. Therefore, both phases of awards are relevant as some firms have receive multiple phase I awards without ever receiving phase II awards (SBIR, 2015b).

Results

We used Newey and West (1987) heteroskedasticity-autocorrelation consistent robust standard errors in our regression model estimation (Table 11). The coefficient on the primary variable of interest, HHI for SBIR awards, is negative and statistically significant beyond the 1% level. This suggests that we would expect states with lower award concentrations (i.e., lower HHI values) to have higher awards per high tech firms. This may also provide more evidence for the clustering

[11] We specifically selected the NSF S&E indicators because they provided a unique and readily available source of variables appropriate for this type of modeling. Further, the NSF has recently launched efforts to encourage the use of these indicators (NSF, 2014).
[12] We did not include Washington D.C. due to missing values in the NFS data for Washington D.C. over the 2000-2010 time horizon.
[13] We use a 2-year because this is the phase II awards time maximum, and in pretesting this resulted in the strongest model fit statistics.

effect described by Van der Vlist, Gerking, and Folmer (2004), as states with lower HHI values also have larger numbers of firms that received multiple awards. While measures are made at the state level, it is likely that many of these multiple-award firms are in the same regions in their respective states.[14] Coefficients representing academic inputs, academic articles per academic R&D and academic R&D per GDP, as well as federal R&D per GDP are positive (and statistically significant) which provides some support for the Hall and Link (2015) finding that university inputs may positively impact future SBIR awards by increasing commercialization success and generating research that go into new SBIR applications.

One venture capital variable, venture capital per high tech firm, is positive while the other, venture capital per VC deal, is negative. This implies that total available venture capital is a potentially important consideration for applying for future awards. However, the negative sign on the second variable may support Freedman's (2013) assertion that firms are now able to do more with less venture capital (enabling a reduction in the venture capital per deal) due to the reduced cost of other input technologies such as computing power. The alternating signs may also suggest SBIR and venture capital funding amounts may compete for viable projects, though complementarity exists between bridge funding using SBIR awards and venture capital investment of high tech firms. Last, the sign on firm entry rate is negative and statistically significant. This result is intuitive and suggests that as more firms compete for limited SBIR funds, the award dollars per firm will decrease.

[Insert Table 11 approximately here]

To help put the results in perspective, we transformed the production function coefficients (from translog to the exponential form) and plotted the function along the two

---

[14] For example, Qian and Haynes (2014) showed that the geographic distribution of award dollars was very high in specific areas of California and Massachusetts, which are also know innovation centers in these states.

dimensional plot of the non-log form of the dependent variable and HHI for SBIR awards, where points are grouped by the number of high tech firms within each state. While these ranges are somewhat ad hoc (0-4500, 4500-9000, 9000-18000, and 18000+), they were selected to provide observable distinctions between states based on the number of high tech firms. The idea was to be able to easily distinguish the location of observations based the number of high tech firms while also considering the vertical and horizontal axis.[15]

As seen in Figure 2, there is an inverse relationship between firm award concentrations and the geographic concentration of high tech firms. The finding is consistent with Van der Vlist, Gerking, and Folmer (2004) in that higher innovation concentration (innovation clusters) impacts the number of awards per high tech firm. A few states with higher firm award concentrations also had higher levels of SBIR award dollars per high tech firm, as indicated by positive outliers in Figure 2. It appears that these observations may have had a strong influence on the estimated model, given the location of the predicted line. Additionally, Figure 2 and the regression results seem to counter the notion that there are agglomeration effects where regions steeped in success by one firm should expect greater successes with other firms. .

[Insert Figure 2 approximately here]

In Table 12, we identified the states that appeared above the production function predicted line. While Massachusetts[16] is the top performing state based on award dollars per high tech firms, its observations occurred less than, but very near, the predicted line (appearing in the upper left of the Figure 2). On the other hand, all of states with the highest numbers of high tech firms (including California) were well below the predicted line (appearing in the lower left quadrant as squares in Figure 2). New Hampshire (with 90% of observation greater than the

[15] As a visual exercise, this was easier than distinguish observations in a 3-dimensional surface.
[16] Massachusetts observations also strongly influenced the model estimation—especially the intercept.

predicted line) and Rhode Island (with 30% of observations above the predicted line) performed well with this measure. Five smaller states, Hawaii, Maine, Montana, New Mexico, and Wyoming, each had one observation that landed on or just above the predicted line of the production model. Given that these states have very small numbers of high tech firms compared to other states, a small change in awards would have a more significant result in their relative position along the frontier.

[Insert Table 12 approximately here]

Summary and Conclusion

The purpose of this paper is to examine the distribution of SBIR awards across firms, between states, and by different agencies to better inform those using it for economic impact modeling. Our motivation is to provide some additional information that may help explain the disparity between studies that include some form of SBIR data as predictor variables. A review of the distribution of awards across firms revealed that there are potential differences among motivates of firms that apply for and receive awards, and these differences could greatly affect how these firms impact their regional economies. For example, if a firm is dependent on awards for its financial wellbeing, then award dollars would have one potential economic impact. By definition, firms with a high share of awards have remained small (500 or fewer employees) even while engaged in an enterprise that is designed to help small firms grow. It may be that for a few of these firms, the SBIR source is so important to their business model that they simply offload viable technology to other firms to avoid growing beyond the confines of program qualification. On the other hand, firms that successfully leverage awards to further develop and commercialize technologies and secure different stages of venture capital would have different potential economic impacts. In general, these are the firms that the spirit of the program was designed to serve, at least for some agencies. At the same time, many innovative start-ups fail and some awards will be allocated to these firms as well. Failure is part of the innovative process and in and of itself would not present a major hurtle in developing impact studies related to the SBIR program. Our findings, therefore, imply that more work needs to be done to better understand the business models of firms obtaining SBIR awards, especially of firms obtaining large shares of awards. While there has been much criticism about these firms (called SBIR mills by some) it is possible that at least some of these firms fill a necessary gap. However, not treating these firms appropriately in economic modeling will potentially generate misleading results.

The results of the empirical model show that similar states (based on number of high tech firms) with one or a few dominant firms (higher HHI) have lower values of SBIR awards per high tech firms than states with several firms with multiple awards (moderate/lower HHI). This implies that for some lower performing states (in the context of SBIR awards per high tech firms) who are interested in expanding their innovation efforts, investing recourses that encourage more diversity of firms seeking awards could be fruitful. This result also points to new areas of investigation, for example examining the economic impact of awards going to first-time awarded firms compared to those with a few awards, and those with many awards. In other words, is there a potential “sweet spot” regarding the distribution of awards across firms such that a state or region could be more successful with the development and commercialization of innovations. To examine this possibility, identifying rates of commercialization and how that commercialization occurs through different agency managed programs would be necessary. It may also be helpful to match up SBIR awarded firms to US Patent and Trademark Office data to explore the role of SBIR awards in seeking intellectual property protection.

An additional lesson that could be learned from firms that have received multiple SBIR awards, especially those that cross into other agency managed programs (or for DOD, the different branches of the military), is how to apply technologies to different arenas. This last point is especially relevant for faculty-entrepreneurs and university developed technologies as the traditional forms of federal and state R&D funding has become more difficult to acquire. For example, as national research priorities shift toward the development of more health related innovations, there may be new and less orthodox opportunities for collaboration across disciplines in university research funding, and the experience of SBIR multi-agency awarded firms could help identify and facilitate these opportunities.

References

Cleland, C. (March 2014). Personal Communications. National Program Leader, National Institute of Food and Agriculture.

Cleland, C. (October 2015). Personal Communications. National Program Leader, National Institute of Food and Agriculture.

Connell, D. (2009). Using Government Procurement to Help Grow New Science and Technology Companies: Lessons from the US Small Business Innovation Research (SBIR) Programme. Innovation, 11(1): 127-134

Freedman, D. H. (October 2013). Why Series A Crunch Might Be A Good Thing. Money: Inc. Magazine.

Goetz, S. J. (2008). State Entrepreneurial Climate Estimates: An Update Based on the Kauffman Index. The Northeast Regional Center for Rural Development, Rural Development Paper no. 41

Hall, M. J., and Link, A. N. (2015). Technology-Based State Growth Policies: The Case of North Carolina’s Green Business Fund. Annals of Regional Science, 54:437-449.

Kumbhakar, S. C., and Knox Lovell, C. A. (2000). Stochastic Frontier Analysis. New York: Cambridge University Press

Lerner, J. (1999). The Government as Venture Capitalist: The Long-Run Impact of the SBIR Program. The Journal of Business, 72(3): 285-318.

Link, A. N., and Scott, J. T. (2012). Employment Growth from Public Support of Innovation in Small Firms. Economics of Innovation and New Technology, 21(7): 655-678.

Link, A. N., and Scott, J. T. (2009). Private Investor Participation and Commercialization Rates for Government-sponsored Research and Development: Would a Prediction Market Improve the Performance of the SBIR Programme? Econometrica 76(302):264-281

Mowery, D.C., R.R. Nelson, and B.R. Martin. (2010). Technology Policy and Global Warming: Why New policy Models Are Needed (or Why Putting New Wine in Old Bottles Won't Work)." Research Policy, 39(8):1011-1023.

National Research Council. (2009). An Assessment of the Small Business Innovation Research Program at the Department of Defense. Washington, D.C.: National Academies Press.

National Science Foundation. (2014). National Center for Science and Engineering Statistics Data, 2014. Accessed at: http://www.nsf.gov/statistics/data.cfm

Newey, W. K. and West, K. D. (1994). Automatic Lag Selection for Covariance Matrix Estimation. Review of Economic Studies, 61: 631–653.

PricewaterhouseCoopers and the National Venture Capital Association (PWC/NVCA). (2015). MoneyTree Report. Access at: https://www.pwcmoneytree.com/HistoricTrends/CustomQueryHistoricTrend

SAS Institute. (2012). SAS® 9.3 In-Database Products: User's Guide, 4th ed. Cary, NC: SAS Institute Inc.

Small Business Innovation Research. (2015a). Small Business Innovation Research (SBIR) and Small Business Technology Transfer (STTR) Program Interagency Policy Committee Report to Congress: SBIR/STTR Standard Evaluation Framework. Washington, D.C.: US Small Business Administration.

Small Business Innovation Research. (2015b). SBIR Awards, 1983-2013. Accessed at: http://www.sbir.gov/about/about-sbir

Qian, H., and Haynes, K. E. (2014). Beyond innovation: the Small Business Innovation Research program as entrepreneurship policy. Journal Technology Transfer, 39(4): 524–543.

Van der Vlist, A., Gerking, S., and Folmer, H. 2004. What Determines the Success of States in Attracting SBIR Awards? Economics Quarterly, 18(1): 81-90.

Wallsten, S. (2001). The Role of Government in Regional Technology Development: The Effects of Public Venture Capital and Science Parks. SIEPR Discussion Paper No. 00-39.

Table 1. Proportion of Total SBIR Awards by Agency

Year	DHS	DOC	DOD	DOE	DOT	ED	EPA	HHS	NASA	NSF	USDA	Total
1990	0.00%	0.16%	48.18%	9.14%	0.92%	0.55%	0.72%	19.89%	15.06%	4.33%	0.92%	100%
2000	0.00%	0.60%	51.56%	8.10%	0.34%	0.00%	0.73%	21.90%	9.35%	5.69%	1.73%	100%
2010	1.20%	0.34%	48.55%	9.15%	0.34%	0.46%	0.22%	27.75%	6.21%	4.80%	1.03%	100%
2013	1.08%	0.29%	44.45%	7.94%	0.44%	0.44%	0.23%	32.76%	5.29%	6.03%	1.04%	100%

Note: NRC in 1990 was 0.12% but not included in the table as it was no longer participating after 1997. Also, the DOC manages two SBIR programs.

Table 2. Summary of SBIR Awards for All States, 2000-2014

State	Highest # awards to a single firm[a]	Total unique firms	Total # phase I awards	Total # phase II awards	Total $ phase I awards	Total $ phase II awards	Highest $ awarded to a single firm[b]	Highest as % of Total Awards
Alabama	356	178	1,064	536	$107,832,062	$393,311,188	$104,767,466	20.9%
Alaska	9	23	42	11	$3,947,876	$5,665,470	$1,447,049	15.1%
Arizona	225	245	1,012	475	$112,456,643	$343,988,854	$59,158,499	13.0%
Arkansas	52	54	214	83	$25,860,223	$52,882,084	$16,880,270	21.4%
California	1,081	2,607	10,785	4,864	$1,349,670,000	$3,770,250,000	$301,764,119	5.9%
Colorado	388	472	2,599	1,197	$282,672,106	$909,254,511	$108,485,524	9.1%
Connecticut	75	203	806	352	$103,561,824	$247,270,510	$25,574,999	7.3%
District of Columbia	25	42	90	46	$10,404,330	$29,754,660	$8,724,239	21.7%
Delaware	20	47	129	42	$13,374,824	$29,718,457	$4,255,585	9.9%
Florida	195	416	1,409	647	$153,788,259	$482,499,306	$53,302,563	8.4%
Georgia	73	234	604	252	$76,845,647	$191,987,939	$19,606,647	7.3%
Hawaii	82	75	228	101	$29,742,339	$71,278,749	$22,844,528	22.6%
Idaho	42	62	133	56	$13,179,776	$37,157,812	$13,177,335	26.2%
Illinois	74	346	947	422	$112,096,945	$310,647,669	$21,322,154	5.0%
Indiana	63	167	461	194	$55,814,519	$145,501,312	$22,440,130	11.1%
Iowa	15	72	141	54	$18,849,216	$34,496,643	$4,967,027	9.3%
Kansas	27	60	151	73	$19,074,972	$42,871,434	$8,902,668	14.4%
Kentucky	23	102	213	80	$33,266,140	$66,810,265	$7,253,814	7.2%
Louisiana	31	60	129	60	$14,544,009	$43,154,890	$9,241,690	16.0%
Maine	53	83	175	76	$16,791,533	$50,998,600	$14,976,205	22.1%
Maryland	579	609	2797	1,201	$360,614,482	$945,171,269	$156,503,043	12.0%
Massachusetts	575	1,059	6,911	3,187	$835,994,894	$2,495,160,000	$178,408,226	5.4%
Michigan	147	347	1,179	550	$140,015,556	$437,957,739	$36,418,981	6.3%
Minnesota	126	169	732	323	$90,120,997	$251,363,686	$34,645,813	10.1%
Mississippi	16	41	80	34	$7,122,005	$20,494,805	$4,019,767	14.6%
Missouri	24	136	324	116	$39,848,086	$82,506,461	$5,801,048	4.7%
Montana	85	73	275	124	$33,009,370	$73,566,777	$20,118,034	18.9%
Nebraska	77	34	121	50	$16,345,933	$40,655,172	$18,571,669	32.6%
Nevada	18	57	149	89	$14,664,183	$62,425,905	$7,873,100	10.2%
New Hampshire	545	108	641	346	$71,525,824	$268,817,775	$173,824,258	51.1%

a. Sum of all phase I and 2 awards from 2000-2014 to the single highest awarded firm.

b. Sum of all phase I and 2 award amounts from 2000-2014 to the single highest awarded firm.

Source: Data retrieved from https://www.sbir.gov/sbirsearch/technology on March 11, 2015.

Table 2. Cont.

New Jersey	109	396	1,435	681	$164,145,331	$519,843,908	$27,897,919	4.1%
New Mexico	132	181	857	350	$93,533,637	$257,245,235	$32,270,317	9.2%
New York	202	611	2,267	1,082	$292,735,298	$870,181,690	$61,128,952	5.3%
North Carolina	46	327	895	406	$134,002,807	$364,298,742	$32,374,964	6.5%
North Dakota	25	22	52	27	$8,441,538	$15,019,892	$7,165,372	30.5%
Ohio	122	442	2,166	996	$254,429,150	$773,063,712	$37,161,803	3.6%
Oklahoma	71	64	194	72	$31,966,386	$59,355,287	$19,107,039	20.9%
Oregon	142	190	670	335	$89,027,660	$286,361,661	$53,846,134	14.3%
Pennsylvania	172	550	2,028	948	$248,219,271	$731,450,618	$63,772,872	6.5%
Rhode Island	70	65	223	102	$29,364,007	$82,135,765	$19,173,963	17.2%
South Carolina	56	77	227	88	$27,263,718	$66,524,718	$11,428,493	12.2%
South Dakota	12	29	47	17	$4,789,892	$8,147,802	$2,213,900	17.1%
Tennessee	46	113	336	171	$36,325,686	$129,068,902	$16,743,649	10.1%
Texas	478	530	2,370	1004	$280,420,074	$762,009,296	$129,068,857	12.4%
Utah	56	186	471	192	$60,500,804	$147,441,459	$15,214,214	7.3%
Vermont	20	46	133	75	$15,474,973	$58,660,685	$12,543,387	16.9%
Virginia	500	653	3,386	1,631	$342,438,610	$1,221,770,000	$136,422,561	8.7%
Washington	91	383	1,172	559	$162,170,651	$439,776,597	$35,524,848	5.9%
West Virginia	68	33	107	50	$9,992,470	$37,772,706	$21,393,861	44.8%
Wisconsin	127	215	573	256	$89,355,383	$219,015,604	$30,514,493	9.9%
Wyoming	11	45	85	43	$9,081,556	$22,498,199	$3,334,856	10.6%

a. Sum of all phase I and 2 awards from 2000-2014 to the single highest awarded firm.

b. Sum of all phase I and 2 award amounts from 2000-2014 to the single highest awarded firm.

Source: Data retrieved from https://www.sbir.gov/sbirsearch/technology on March 11, 2015.

Table 3. Percent distribution by number of cumulative awards across agencies, 1983-2014

Agency	Number of Cumulative Awards							
	1 to 2	3 to 5	6 to 10	11 to 20	21 to 30	31 to 50	> 50	> 100
DHS	83.7%	12.6%	3.2%	0.0%	0.0%	0.5%	0.0%	0.0%
DOC	82.7%	13.2%	3.9%	0.2%	0.0%	0.0%	0.0%	0.0%
DOD	56.7%	19.2%	10.5%	6.4%	2.6%	1.9%	2.0%	0.6%
DOE	68.1%	16.8%	8.1%	3.8%	1.2%	1.1%	0.8%	0.2%
DOT	83.9%	13.8%	1.8%	0.2%	0.4%	0.0%	0.0%	0.0%
ED	80.9%	15.3%	2.0%	1.6%	0.2%	0.0%	0.0%	0.0%
EPA	81.5%	11.6%	3.6%	2.2%	0.7%	0.3%	0.0%	0.0%
HHS	64.0%	20.0%	9.2%	4.5%	1.1%	0.7%	0.4%	0.1%
NASA	60.5%	20.1%	9.9%	5.9%	1.6%	1.3%	0.6%	0.1%
NSF	78.6%	14.2%	4.9%	1.5%	0.5%	0.2%	0.1%	0.0%
USDA	81.7%	14.3%	3.5%	0.4%	0.1%	0.1%	0.0%	0.0%

Table 4. Firms with Multiple Agency Awards, 1983-2014

# agency awards[a]	# of firms	% of all awards
11	3	0.01%
10	9	0.04%
9	13	0.06%
8	22	0.10%
7	73	0.34%
6	86	0.40%
5	203	0.95%
4	451	2.12%
3	1,041	4.89%
2	3,013	14.14%
1	16,396	76.94%

[a] The two DOC managed programs are combined into one; therefore, the total agency manage programs is equal to 11 and not 12. Additionally, the DOI and DRC are not included in the agency distribution.

Source: Data retrieved from https://www.sbir.gov/sbirsearch/technology on March 11, 2015

Table 5. Correlation of Multiple Agency Awards Among Firms, 1983-2014

	DHS	DOC	DOD	DOE	DOT	ED	EPA	HHS	NASA	NSF	USDA
DHS	1.00	0.22	0.52	0.43	0.12	0.03	0.11	0.27	0.30	0.29	0.06
DOC	-	1.00	0.31	0.23	0.15	0.03	0.12	0.11	0.25	0.26	0.08
DOD	-	-	1.00	0.38	0.34	0.04	0.16	0.18	0.62	0.37	0.06
DOE	-	-	-	1.00	0.10	0.02	0.36	0.29	0.40	0.49	0.13
DOT	-	-	-	-	1.00	0.05	0.09	0.05	0.26	0.11	0.03
ED	-	-	-	-	-	1.00	0.02	0.06	0.04	0.05	0.04
EPA	-	-	-	-	-	-	1.00	0.15	0.23	0.37	0.24
HHS	-	-	-	-	-	-	-	1.00	0.21	0.26	0.10
NASA	-	-	-	-	-	-	-	-	1.00	0.41	0.10
NSF	-	-	-	-	-	-	-	-	-	1.00	0.20
USDA	-	-	-	-	-	-	-	-	-	-	1.00

Note: all correlations are statistically significant beyond the 1% level.

Table 6. Distribution by Number of SBIR Awards for All States, 2000-2014

State	# Firms with 5 or more awards[a]	# Firms with 10 or more awards	# Firms with 25 or more awards	# Firms with 50 or more awards
Alabama	70	33	12	4
Alaska	3	0	0	0
Arizona	67	32	12	4
Arkansas	15	10	2	1
California	670	319	107	42
Colorado	137	66	28	12
Connecticut	52	30	9	4
Delaware	11	4	0	0
District of Columbia	9	3	1	0
Florida	97	47	15	3
Georgia	42	15	3	1
Hawaii	14	8	1	1
Idaho	9	3	1	0
Illinois	67	26	6	2
Indiana	41	14	3	1
Iowa	9	3	0	0
Kansas	12	5	1	0
Kentucky	15	6	0	0
Louisiana	8	5	1	0
Maine	13	1	1	1
Maryland	168	87	29	7
Massachusetts	321	171	64	34
Michigan	86	40	13	3
Minnesota	46	22	6	4
Mississippi	5	2	0	0
Missouri	25	10	0	0
Montana	16	8	2	2
Nebraska	7	3	1	1
Nevada	13	8	0	0
New Hampshire	29	10	3	1
New Jersey	89	54	14	5
New Mexico	53	27	8	6
New York	162	79	24	7
North Carolina	62	28	9	0
North Dakota	5	1	1	0
Ohio	137	66	34	16
Oklahoma	11	4	1	1
Oregon	46	22	6	2
Pennsylvania	133	68	19	7
Rhode Island	14	7	2	1
South Carolina	17	7	2	1
South Dakota	2	1	0	0
Tennessee	24	12	4	0
Texas	123	59	23	7
Utah	37	14	3	1
Vermont	12	8	0	0
Virginia	178	90	37	14
Washington	87	38	10	3
West Virginia	7	2	1	1
Wisconsin	39	13	4	1
Wyoming	8	1	0	0

[a] Includes phase I and 2 awards

Source: Data retrieved from https://www.sbir.gov/sbirsearch/technology on March 11, 2015.

Table 7. Quantiles by Total SBIR Firm Award Value as % Total US, 2000-2014

Quantile	# Firms in Quantile	Ave. Firm Total Award	Ave. # Awards Per Firm
0-25%	151	$42,232,552	130
25-50%	582	$10,976,295	30
50-75%	1,624	$3,934,598	11
75-100%	10,981	$581,904	2

Note: Includes phase I and 2 awards
Source: Data retrieved from https://www.sbir.gov/sbirsearch/technology on March 11, 2015.

Table 8. Percent Change in SBIR Award Concentration By Selected Agencies

Change Period	DOD	DOE	HHS	NASA	NSF	USDA
1983 to 2013	-36.9%	-26.2%	-69.4%	-27.1%	-71.1%	-67.4%
2000 to 2013	40.5%	-27.6%	-0.1%	28.3%	-45.6%	31.6%

Note: values shown are changes in derived HHI values based on the concentration of firms' awards within a given agency.

Table 9. Summary Statistics of Model Variables (Variables are in Natural Log Form)

Variable	Mean	Std. Dev	Minimum	Maximum
SBIR Dollar Awards per High Tech Firms	7.5517	0.8922	3.7190	9.68283
HHI for SBIR Awards	-2.3866	1.0218	-5.2553	0
Academic Articles per Academic R&D	-5.6795	0.2717	-6.7016	-5.00733
Utility Patents per GDP	-5.2934	0.7289	-7.8202	-3.02721
Academic R&D per GDP	-5.6944	0.3601	-6.7700	-4.62755
Industry R&D per GDP	-4.5792	0.9068	-7.0736	-2.89491
Federal R&D per GDP	1.7482	0.7915	0.0819	4.0165
Venture Capital per VC Deal	1.5063	0.8919	-1.3863	4.82991
Venture Capital per High Tech Firms	8.8142	2.7253	0.0000	13.43467
Firm Entry Rate	2.4093	0.1773	1.9795	2.91777
% of Engineers in Labor Force	-4.3340	0.2633	-4.9880	-3.54607
% of Science Workers in Labor Force	-5.0113	0.3330	-5.7160	-4.13285
% of S&E docs in Labor Force	-2.5371	0.4427	-4.0064	-1.21831

Table 10. Correlation of Regression and Stochastic Frontier Model Variables (Variables are in Natural Log Form)

	SBIR Dollar Awards per High Tech Firms	HHI for SBIR Awards	Academic Articles per Academic R&D	Utility Patents per GDP	Academic R&D per GDP	Industry R&D per GDP	Federal R&D per GDP	Venture Capital per VC Deal	Venture Capital per High Tech Firms	Firm Entry Rate	% of Engineers in Labor Force	% of Science Workers in Labor Force	% of S&E docs in Labor Force
SBIR Dollar Awards per High Tech Firms	1.00	-0.52	0.16	0.43	0.41	0.49	0.57	0.21	0.43	-0.09	0.47	0.23	0.42
HHI for SBIR Awards	-	1.00	-0.30	-0.41	-0.16	-0.57	-0.41	-0.40	-0.54	-0.14	-0.46	-0.10	-0.47
Academic Articles per Academic R&D	-	-	1.00	0.49	-0.30	0.50	-0.17	0.37	0.45	-0.02	0.11	-0.13	0.40
Utility Patents per GDP	-	-	-	1.00	0.08	0.77	0.20	0.31	0.50	0.15	0.54	0.23	0.34
Academic R&D per GDP	-	-	-	-	1.00	0.16	0.48	-0.02	0.04	-0.24	0.21	0.23	0.49
Industry R&D per GDP	-	-	-	-	-	1.00	0.28	0.42	0.62	-0.08	0.58	0.15	0.57
Federal R&D per GDP	-	-	-	-	-	-	1.00	0.10	0.28	0.12	0.49	0.28	0.25
Venture Capital per VC Deal	-	-	-	-	-	-	-	1.00	0.70	0.10	0.22	-0.08	0.27
Venture Capital per High Tech Firms	-	-	-	-	-	-	-	-	1.00	0.07	0.37	-0.07	0.38
Firm Entry Rate	-	-	-	-	-	-	-	-	-	1.00	0.14	0.10	-0.24
% of Engineers in Labor Force	-	-	-	-	-	-	-	-	-	-	1.00	0.32	0.31
% of Science Workers in Labor Force	-	-	-	-	-	-	-	-	-	-	-	1.00	0.27
% of S&E docs in Labor Force	-	-	-	-	-	-	-	-	-	-	-	-	1.00

Table 11. Regression Model Estimation

Parameter Name	Estimate	Std. Err	p-Value
Intercept	16.3050	1.8032	0.0001
HHI for SBIR Awards	-0.1986	0.0390	0.0001
Academic Articles per Academic R&D	0.4994	0.2100	0.0178
Utility Patents per GDP	0.1712	0.1060	0.1072
Academic R&D per GDP	0.5318	0.1445	0.0003
Industry R&D per GDP	-0.0288	0.0747	0.6994
Federal R&D per GDP	0.3737	0.0493	0.0001
Venture Capital per VC Deal	-0.0809	0.0451	0.0733
Venture Capital per High Tech Firms	0.0573	0.0256	0.0257
Firm Entry Rate	-0.8504	0.1746	0.0001
% of Engineers in Labor Force	0.2042	0.1711	0.2333
% of Science Workers in Labor Force	0.2305	0.1413	0.1036
% of S&E docs in Labor Force	-0.1829	0.1349	0.1758
Total R-Square	0.5497		

Dependent Variable is SBIR dollar awards per high-tech firms

All variables are measured in natural logs

Table 12. States With HHI Values Greater than the Predicted Production Model.

State	Obs > Predicted	No. High Tech Firm Range
New Hampshire	90%	0 - 4500
Rhode Island	30%	0 - 4500
New Mexico	10%	0 - 4500
Vermont	10%	0 - 4500
Hawaii	10%	0 - 4500
Maine	10%	0 - 4500
Wyoming	10%	0 - 4500

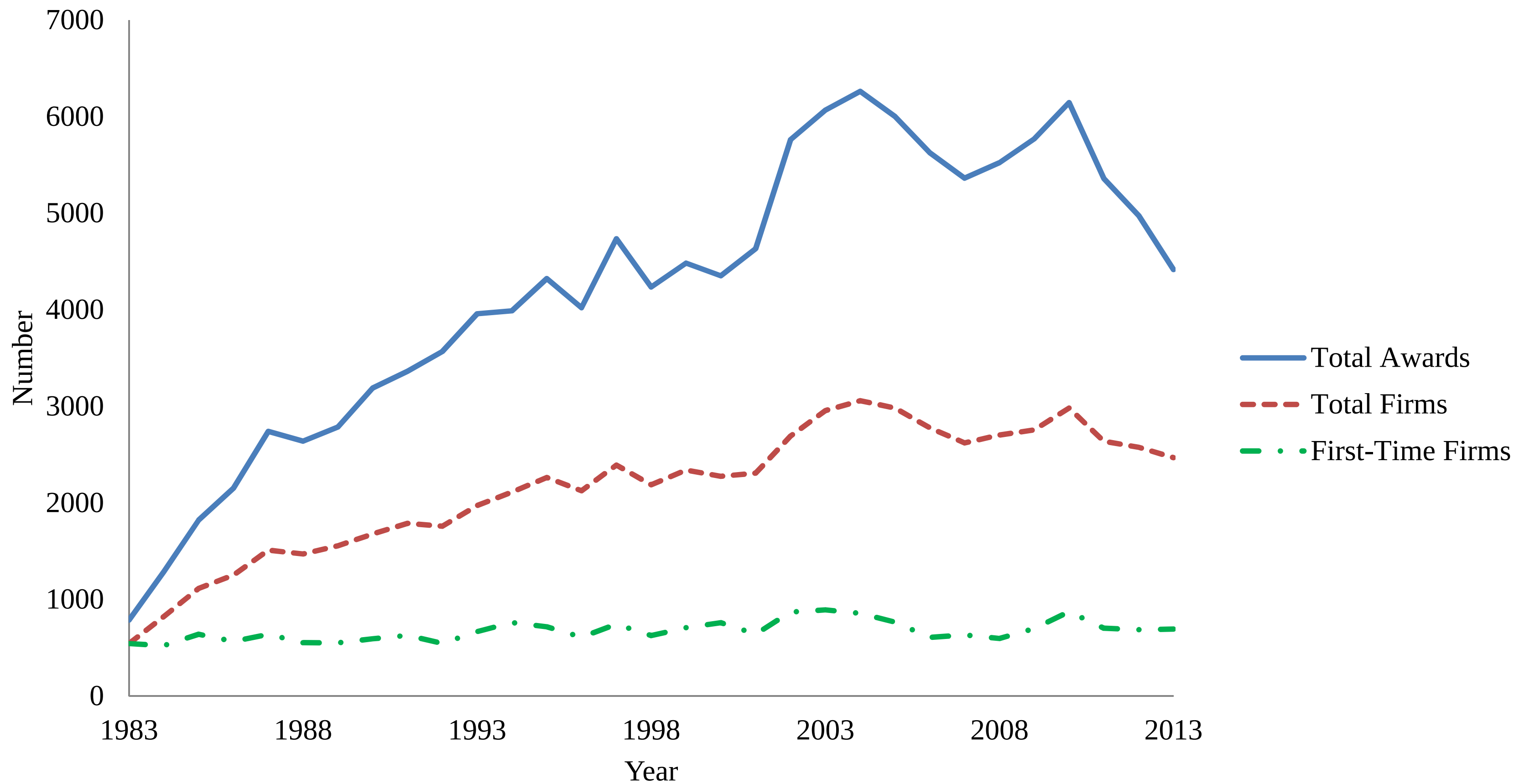

Figure 1. Comparison of annual total SBIR awards, total firm receiving SBIR awards, and first-time awards firms, 1983-2013.

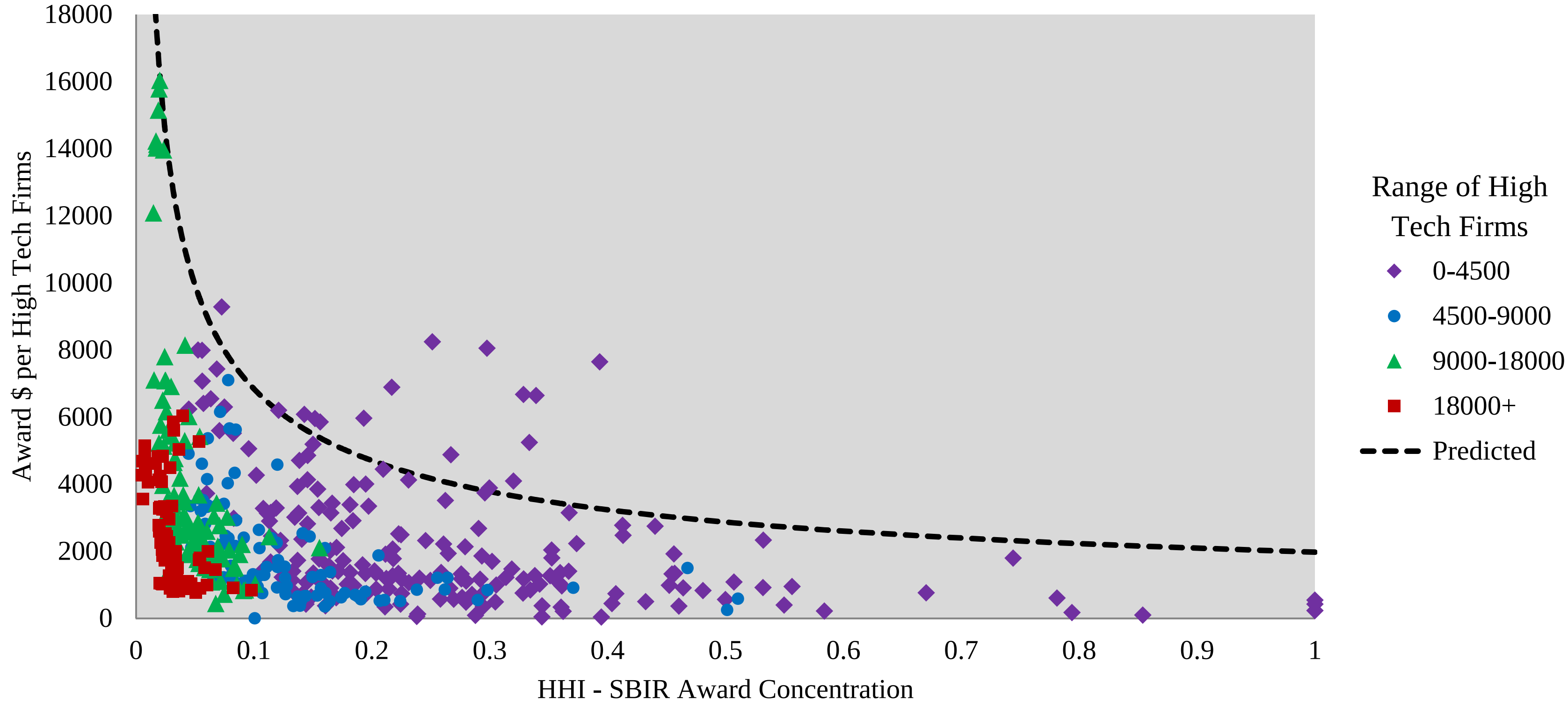

Figure 2. Scatter plot of state level SBIR awards per high tech firms (2002-2010) versus award concentration (HHI) (2000-2008) with the fitted production function model.