# Toward an assessment of the US Small Business Innovation Research Program at the National Institutes of Health

By: Albert N. Link and John T. Scott

**This is a pre-copyedited, author-produced version of an article accepted for publication in *Science and Public Policy* following peer review. The version of record**

Albert N Link, John T Scott, "Toward an Assessment of the U.S. Small Business Innovation Research (SBIR) Program at the National Institutes of Health," *Science and Public Policy*, 2018, 45(1): 83-91. https://doi.org/10.1093/scipol/scx049

**is available online at: https://doi.org/10.1093/scipol/scx049**



**Abstract:**

The Small Business Innovation Development Act of 1982, which established the Small Business Innovation Research (SBIR) program, is arguably the hallmark policy initiative in USA to support technology development and commercialization in small firms. While scholars have studied this program in detail, there has yet to be a systematic assessment of how well it is meeting its legislated goals of stimulating technological innovation and increasing private sector commercialization. We use a unique set of data on projects funded by the National Institutes of Health (NIH) SBIR program to assess the extent to which these program goals are being met. We find that, relative to a counterfactual control group, NIH can be characterized as supporting, on average, the development of high commercialization risk technologies, and we suggest that this finding aligns with the goals of the SBIR program and may in fact be for the common weal.

**Keywords:** SBIR program | technology | innovation | commercial risk

**Article:**

## 1. Introduction

In response to the productivity slowdown in USA in the early 1970s and to signs of a more severe future slowdown, President Jimmy Carter established the Domestic Policy Review System in 1977 (Office of the President 1977) and then proposed a number of specific initiatives through a memorandum to Congress in 1979. The memorandum stated (US Congress Committee on Commerce, Science, and Transportation 1979):

> I am today announcing measures which will help ensure our country's continued role as the world leader in industrial innovation. These initiatives address nine critical areas [including] … fostering the development of small innovative firms … (64)

More specifically,

> I propose the enhancement by $10 million of the Small Business Innovation Research Program of the National Science Foundation.[1] This program supports creative, high-risk, potentially high-reward research performance by small businesses. (65)

This proposal to Congress eventually led to the passage of the Small Business Innovation Development Act of 1982, Public Law 97-219. The purposes of the 1982 Act, as stated in the enabling legislation, are

1. to stimulate technological innovation;
2. to use small business to meet Federal research and development needs;
3. to foster and encourage participation by minority and disadvantaged persons in technological innovation; and
4. to increase private sector commercialization of innovations derived from Federal research and development.

The 1982 Act was not permanent and thus was reauthorized a number of times to, among other things, change the dollar amount of the set aside by each agency to fund the program and to modify the stated purposes of the program (i.e. the Small Business Technology Transfer Act of 1992, Public Law 102-564, expanded the wording of point (3) above to include: 'the participation of … small businesses that are 51 percent owned and controlled by women').[2] However, throughout all of the reauthorizations, policy makers, as well as academics (e.g. Link and Ruhm 2009; Link and Scott 2010; Siegel and Wessner 2012; Gicheva and Link 2016), have focused primarily on the commercialization purpose of the program.[3] We suggest in this article that focusing on whether Small Business Innovation Research (SBIR)-funded firms commercialize or not is only one dimension of an assessment of the SBIR program. The criterion of commercializing or not as an assessment metric ignores a separable aspect of the first stated purpose of the program, namely to stimulate technological innovation. The commercialization purpose (i.e. bringing the new product or process into the market) is of course related to the first stated purpose; the purposes are, however, separable since 'stimulating' can include work that is not commercialized but paves the way for subsequent commercialization of another research project's results.

In Section 2 of this article we suggest an assessment framework. Our suggested framework does begin with a model of the probability that a SBIR-funded project will result in a commercialized

---

[1] The Small Business Innovation Research (SBIR) program began at the National Science Foundation (NSF) in 1977 to encourage small businesses to participate in NSF-sponsored research that had commercial potential (Tibbetts 1999). For a brief history of the SBIR program at NSF, see <https://www.sbir.gov/birth-and-history-of-the-sbir-program> accessed 14 Mar 2017.

[2] The Small Business Administration's 2014 directive changed 'minority and disadvantaged persons' to 'socially and economically disadvantaged small businesses' (National Academies of Sciences, Engineering, and Medicine 2015).

[3] Scholars have also examined SBIR as a predictive factor for entrepreneurial motivation (Hayter 2011, 2015) as well as the success of university spin-offs (Hayter 2013).

technology, but our interpretation of our findings expands how one thinks about the stated purposes of the program.[4]

In Section 3, we operationalize this framework using National Institutes of Health (NIH) SBIR-funded project-level data collected by the National Research Council (NRC) of the National Academies. We focus on NIH's SBIR projects for two reasons. First, NIH's is one of the largest SBIR programs in terms of dollars allocated to funded projects, second only to the SBIR program at the Department of Defense (DoD). However, commercialization of DoD-funded SBIR technologies is different than for other programs' projects; commercialization of many DoD-funded technologies is not entirely market based. For example, 37.3 per cent of marketable SBIR products and services were purchased by DoD, and another 21.6 per cent were purchased by DoD prime contractors; only 21.4 per cent were purchased through the domestic private market (National Academies of Sciences, Engineering, and Medicine 2014). Second, the associated net social benefits from NIH SBIR projects have been estimated to be large, especially in comparison with those SBIR projects funded by other agencies.[5]

Finally, the article concludes in Section 4 with a discussion of our empirical findings and with an interpretation of our findings relative to an assessment of NIH's SBIR program.

## 2. A framework for assessing NIH's SBIR program

Commercialization is not the only goal or purpose of the SBIR program; it is one purpose and it is the purpose that has been emphasized by most scholars. Accordingly, we focus here on the assessment question: what is the impact of SBIR funding on the probability that a firm will commercialize the technology resulting from the project? To anticipate our discussion below, the answer to this assessment question is: 'It depends.' We argue below that one does not know *a priori* whether SBIR funding will increase or decrease the probability of commercialization; the impact of SBIR funding on the probability of commercialization is an empirical issue because SBIR funding could also or alternatively stimulate technological innovation (Program Goal 1 of the 1982 Act) without having an impact on commercialization. Stated differently, the program could be meeting an important program goal even if the funded research project does not result in a commercialized technology within a defined window of time.[6]

Consider a firm that has an expectation about the rate of return that it will earn by pursuing a research project that is a candidate for SBIR funding. If the firm's expected rate of return from this project is less than its internal hurdle rate or internal required rate of return, it will, absent SBIR funding, not pursue the research project, as has been shown by Link and Scott

[4] Program assessment, from our perspective, is based primarily on the criterion of effectiveness: has the program met its stated goals and objectives? Program evaluation is based primarily on the criterion of efficiency: how do the social benefits associated with the program compare to the social costs? See Link and Scott (2011) for an elaboration of these two perspectives.

[5] See Allen et al. (2012).

[6] Kesselheim et al. (2015) present compelling evidence that transformative drugs often build on earlier innovative ideas. Thus, research that results in the commercialization of a new product or process is not always a litmus test for research success. Kesselheim et al. (2015: 292) suggest that '[p]olicies that support biomedical research and those that foster the development of ideas … may be more powerful ways of producing more transformative drugs in the future.'

(2010, 2012). SBIR funding shifts rightward the probability distribution of the firm's rate of return on the research project in question; thus, SBIR funding makes it more likely that the firm will find that the expected rate of return from the funded project exceeds its internal hurdle rate.[7] This argument holds for a candidate research project that has, *a priori*, low commercialization risk as well as for one with high commercialization risk. Consider two hypothetical situations.

Using hypothetical commercialization percentages and rate of return percentages for illustrative purposes, consider firm A with a research project with very low commercialization risk. If this firm's project is undertaken, the probability of commercialization is thought to be close to 100 per cent. If this low commercialization risk project has an expected rate of return on its R&D investment of 5 per cent but its hurdle rate of return is 10 per cent, then the firm will not pursue the research. If, however, the firm receives SBIR funding, which decreases the firm's own R&D investments in the project, and if the expected rate of return thus increases above 10 per cent, the firm will undertake the project and will in all likelihood realize a commercialized technology.

Consider firm B with a candidate research project with very high commercialization risk (i.e. low probability of commercialization). If this firm's project is undertaken, the probability of commercialization will be close to 2 per cent. The firm's hurdle rate is 40 per cent, but the expected rate of return from the project will only be 20 per cent. With sufficient SBIR funding, this firm's expected rate of return will increase above 40 per cent; and thus, it will pursue the research project, although the probability of commercializing from the project is very low.

Our point from these two hypothetical examples is that focusing on whether a technology supported by SBIR funding is commercialized or not is neither a complete assessment of the SBIR program nor an effort to understand fully the economic importance of SBIR funding. Thus, our answer is 'It depends' to the assessment question: what is the impact of SBIR funding on the probability that a firm will commercialize the technology resulting from the project?

Consider a simple model applicable to a sample of research projects funded and not funded through an SBIR award

$$\text{Commercialization} = \alpha + \beta \text{Dmy} + \varepsilon \qquad (1)$$

where Commercialization is a binary variable equal to 1 if the research project resulted in a commercialized technology, and 0 otherwise; Dmy is also a binary variable equal to 1 if the research project was supported by SBIR funding, and 0 otherwise; $\alpha$ and $\beta$ are parameters, and $\varepsilon$ is random error. If estimated, one could not predict *a priori* the sign of the coefficient $\beta$. Based on the two hypothetical examples above, were one to find the estimated value of $\beta > 0$, one might infer that research projects, like that of firm A, with low commercialization risk were,

[7] As Link and Scott (2010, 2012) have shown, this policy argument holds for projects that have an expected social rate of return that is greater than the social hurdle rate of return. As such, SBIR funding not only incentivizes firms to pursue such socially important research, but also it enhances economic well-being though the creation and dissemination of new knowledge, be it codified or tacit in nature. And, as Link and Scott (2011) has argued within the policy context of publicly funded research, knowledge as a public good has positive spillover benefits to society through the generation of public gains.

on average, being funded by SBIR awards. And, if one were to find $\beta < 0$, one might conclude that SBIR was funding, on average, projects with a high commercialization risk, like that of firm B.

## 3. An empirical assessment

The Small Business Reauthorization Act of 2000 mandated that Congress commission the NRC of the National Academies to conduct an evaluation of the SBIR program prior to the program being considered for reauthorization in 2008. As part of that study, the NRC created a database of funded Phase II projects across the largest five agencies with SBIR programs.[8] Across agencies, Link and Scott (2010) previously estimated, using the 2005 NRC survey data on a random sample of Phase II projects funded between 2001 and 2010, that the average probability that a funded Phase II project resulted in a commercialized technology was slightly less than 50 per cent, with a range from 0 to 100 per cent.[9]

The 2008 reauthorization was delayed until the passage of the SBIR/STTR Reauthorization Act of 2011, Public Law 112-81, and through that act the program was reauthorized until 2017.[10] Again, the NRC was charged by Congress to create and administer a survey similar to that in 2005. Selected findings from the 2014 survey of a representative sample of Phase II NIH SBIR projects are used in this article to explore an assessment of the SBIR program by estimating variations of Equation (1) above. The methodology used by the NRC to develop the representative sample is described in the Council's summary report (National Research Council 2015).[11] The criteria used by NIH to review applications to its program are also public.[12]

In the absence of data on matched pairs of research projects that were not funded through the NIH SBIR program,[13] we constructed a counterfactual control group of projects on the basis of the following survey question[14]:

---

[8] Phase I SBIR awards are small (currently capped at $150,000) and are to assist firms conduct research to assess the feasibility of a project's scientific and commercial potential in response to the funding agency's objectives; they generally last for 6 months. Phase II awards (currently capped at $1 million), which generally last for 2 years, are to support the firm's initial steps toward commercialization of the technology being researched.

[9] For more detail about the Congressionally mandated 2005 National Research Council (NRC) database, see Wessner (2008).

[10] See National Research Council (2009) for a discussion of issues that delayed the 2008 reauthorization. The SBIR/Small Business Technology Transfer (STTR) act is part of the National Defense Authorization Act for Fiscal Year 2012.

[11] See, in particular, Tables 5–7 (2015: 160).

[12] See <https://sbir.nih.gov/review/selection-process> accessed 14 Mar 2017.

[13] Lerner's (1999) pioneering study of the SBIR program is based on estimating empirically the relationship between changes in firm sales and changes in firm employment over the period 1985–95 using a data set provided by the General Accounting Office (GAO). The GAO dataset contained information on firms that were and were not funded by SBIR. Lerner's matched pair analysis concluded that sales and employment growth were on average greater in the funded firms.

[14] We acknowledge that some readers will see problems associated with expressed preference data as opposed to revealed preference data. However, we have no reason to think that the respondents who report that they would have done the project without the SBIR support were lying; indeed, it appears that they are uncommonly frank. In the absence of a control group of SBIR applicants that were not funded, we believe our new approach to forming a counterfactual group doing projects that did not need SBIR support provides useful information for an assessment of the program. Moreover, even with the Lerner (1999) data comparing SBIR awardees and matched firms, no measure

> In your opinion, in the absence of this SBIR award, would the company have undertaken this project?
>
> (a) Definitely yes, (b) Probably yes, (c) Uncertain, (d) Probably not, (e) Definitely not

We grouped responses to this question into two groups: projects that would have been undertaken (responses 'Definitely yes' or 'Probably yes'), and projects that would not have been undertaken (responses 'Uncertain', 'Probably not', or 'Definitely not'). Within the group of projects ($n$ = 442) for which all of the variables for our model are available, our counterfactual control group consisted of the 49 projects that would have been undertaken in the absence of SBIR funding. The variable Dno is thus defined to be a binary variable equal to 1 if the firm would not have undertaken the research in the absence of SBIR funding ($n$ = 393), and 0 if the project would have been undertaken ($n$ = 49). Dno is constructed to approximate the concept associated with Dmy in Equation (1).

We use two alternative measures of commercialization. Dactsales is defined to be a binary variable equal to 1 if the firm realized sales from the SBIR-developed technology, and 0 otherwise; Dactexpsales is defined to be a binary variable equal to 1 if the firm realized or expected to realize sales from the SBIR-developed technology, and 0 otherwise. See Table 1 for definitions of these variables and the other variables discussed below, and see Table 2 for descriptive statistics on these variables and on the other variables that are discussed below.

**Table 1.** Definition of the variables

| Variable | Definition |
|---|---|
| Dno | = 1 if the firm reported that it would not have undertaken the research project in the absence of SBIR funding; 0 otherwise |
| Dactsales | = 1 if the firm conducting the SBIR-funded technology realized sales from the SBIR-funded technology; 0 otherwise |
| Dactexpsales | = 1 if the firm conducting the SBIR-funded technology realized sales or is expecting to realize sales from the SBIR-funded technology; 0 otherwise |
| rltdphII | Number of previous Phase II awards related to the research supported by the current Phase II SBIR award |
| FDAapp | = 1 if the technology being researched through the SBIR award will require FDA approval before it can be marketed; 0 otherwise |
| Daerodefense | = 1 if the technology category of aerospace and defense applies to the research project; 0 otherwise |
| Denergyenv | = 1 if the technology category of energy and the environment applies to the research project; 0 otherwise |
| Dengineering | = 1 if the technology category of engineering applies to the research project; 0 otherwise |
| DIT | = 1 if the technology category of information technology applies to the research project; 0 otherwise |
| Dmaterials | = 1 if the technology category of materials applies to the research project; 0 otherwise |
| Dmedicaltech | = 1 if the technology category of medical technology applies to the research project; 0 otherwise |
| Dother | = 1 if a technology category not listed above applies to the research project; 0 otherwise |
| numbtechs | Number of different technology categories listed above in which the research project fits |

of risk taking was possible, and Lerner and Kegler (2000: 321) have observed that with the matched pairs analysis 'it is difficult to disentangle whether the superior performance of the awardees is due to the selection of better firms or the positive impact of the awards.'

**Table 2.** Descriptive statistics on the variables

| Variable | *n* | Mean | Standard deviation | Range |
|---|---|---|---|---|
| Dno | 442 | 0.8891 | 0.3143 | 0/1 |
| Dactsales | 442 | 0.4729 | 0.4998 | 0/1 |
| Dactsales (Dno = 1) | 393 | 0.4580 | 0.4989 | 0/1 |
| Dactsales (Dno = 0) | 49 | 0.5918 | 0.4966 | 0/1 |
| Dactexpsales | 442 | 0.7285 | 0.4452 | 0/1 |
| Dactexpsales (Dno = 1) | 393 | 0.7099 | 0.4544 | 0/1 |
| Dactexpsales (Dno = 0) | 49 | 0.8776 | 0.3312 | 0/1 |
| rltdphII | 442 | 1.3507 | 1.6334 | 0/18 |
| FDAapp | 442 | 0.4774 | 0.5001 | 0/1 |
| Daerodefense | 442 | 0.02941 | 0.1691 | 0/1 |
| Denergyenv | 442 | 0.02715 | 0.1627 | 0/1 |
| Dengineering | 442 | 0.09955 | 0.2997 | 0/1 |
| DIT | 442 | 0.07466 | 0.2631 | 0/1 |
| Dmaterials | 442 | 0.03167 | 0.1753 | 0/1 |
| Dmedicaltech | 442 | 0.9163 | 0.2773 | 0/1 |
| Dother | 442 | 0.07919 | 0.2703 | 0/1 |
| numbtechs | 442 | 1.2579 | 0.6183 | 1/5 |

As reported in Table 2, the mean probability, restated as a percent, of a funded project resulting in a commercialized technology for the sample for 442 projects is 47.29 per cent, and the mean probability of a funded project resulting in or expected to result in a commercialized technology is 72.85 per cent. Among those research projects that would not have been undertaken in the absence of SBIR funding (Dno = 1, $n = 393$), the mean probabilities are 45.80 per cent and 70.99 per cent, respectively; among those research projects that would have been undertaken (Dno = 0, $n = 49$), the mean probabilities are 59.18 per cent and 87.76 per cent. Clearly, the probability of commercialization, however defined, is greater among those research projects that would have been undertaken in the absence of SBIR funding (Dno = 0).

More formally and in terms of a regression framework, the estimated coefficient on Dno is negative in both a bivariate linear probability model and in a probit model when actual sales are required for the dependent variable to indicate commercialization—columns (1) and (2) in Table 3—and when actual or expected sales are required to indicate commercialization—columns (1) and (2) in Table 4. Based on the regression results in column (1) in Table 3, the probability of commercialization (i.e., actual sales) for the counterfactual case where SBIR support was not needed is 59.18 per cent (the constant term in column (1)) and 45.80 per cent where SBIR support was needed (the constant term less the estimated coefficient on Dno in column (1)).[15] Similarly in column (1) in Table 4, the probability of commercialization (i.e., actual sales or expected sales) where SBIR support was not needed is 87.76 per cent and 71.00 per cent where SBIR support was needed.[16] Both the descriptive statistics in Table 2 and the regression results from the bivariate models in Tables 3 and 4 suggest, following our previous arguments,

[15] Using the probit results in column (2), these probabilities are respectively 59.18 (0.5918 is the value of the cumulative normal distribution at $z = 0.2323$) and 45.80 (0.4580 is the cumulative normal distribution evaluated at $z = -0.1054$).

[16] Using the probit results in column (2), these probabilities are 87.75 and 70.99, respectively (normal(1.1628) = 0.8775), and normal(0.5531) = 0.7099).

that the SBIR program is indeed stimulating technological innovation (program goal 1 of the 1982 Act) by shifting firms toward riskier research projects in terms of higher commercial risk. And, with higher commercial risk, might come lower actual sales because of both higher commercial risk and also any associated higher technical risk.

Reliable magnitudes of actual sales or expected sales data are not available from the 2014 SBIR survey, although a small subset of the responding firms provided categorical ranges for sales of products, processes, or services, and for other sales such as sales of rights to the technology. For both types of sales revenues, some responding firms reported 'None ($0), Under $100,000, $100,000–$499,999, $500,000–$999,999, $1,000,000–$4,999,999, $5,000,000–$9,999,999, $10,000,000–$19,999,999, $20,000,000–$49,999,999, $50,000,000 or more'). While median values could be assigned to the unequal range categories, it would be completely arbitrary to assign a value for the top category. Moreover, the timing of what sales information is reported is unknown, and the full record of sales is not yet complete even for those respondents who provide the magnitudes of sales. Without the knowledge of the timing of the reported sales, constant dollar sales cannot be constructed to properly compare even the incomplete series.

The conclusion, which is also supported through the estimation of more refined models below, that the SBIR program is causing firms to undertake research projects that have higher commercial risk than the projects that would be undertaken without the SBIR support should not be interpreted to mean that the SBIR program is not successful. On the contrary, in the development of new technology, as in the development of new science, failure (i.e. in our case, commercializing less often and in lower amounts) is an integral part of gaining the knowledge needed for success. As Firestein (2016: 64) observes

> Put most simply, how reliable is success if there is not sufficient possibility of failure? Success becomes more successful, and often more interesting, the harder it is to obtain, the more likely the process that led to it could have led instead to failure.

Or (Firestein 2016: 69), 'If science is to produce something more than trivial knowledge it must be hard …'

The specifications in columns (3) and (4) in both tables include the variable rltdphII. This variable measures the number of previous Phase II awards that a firm has received that are related to the research supported by the current Phase II award. This variable captures the technology-related experience of the firm, or what might be viewed as the technical capital that is specific to its current research. We predict that this variable will be positively related to the probability of commercialization, and in fact the estimated coefficients are positive and significant. The importance of the previous awards supports the view that doing related projects has a positive impact on success of a particular project even if those related projects do not commercialize. The data are not available to let us know whether the previous, related projects were commercially successful or not, but possibly a portion, perhaps a large portion, of the related projects were not commercially successful and yet contribute positively to the commercial success of the project in the current sample.

**Table 3.** Regression results for variations of Equation (1), dependent variable is *Dactsales*, standard errors in parentheses ($n$ = 442)

| Variable | (1) Linear | (2) Probit | (3) Linear | (4) Probit | (5) Linear | (6) Probit | (7) Linear | (8) Probit | (9) Linear | (10) Probit |
|---|---|---|---|---|---|---|---|---|---|---|
| Dno | −0.1338 (0.0755)*** | −0.3377 (0.1916)*** | −0.1349 (0.0750)*** | −0.3417 (0.1913)*** | −0.1399 (0.0697)**** | −0.4121 (0.2042)**** | −0.1418 (0.0709)**** | −0.4142 (0.2062)**** | −0.1418 (0.0709)**** | −0.4126 (0.2060)**** |
| rltdphII | – | – | 0.0390 (0.0144)***** | 0.0982 (0.0370)***** | 0.0349 (0.0134)***** | 0.0995 (0.0391)**** | 0.0356 (0.0135)***** | 0.1032 (0.0396)***** | 0.0340 (0.0137)**** | 0.1008 (0.0400)**** |
| FDAapp | – | – | – | – | −0.3664 (0.0439)***** | −0.9787 (0.1262)***** | −0.3650 (0.0464)***** | −0.9764 (0.1328)***** | −0.3604 (0.0467)***** | −0.9628 (0.1335)***** |
| Daerodefense | – | – | – | – | – | – | −0.1049 (0.1406) | −0.3435 (0.4368) | −0.1968 (0.1765) | −0.6641 (0.5549) |
| Denergyenv | – | – | – | – | – | – | 0.0589 (0.1582) | 0.1726 (0.4455) | –0.0135 (0.1792) | –0.0431 (0.5035) |
| Dengineering | – | – | – | – | – | – | –0.1049 (0.0772)* | –0.2826 (0.2179)* | –0.1841 (0.1201)** | –0.5428 (0.3494)** |
| DIT | – | – | – | – | – | – | 0.1131 (0.0899) | 0.3428 (0.2591)* | 0.0386 (0.1248) | 0.0998 (0.3626) |
| Dmaterials | – | – | – | – | – | – | 0.0669 (0.1354) | 0.2103 (0.3741) | −0.0255 (0.1728) | −0.0921 (0.4900) |
| Dmedicaltech | – | – | – | – | – | – | 0.0560 (0.0884) | 0.1516 (0.2537) | 0.0152 (0.1004) | 0.0197 (0.2901) |
| numbtechs | – | – | – | – | – | – | – | – | 0.0824 (0.0957) | 0.2676 (0.2798) |
| Constant[a] | 0.5918 (0.0712)***** | 0.2323 (0.1808)* | 0.5401 (0.0733)***** | 0.1029 (0.1866) | 0.7249 (0.0716)***** | 0.6234 (0.2103)***** | 0.6751 (0.1087)***** | 0.4810 (0.3132)** | 0.6298 (0.1208)***** | 0.3303 (0.3528) |
| $R^2$ | 0.0071 | – | 0.0233 | – | 0.1575 | – | 0.1655 | – | 0.1669 | – |
| F[b] | 3.14 (1, 440)*** | – | 5.24 (2, 439)***** | – | 27.29 (3, 438)***** | – | 9.52 (9, 432)***** | – | 8.64 (10, 431)***** | – |
| Pseudo $R^2$ | – | 0.0051 | – | 0.0168 | – | 0.1189 | – | 0.1257 | – | 0.1272 |
| Likelihood ratio ψ2ψ2 (degrees of freedom) | – | 3.13 (1)*** | – | 10.30 (2)***** | – | 72.70 (3)***** | – | 76.84 (9)***** | – | 77.76 (10)***** |
| Log-likelihood | – | −304.15 | – | −300.57 | – | −269.37 | – | −267.30 | – | −266.84 |

[a] In the models in columns (7)–(10), *Dother* is subsumed in the constant term.

[b] In parentheses is the degrees of freedom for the numerator followed by the degrees of freedom for the denominator.

***** significant at 0.01 level, ****significant at 0.05 level, ***significant at 0.10 level, **significant at 0.15 level, *significant at 0.20 level.

**Table 4.** Regression results for variations of Equation (1), dependent variable is Dactexpsales, standard errors in parentheses ($n$ = 442)

| Variable | (1) Linear | (2) Probit | (3) Linear | (4) Probit | (5) Linear | (6) Probit | (7) Linear | (8) Probit | (9) Linear | (10) Probit |
|---|---|---|---|---|---|---|---|---|---|---|
| Dno | –0.1676 (0.0671)**** | –0.6097 (0.2403)**** | –0.1683 (.0669)**** | –0.6070 (0.2399)**** | –0.1701 (0.0662)**** | –0.6386 (0.2448)***** | –0.1624 (0.0672)**** | –0.6098 (0.2464)**** | –0.1624 (0.0671)**** | –0.6086 (0.2472)**** |
| rltdphII | — | — | 0.0232 (0.0129)*** | 0.0685 (0.0398)*** | 0.0217 (0.0127)*** | 0.0658 (0.0405)** | 0.0226 (0.0128)*** | 0.0676 (0.0409)*** | 0.0200 (0.0129)** | 0.0625 (0.0417)** |
| FDAapp | — | — | — | — | –0.1318 (0.0416)***** | –0.4129 (0.1303)***** | –0.1288 (0.0440)***** | –0.4022 (0.1383)***** | –0.1213 (0.0442)***** | –0.3770 (0.1391)***** |
| Daerodefense | — | — | — | — | — | — | –0.1405 (0.1333) | –0.4320 (0.4020) | –0.2878 (0.1670)*** | –1.1101 (0.5645)**** |
| Denergyenv | — | — | — | — | — | — | 0.1339 (0.1499) | 0.5165 (0.5498) | 0.0176 (0.1695) | 0.02222 (0.6221) |
| Dengineering | — | — | — | — | — | — | –0.1402 (0.0732)*** | –0.4203 (0.2209)*** | –0.2672 (0.1136)**** | –1.0131 (0.4097)**** |
| DIT | — | — | — | — | — | — | 0.0611 (0.0852) | 0.2139 (0.2881) | –0.0584 (0.1180) | –0.3193 (0.4245) |
| Dmaterials | — | — | — | — | — | — | 0.0291 (0.1283) | 0.0473 (0.4047) | –0.1193 (0.1635) | –0.6205 (0.5602) |
| Dmedicaltech | — | — | — | — | — | — | –0.0078 (0.0838) | –0.0454 (0.2802) | –0.0733 (0.0950) | –0.3526 (0.3416) |
| numbtechs | — | — | — | — | — | — | — | — | 0.1322 (0.0905)** | 0.6030 (0.3492)*** |
| Constant[a] | 0.8776 (0.0632)***** | 1.1628 (0.2308)***** | 0.8468 (0.0653)***** | 1.0711 (0.2361)***** | 0.9133 (0.0680)***** | 1.3139 (0.2541)***** | 0.9200 (0.1030)***** | 1.3521 (0.3646)***** | 0.8474 (0.1143)***** | 1.0313 (0.4152)**** |
| $R^2$ | 0.0140 | — | 0.0212 | — | 0.0431 | — | 0.0553 | — | 0.0599 | — |
| F[b] | 6.25 (1, 440)**** | — | 4.76 (2, 439)***** | — | 6.58 (3, 438)***** | — | 2.81 (9, 432)***** | — | 2.75 (10, 431)***** | — |
| Pseudo $R^2$ | — | 0.0138 | — | 0.0197 | — | 0.0393 | — | 0.0499 | — | 0.0562 |
| Likelihood Ratio ψ2ψ2 (degrees of freedom) | — | 7.13 (1)***** | — | 10.17 (2)***** | — | 20.30 (3)***** | — | 25.80 (9)***** | — | 29.06 (10)***** |
| Log-likelihood | — | –254.89 | — | –253.37 | — | –248.30 | — | –245.56 | — | –243.93 |

[a] In the models in columns (7)–(10), *Dother* is subsumed in the constant term.

[b] In parentheses is the degrees of freedom for the numerator followed by the degrees of freedom for the denominator.

***** significant at 0.01 level, ****significant at 0.05 level, ***significant at 0.10 level, **significant at 0.15 level.

One possible constraint on observing a commercialized technology from a research project in the NIH data is if the research project is expected to result in a technology that will require Food and Drug Administration (FDA) approval before being marketed (FDAapp = 1). The time from research funding to even expected sales will likely be longer than for other research projects (FDAapp = 0) and thus commercialization might not be observed within the window of time during which the NRC collected its data. As seen from the regression results in columns (5) and (6), the estimated coefficients on FDAapp are negative and significant.

To account for possible differences in research time or technology development time among research projects with varying application emphases, we included in the specifications in columns (7) and (8), application sector fixed effects. Respondents to the survey were asked to indicate all the technology areas that applied to their SBIR project. One possible generalization from these results is that technologies applicable to the engineering sector are less likely to be commercialized, other factors held constant. Across specifications and commercialization variables, the estimated coefficients on Dengineering are negative and significant at various levels. However, for both dependent variables, the technology sector variables, as a group, are not significant.[17]

Finally, the specifications in columns (9) and (10) include the variable numbtechs. This variable quantifies the number of technology sectors to which the research is relevant. We focus on this variable following the work of Nelson (1959). He argued that product diversity is a prerequisite for firms investing in basic research because of the uncertainty of what might result from basic research (1959: 302). Simply, 'firms that have their fingers in many pies' are in a position to profit from whatever discoveries might result.[18] To the extent that Nelson's argument holds for SBIR funded research, which is also characterized by uncertainty not because of its basic nature but because the firms that receive SBIR awards are small and often research inexperienced, we predict that the effect of numbtechs on commercialization will be positive. The estimated coefficients on that variable are positive in columns (9) and (10) in both tables, although the estimated coefficients are only significant for Dactexpsales.[19]

---

[17] Details of the statistical tests, showing that the technology effects are not significant as a group, are available from the authors on request.

[18] See Link and Long (1981) for empirical evidence in support of Nelson's diversification hypothesis. Relatedly, Scott et al. (2017) show theoretically and empirically that the probability of a small firm obtaining outside financing increases with the number of potential applications of their anticipated innovative results.

[19] The technology sector fixed effects in Tables 3 and 4 are broadly defined. The NRC survey also asked for more disaggregated application areas. For example, the energy and environment technology sector can be disaggregated into (1) renewable energy production (solar, wind, geothermal, bioenergy, wave), (2) energy storage and distribution, (3) energy efficiency, and (4) other energy or environmental products and services. Similarly, the engineering technology sector can be disaggregated into (1) engineering services, (2) scientific instruments and measuring equipment, (3) robotics, (4) sensors, and (5) other engineering. When the narrowly defined technology sectors are considered in construction of numbtechs, the regression results are similar to those in Tables 3 and 4 in the sense that the diversification effect is positive and statistically significant in the models for one of the commercialization variables but not for the other one. However, with the narrowly defined technologies, the significance comes with the commercialization variable that is based on actual sales (rather than with the dependent variable based on actual plus expected sales). Moreover, using the narrower technologies, the level of significance is higher (at the 5 per cent level rather than just the 10 per cent or 15 per cent level) for the diversification effect. These results are available on request from the authors.

## 4. Discussion and concluding remarks

We introduced in this article a new way to form a control group against which the performance of SBIR-supported research projects can be compared. We, thereby, have a counterfactual research performance for projects that the small businesses would have undertaken without the SBIR program's support. Comparing that counterfactual performance with the performance of research projects requiring the SBIR program's support, we have discovered that the program is stimulating projects with high commercialization risk.

The academic and policy literatures related to the SBIR program, including the recent Congressionally mandated Academy report (National Academies of Sciences, Engineering, and Medicine 2015), have emphasized the commercialization of award-developed technology in their discussions about the so-called success of the program. The consensus opinion is that the likelihood that a SBIR-developed technology, through NIH's or another agency's funding, within the time window of available data, is about equal to the flip of a fair coin.

As we have suggested in this article, this average commercialization percentage does not suggest that only about one-half of SBIR-funded projects are successful. On the contrary, it emphasizes, in our view, that commercialization is only one goal or purpose of the program. Equally important is that the program is to stimulate technological innovations. Our findings suggest that the type of technologies that are being stimulated are high commercialization risk technologies (i.e. low probability of commercialization technologies). However, to reflect on President Carter's observation that the SBIR program supports 'high-risk, potentially high-reward research' and also on the comments of Firestein—both quoted above, under the view that commercialization is the accepted measure of SBIR success—our findings might possibly suggest that stimulating high commercialization risk technologies, over time, will be for the common weal.[20] The positive internality from SBIR funding is that the recipient firm is in fact able to pursue its R&D project, which would not likely have occurred in the absence of the funding (Link and Scott 2012), and thus, with some probability, the firm will bring a new technology into the market. The positive externality might be thought of in terms of Arthur's (2009) argument that new technology is a combination of prior technologies; thus, today's SBIR-funded technologies might become a building block for new technologies in the future and, therefore, become a foundation for all of the social benefits that new technology might engender.

Although our observations are only for research projects supported by the NIH SBIR program, our findings—that government subsidy of privately performed research causes the firms to do research that is more commercially risky than the research they would do without government support—and our interpretation—that the more commercially risky research may ultimately have greater benefits for the public than the research that would be done without government support—are of general importance.

---

[20] Unfortunately, as discussed in Section 3, the NRC database does not include reliable sales information for projects. There are, for less than one-half of the projects, sales-to-date information (with no indication of the years in which sales were realized) reported by broad categories with the final category being $50 million or more. Even with sales data as of the 2014 survey date, it would be reasonable to expect that a number of projects that will eventually generate sales (i.e. those requiring FDA approval, for example) were not observed as doing so by the survey year 2014.

**References**


Allen, S. D., Layson, S. K., and Link, A. N. (2012) 'Public Gains from Entrepreneurial Research: Inferences about the Economic Value of Public Support of the Small Business Innovation Research Program', Research Evaluation, 21: 105–12.

Arthur, W. B. (2009) The Nature of Technology: What it Is and How it Evolves. New York: Barnes and Noble.

Firestein, S. (2016) Failure: Why Science is So Successful. New York: Oxford University Press.

Gicheva, D., and Link, A. N. (2016) 'On the Economic Performance of Nascent Entrepreneurs', European Economic Review, 86: 109–17.

Hayter, C. S. (2011) 'In Search of the Rational, Profit-Maximizing Actor: Motivations and Growth Ambitions among Academic Entrepreneurs', Journal of Technology Transfer, 36: 340–52.

——— (2013) 'Harnessing University Entrepreneurship for Economic Growth: Factors of Success among University Spinoffs', Economic Development Quarterly, 27: 18–28.

——— (2015) 'Public or Private Entrepreneurship? Revisiting Motivations and Definitions of Success among Academic Entrepreneurs', Journal of Technology Transfer, 40: 1003–15.

Kesselheim, A. S., Tan, Y. T., and Avorn, J. (2015) 'The Roles of Academia, Rare Diseases, and Repurposing in the Development of the Most Transformative Drugs', Health Affairs, 34: 286–93.

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

——— and Kegler, C. (2000) 'Evaluating the Small Business Innovation Research Program: A Literature Review', in Wessner, C. W. (ed.) The Small Business Innovation Research Program: An Assessment of the Department of Defense Fast Track Initiative, pp. 307–24. Washington, DC: National Academy Press.

Link, A. N., and Long, J. E. (1981) 'The Simple Economics of Basic Scientific Research: A Test of Nelson's Diversification Hypothesis', Journal of Industrial Economics, 30: 105–9.

——— and Ruhm, C. J. (2009) 'Bringing Science to Market: Commercializing from NIH SBIR Awards', Economics of Innovation and New Technology, 18: 381–402.

——— and Scott, J. T. (2010) 'Government as Entrepreneur: Evaluating the Commercialization Success of SBIR Projects', Research Policy, 39: 589–601.

——— and ——— (2011) Public Goods, Public Gains: Calculating the Social Benefits of Public R&D. New York: Oxford University Press.

——— and ———,(2012) Employment Growth from Public Support of Innovation in Small Firms. Kalamazoo, MI: W.E. Upjohn Institute for Employment Research.

National Academies of Sciences, Engineering, and Medicine (NAS) (2014). SBIR/STTR at the Department of Defense. Washington, DC: National Academies Press.

——— (2015). SBIR/STTR at the National Institutes of Health. Washington, DC: National Academies Press.

National Research Council (2009) Venture Funding and the NIH SBIR Program. Washington, DC: National Academy Press.

——— (2015) SBIR/STTR at the National Institutes of Health. Washington, DC: National Academy Press.

Nelson, R. R. (1959) 'The Simple Economics of Basic Scientific Research', Journal of Political Economy, 67: 297–306.

Office of the President (1977), Presidential Domestic Policy Review System Memorandum for the Heads of Executive Departments and Agencies, http://www.presidency.ucsb.edu/ws/?pid=6631. accessed 21 Jan 2017.

Scott, T. J., Scott, John T., and Link, Albert N. (2017). 'Commercial Complexity and Entrepreneurial Finance', Economics of Innovation and New Technology, 26: 489–500.

Siegel, D. S., and Wessner, C. W. (2012) 'Universities and the Success of Entrepreneurial Ventures: Evidence from the Small Business Innovation Research Program', Journal of Technology Transfer, 37: 404–15.

Tibbetts, R. (1999) The Small Business Innovation Research Program and NSF SBIR Commercialization Results, Mimeograph Report. Washington, DC: National Science Foundation.

US Congress Committee on Commerce, Science, and Transportation; Select Committee on Small Business, United States Senate; Committee on Science and Technology; and Committee on Small Business, U.S. House of Representatives (1979) Office of the White House Secretary to the Congress of the United States, serial no. 96–68. Washington, DC: US Government Printing Office.

Wessner, C. W. (2008). An Assessment of the SBIR Program, Washington, DC: National Academy Press.