Public gains from entrepreneurial research: Inferences about the economic value of public support of the Small Business Innovation Research program.

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Abstract:

This article presents a systematic analysis of the net economic benefits associated with the Small Business Innovation Research (SBIR) program. We offer a derivation of producer and consumer surplus to estimate economic benefits. Fundamental to the implementation of these models is a specific value of the elasticity of demand, but in its absence we estimate what its value would be when the benefit-to-cost ratio associated with public support of the SBIR program equals unity. We infer from these calculations, and from general knowledge about the ability of SBIR-funded firms to exploit their monopoly position, that the SBIR program likely generates positive net economic benefits to society.

Keywords: entrepreneurship | innovation | technology | SBIR program | benefit to cost ratio | program evaluation | producer surplus | consumer surplus

Article:

1. Introduction

The Small Business Reauthorization Act of 2000 mandated that the National Research Council (NRC) within the National Academies conduct ‘an evaluation of the economic benefits achieved by the SBIR [Small Business Innovation Research] program’ and make recommendations to the Congress for ‘improvements to the program’. The NRC steering committee, charged with the design of the study, took several approaches to the evaluation. These approaches included multiple award-recipient firm surveys, Principle Investigator and firm interviews, and over 100 case studies.1 Based on descriptive information from the surveys and insight from the case studies, the NRC made important recommendations to the Congress regarding, in particular, increases in the size of each award.2

Although the NRC and others used its survey data to provide well detailed descriptions of the program in their reports and testimony to the Congress, their analyses were narrow and did not include any evaluation metrics to quantify the broader-based net economic benefits from such use of public resources.3 Rather, the NRC and others relied primarily on case studies and descriptive statistics from the survey data to illustrate the importance of the program to the award-recipient businesses and then only suggestively to the society as a whole.

This article presents the results of a systematic analysis of the net economic benefits associated with the SBIR program using the data collected by the NRC for the Department of Defense (DoD), the National Institutes of Health (NIH), the National Aeronautics and Space Administration (NASA), the Department of Energy (DOE), and the National Science Foundation (NSF).4

The remainder of this article is outlined as follows. In Section 2 we provide institutional background on the SBIR program. In Section 3 we describe the NRC's data collection effort and the resulting database that is used herein. In Section 4 we offer a derivation of producer and consumer surplus to estimate economic benefits; estimation of producer and consumer surplus from these models is based on an elasticity of demand value for the technology-based products resulting from the SBIR-funded research. Absent specific information about the elasticity of demand, we calculate in Section 5 what its value would be when the benefit-to-cost ratio associated with public support of the SBIR program equals unity. And, we infer from these calculations, and from general knowledge about the ability of SBIR-funded firms to exploit their monopoly position, that the SBIR program generates net positive economic benefits to society. Section 6 concludes the article with a summary statement.

2. Background on the SBIR program

The SBIR program is a public/private partnership that provides grants to fund private-sector R&D projects. It aims to help fulfill the government's mission to enhance private-sector R&D and to complement the results of federal research.5

A prototype of the SBIR program began at NSF in 1977 (Tibbetts 1999), and because of the success of that program, the Congress passed the Small Business Innovation Development Act of 1982 (Public Law 97-219; hereafter, the 1982 Act). It required at that time all government departments and agencies with external research programs of >$100 million to establish their own SBIR program and to set aside funds equal to 0.20% of their external research budget. In 1983, that set aside totaled to $45 million.

Specifically, the 1982 Act stated that the objectives of the program are to: stimulate technological innovation, use small business to meet federal research and development needs, foster and encourage participation by minority and disadvantaged persons in technological innovation, and increase private sector commercialization of innovations derived from federal research and development.6

As part of the 1982 Act, awards were structured and defined by three phases (National Research Council 2004). Phase I awards were small, generally <$50,000 for a 6-month award period, and they were to assist businesses assess the feasibility of an idea's scientific and commercial potential in response to the funding agency's objectives. Phase II awards, capped at $500,000, and generally lasting 2 years, were to support the business develop further its proposed research that was to lead to a commercializable product, process, or service. Post-Phase II research occurs in what is called Phase III. No SBIR funds are awarded during Phase III; it defines the period during which third-party financing (e.g. from venture capitalists) is obtained to move the Phase II developed technology into the marketplace.

As stated in the 1982 Act, to be eligible for an SBIR award, the small business must be: independently owned and operated; other than the dominant firm in the field in which they are proposing to carry out SBIR projects; organized and operated for profit; the employer of ≤500 employees, including employees of subsidiaries and affiliates; the primary source of employment for the project's principal investigator at the time of award and during the period when the research is conducted; and at least 51% owned by US citizens or lawfully admitted permanent resident aliens.

In 1986, the 1982 Act was extended through 1992 (Public Law 99-443). In 1992 the SBIR program was reauthorized until 2000 through the Small Business Research and Development Enactment Act (Public Law 102-564). Under the 1982 Act, the set aside had increased to 1.25%; the 1992 reauthorization raised that amount over time to 2.50% and re-emphasized the commercialization intent of SBIR-funded technologies. The reauthorization also increased Phase I awards to $100,000 and Phase II awards to $750,000, although it has not been uncommon for awards to exceed the $750,000 threshold. The 1992 reauthorization broadened the 1982 objectives to focus on women: ‘to provide for enhanced outreach efforts to increase the participation of … small businesses that are 51 percent owned and controlled by women’.

The Small Business Reauthorization Act of 2000 (Public Law 106-554) extended the SBIR program until 30 September 2008 and kept the 2.50% set aside. It retained the 2.50% set aside but did not increase the amounts of Phase I and Phase II awards.

The Congress did not reauthorize the SBIR program by the legislated date of 30 September 2008, even given the NRC’s report to Congress on the program’s accomplishments and its recommendation to do so. Rather, the Congress has continually extended the program through a series of short-term reauthorizations. On 31 December 2011 the program was reauthorized until 30 September 2017 under the National Defense Reauthorization Act of 2012 (Public Law 112-81).

Currently 11 agencies participate in the SBIR program: DoD, NIH, NASA, DOE, NSF, the Environmental Protection Agency (EPA), and the Departments of Agriculture (USDA), Commerce (DoC), Education (ED), Transportation (DoT), and most recently, Homeland Security (DHS). In 2005 (the year of the NRC survey from which the data analyzed herein come), DoD maintained the largest program, awarding about 51% of total dollars and funding of about 57% of the total awards in that year. Five agencies—DoD, NIH, NASA, DOE, and NSF—account for nearly 97% of the program’s expenditures, with NIH being the second most important, accounting for 30% of total dollars and 19% of awards in 2005 (Table 1).

Table 1 is omitted from this formatted document.

Not only is their variability in funding levels across agencies, as shown in Table 1, but also there are cross-agency differences in programmatic goals. The primary goal of DoD’s SBIR program is to provide technologies that can be used as part of our nation’s defense system, which is the mission of DoD. In contrast, NIH’s primary mission for its SBIR program is the development of fundamental knowledge and its application for improving health. Pioneering the future of space exploration, scientific discovery, and aeronautical research is the mission of NASA and its SBIR program. The DOE’s SBIR program supports technical knowledge related to the agency’s program areas. Finally, NSF’s SBIR program promotes science and the commercialization of science.7

3. The NRC database

The NRC conducted an extensive and balanced survey in 2005 based on a population of 11,214 projects completed from Phase II awards made between 1992 and 2001 by five agencies: DoD, NIH, NASA, DOE, and NSF. It was assumed as part of the NRC's sampling methodology that Phase II awards made in 2001 would be completed by 2005.

The five agencies surveyed accounted for nearly 97% of the program's expenditures in 2005, as shown in Table 1. Table 2 shows the distribution of the population of 11,214 projects by the funding agency, and the percentage of each agency's Phase II projects that was surveyed. The total number of projects surveyed from the 11,214 population of projects was 6,408. The number and percentage of respondents from these 6,408 surveyed projects is shown in Table 3. The total number of responding projects was 1,916, and the average response rate across all five agencies was about 30%.8

Table 2.

Population of SBIR Phase II projects 1992–2001 by agency

Agency	Completed Phase II projects	Percentage
DoD	5,650	50.38
NIH	2,497	22.27
NASA	1,488	13.27
NSF	771	6.88
DOE	808	7.21
Total	11,214	100.00

Table 3.

Descriptive statistics on the National Research Council survey of Phase II awards by agency

Agency	Phase II sample size	Respondents	Response rate (%)	Random sample
DoD	3,055	920	30	891

Agency	Phase II sample size	Respondents	Response rate (%)	Random sample
NIH	1,678	496	30	495
NASA	779	181	23	177
NSF	457	162	35	161
DOE	439	157	36	154
Total	6,408	1,916		1,878

Also shown in Table 3 is the total number of projects in the final random sample of completed Phase II projects by the agency. The NRC surveyed a number of non-randomly selected projects because they were projects that had realized significant commercialization and the NRC wanted to be able to describe to the Congress such success stories. The non-randomly selected projects are not considered herein.

Responses to project survey questions are used in the evaluation analysis below.9 The first survey question asked for the amount of Phase II funding awarded to support the project. The second survey question asked for total sales and licensing revenues to date (i.e. in 2005) from the Phase II technology. Table 4 provides descriptive statistics on these variables.10 Also shown in the table are the award amounts in the current and $2005.

Table 4 is omitted from this formatted document.

The amount of the Phase II award measures the public sector's investment into the private sector's generation of new technology, and thus it is the project cost in the benefit–cost analysis of the program. In the following section we present a framework for translating sales and licensing revenues into the value of producer and consumer surplus, the economics-based concepts related to the social benefits associated with Phase II funding considered herein.

4. Derivation of producer and consumer surplus

Griliches (1958) and Mansfield et al. (1977) are heralded as pioneering the so-called traditional approach to the evaluation of publicly funded research.11 In their model, costs are measured in terms of public allocations in support of private research and benefits are measured in terms of the economic surplus that results through time. For existing businesses that receive publicly funded research support and that face a downward sloping demand curve, the resulting innovation lowers the marginal and average cost of producing a good sold in a competitive market generating an increase in consumer surplus.12

In contrast to the traditional model used by Griliches (1958) and Mansfield et al. (1977) which assumes that the firms receiving public funding sell their products in competitive markets, we assume that the firms receiving SBIR awards have temporary monopoly power. Figure 1 shows a monopolist, with constant marginal and average cost c and facing demand D, that sells its monopoly product or service in amount x* at price p*. In Fig. 1 the area defined by the triangle ABP* represents consumer surplus. Producer surplus is represented by the rectangle P*BEF.

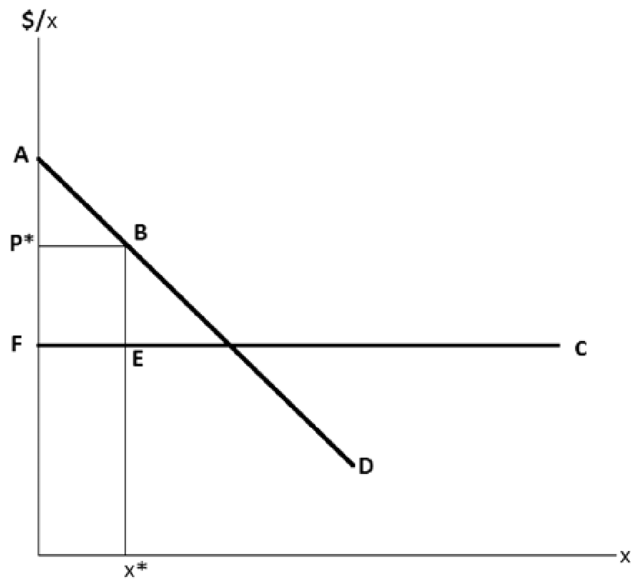

Figure 1.

Graphical description of consumer surplus and producer surplus.

The entrepreneurial businesses that receive Phase II SBIR awards are being funded to research a new technology and eventually either bring it to market or license it to others. Our model of producer and consumer surplus accounts for these two possibilities.

A business that brings a new technology to market enjoys monopoly power for some period of time. Assume constant long-run marginal and average cost equal to c. Profit, π, or producer surplus, PS, is:

$$\mathrm{PS} = (p - c)x = \frac{(p - c)px}{p}$$

where *p* represents price and *x* represents output quantity.

The profit-maximizing monopolist will price its output where the profit margin $\frac{(p* - c)}{p*} = \frac{1}{\varepsilon}$, for ε being the price elasticity of demand.[13] Thus Equation (1) simplifies to:

$$\mathrm{CS} = \frac{1}{2}(a - p)x$$

For profit maximization, set marginal revenue (MR) equal to marginal cost (c):

$$\mathrm{MR} = a - 2bx = c$$

Solving Equation (4) for profit maximizing price and output quantity yields $x^* = \frac{a-c}{2b}$ and $p^* = \frac{a+c}{2}$. Substituting these results into Equation (3) yields $\mathrm{CS} = \frac{1}{2}\pi$. Given Equation (2), it follows that:

$$\mathrm{CS} = \frac{1}{2\varepsilon}p^*x^*$$

To illustrate Equation (5), if the price elasticity of demand is 2, then CS is 25% of sales.16,17

For the case of a business that licenses its technology to others or is sold outright, producer surplus equals licensing sales or the selling price of the business [see Equation (1) for c = 0] and consumer surplus equals zero because no product is being marketed.

5. Calculated value of the elasticity of demand when benefit-to-cost ratio equals unity

The calculation of economic benefits in terms of producer and consumer surplus requires a complete sales and licensing history of each business beginning at the time that it received the Phase II award. That information is not known; all that is known from the NRC database is the sales and licensing history of each business from the time that it received its research award to 2005 (the year of the NRC survey).

Using sales and licensing revenue as of 2005 to approximate producer and consumer surplus clearly understates the economic value of benefits. Some businesses will have generated $0 in sales and licensing revenues from the funded project by 2005, but might begin to generate sales and licensing revenues in the future. Similarly, those businesses that have generated such revenue might continue to do so beyond 2005. And, no information is available on the producer or consumer surplus generated by those companies that purchase a funded-business's technology or that license it.18

The social costs associated with producer and consumer surplus from the funded Phase II research projects have at least three components, two of which represent public support to those businesses that received Phase II awards and the third represents the business's own resources devoted to the Phase II project. The first component is the amount of the Phase II award. The second component is the amount of the Phase I award that each business that received Phase II funding was previously awarded. The third component is the amount of own R&D that the business devoted, as complementary resources, to the funded Phase II project.

The amount of the Phase II award is reported in the NRC database; each award amount was referenced to 2005 using the GDP Implicit Price Deflator (2005 = 100).19 The NRC database does not contain information about the amount of the Phase I award that each business received; however, each business did receive a Phase I award.20 The maximum amount for a Phase I award, over the time period covered by the NRC data, is $100,000.21 Finally, no information is available on the amount of own R&D that the business allocated to the Phase II research project or to marketing, successfully or unsuccessfully, the resulting technology. However, the five-agency case studies conducted by the NRC to complement the construction of its database (National Research Council 2008), as well as earlier case studies associated with DoD's SBIR program, suggest that this amount is minimal, and more likely zero (Link 2000; Link and Scott 2000; Scott 2000).

We iterate over alternative values of the elasticity of demand to determine that value for which the benefit-to-cost ratio equals unity. Benefits are measured in terms of producer and consumer surplus as defined by Equations (2) and (5), respectively.22 Recall, too, that producer surplus equals licensing sales or the selling price of the business for such businesses, and consumer surplus equals zero for such businesses because no product is being marketed. Costs are measured as the sum of the Phase I and Phase II award to each project regardless if the project has any measurable producer or consumer surplus. Phase I awards are valued at $100,000 for each project, and Phase II awards are valued as the amount of the award ($2005).

To illustrate, as shown in Table 4, 383 of 891 DoD-funded projects reported sales and licensing information on the NRC survey. It is assumed that the other 508 projects had zero sales or licensing revenues, but all 891 projects were considered in the calculation below. In other words, as shown in Table 5, for an elasticity of demand value of 3.151, the benefit-to-cost ratio averaged over 891 projects equals unity. That calculation is based on 891 projects, 508 of which have a benefit-to-cost ratio of zero and 383 of which have a benefit-to-cost ratio equal to ((PS + CS)/($100,000 + $Phase II award)).

Table 5.

Calculated values of the elasticity of demand when the benefit-to-cost ratios for Phase II SBIR awards equals unity by agency

Agency	n	Calculated elasticity
DoD	891	3.151
NIH	495	>50
NASA	177	1.290
NSF	161	>50
DOE	154	1.518

Regarding the values reported in Table 5,23 if the actual elasticity of demand for the new technology-based products sold and licensed by DoD-funded businesses is less elastic than 3.151, then the calculated benefit-to-cost ratio will be greater than unity. Unfortunately, we have no independent estimates of the elasticity of demand for new technology-based products sold by a monopolist. Certainly, the businesses selling or licensing such products will enjoy monopoly power for some period of time, and then it will dwindle as others slowly enter the market.24 But, the time frame for the data analyzed in this study is relatively short (1992–2001), thus it might not be unreasonable to conclude that the actual elasticity of demand for DoD-funded projects' products is closer to 1.00 than to 3.151.

For NASA and DOE, a similar story holds. If the actual elasticity of demand for the new technology-based products sold and licensed by the respective funded businesses is less elastic than 1.290 and 1.518, respectively, then the calculated benefit-to-cost ratios will exceed unity.

NIH and NSF are interesting cases. As shown in Table 4, licensing revenues from NIH-funded projects are, on average, equal to sales revenues; and, licensing revenues from NSF-funded projects are, on average, ~3.5 times as great as sales revenue. Thus, the calculation of producer and consumer surplus for these projects are less sensitive—far less sensitive in the case of NSF project— to alternative values of the elasticity of demand. It is not unreasonable to conclude, based on elasticity of demand values that exceed 50, that the benefit-to-cost ratio for both NIH- and NSF-funded projects exceeds unity.

6. Concluding statement

The National Research Council (2008) points out:

> Comparisons between SBIR programs … must be regarded with considerable caution. … [D]iffering agency missions have shaped the agency SBIR programs, focusing them on different objectives and on different mechanisms and approaches. Agencies whose mission is to develop technologies for internal agency use via procurement—notably the Department of Defense (DoD) and the National Aeronautics and Space Administration (NASA)—have a quite different orientation from agencies that do not procure technology and are instead focused on developing technologies for use outside the agency.

Thus, caution should be exercised if making a judgment about the net economic value of one agency's SBIR program with another.

Although one cannot say with certainty that on average the net economic value of the SBIR program is positive, the evidence presented here is suggestive of that fact.

To generalize about the method adopted in this study of the SBIR program in the five largest participating agencies, it is directly applicable to an evaluation of other publicly funded programs. While in the case of SBIR an evaluation was mandated by the Congress, there is a broader mandate in place. The 103rd Congress stated in the Government Performance and Results Act (GPRA) of 1993 (Public Law 103-62) that federal agencies should be accountable for program results. More recently, it was stated in a memorandum from the then Director of the

Office of Management and Budget (OMB) Peter Orszag that ‘rigorous independent program evaluation can be a key resource in determining whether government program are achieving their intended outcomes’. Some agencies, such as DOE and the National Institute of Standards and Technology (NIST) have taken bold steps in that direction. Perhaps the readily implemented method in this article will become a methodological foundation for other agencies to do the same.25

Footnotes

1. See National Research Council (2008) for an overview of these studies, and see the accompanying agency reports for additional details.

2. See Bearse and Link (2010) for an initial analysis of the economic implications associated with increasing the amount of each award.

3. See the testimonies of Audretsch (2011), Link (2011), Siegel (2011), and Wessner (2011).

4. We thank Dr Charles Wessner of the NRC for making these data available to us for this study.

5. For a discussion and a model of the economic role of the SBIR program, see Link and Link (2009) and Link and Scott (2009, 2010, 2012a).

6. For an analysis of the probability that a SBIR project’s technology is commercialized, see Link and Ruhm (2009) and Link and Scott (2009, 2010).

7. A more detailed description of SBIR program goals is in National Research Council (2008) and Link and Scott (2012a).

8. Others, for example, Link and Ruhm (2009) and Link and Scott (2009, 2010, 2012a), have estimated sophisticated econometric models to test for selection bias and they have accepted the null hypothesis of no bias. This conclusion was also reached independently using descriptive analysis by the NRC (National Research Council 2008).

9. The NRC database contains project information. In only a few instances in the data considered did a given business receive two SBIR project awards and those projects were in distinctively different technology areas. Thus, below we refer to the project data describing business behavior because our model of economic surpluses relates to business behavior.

10. Typical descriptive statistics are shown in Table 4. For additional descriptive statistics, see National Research Council (2008) and Link and Scott (2012a).

11. The Griliches/Mansfield approach follows from Schultz’s (1953) agriculture illustration. For a review of applications of the use of producer and consumer surplus to evaluation see, for

example, Bengston (1985), Georghiou and Roessner (2000), Feller and Nelson (1999), Banzhaf (2009), and David et al. (2009). See Link and Scott (2005) for an application of estimating the producer and consumer surplus from survey data. See also the papers in Link and Scott (2011b).

12. See Link and Scott (2011a) for a critique of the Griliches/Mansfield approach.

13. See Tirole (1988).

14. A unitary price elasticity of demand is not reasonable in this case; it assumes that marginal cost equals 0.

15. These results hold without any assumption about the shape of the demand curve. Unfortunately, we do not have exact measures from the NRC database or from the case studies conducted by the NRC on the price elasticity of demand. And, there are no comparable studies from which an approximation can be gleaned.

16. If demand is convex, consumer surplus will be >25% of sales; if demand is concave, consumer surplus will <25% of sales.

17. We do not consider the case that this measure of consumer surplus is not a measure of new consumer surplus because it is a cannibalization of previous existing surplus (Scherer 1979). Our reasoning is that the funded projects are often the small, entrepreneurial company's first effort in researching the subsequently commercialized technology.

18. In addition, the technologies emanating from the funded projects might be complementary to other products produced by the business or by those companies that purchase/license the technology. To the extent that this is the case, the SBIR-funded research will have leveraged gains in producer and consumer surplus from existing products about which we have no information.

19. It may be reasonable to expect that respondents to the NRC survey reported cumulative sales in nominal rather than in $2005. If so, this referencing of costs to 2005 understates the true benefit-to-cost ratios calculated below.

20. Of those businesses that successfully complete a Phase I project, a percentage, which varied by year and by agency, is invited to apply for a Phase II award.

21. It is not uncommon in the policy evaluation literature to treat such pre-award costs as sunk costs. See, for example, Gallaher et al. (2012) and Link and Scott (2011a, 2012b).

22. To the extent that a respondent had projects with positive sales but did not choose to report it on the NRC survey, our final ratios are biased downward.

23. As noted above, Link and Scott (2009, 2010, 2012a) have shown that, in general, selection bias is not present when analyzing the probability that a funded project commercializes its

technology. Because commercialization is related to sales and licensing revenues, we view these calculations as being unbiased.

24. Anecdotally, Reynolds International Pen Corporation sold its first ballpoint pens in 1945 for between $12.00 and $20.00; its per-pen production cost was 80 cents. By 1948, its market share fell to close to zero as competitors entered the market (Whiteside 1951).

25. See Ruegg and Jordan (2011) and Link and Scott (2012b).

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