

**National Economic Impacts from the Air Force and Navy
SBIR/STTR Programs, 2000-2013**

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ABSTRACT

This study compares results from recent economic-impact studies of federal agency Small Business Innovation Research (SBIR) and Small Business Technology Transfer (STTR) programs. These studies were undertaken for the Air Force in 2014-2015 and for the Navy in 2015-2016. Both studies focused on Phase II contracts completed during the 2000-2013 period, and both were undertaken by the same university-based team using virtually the same methodology. These were the first-ever comprehensive economic-impact studies of federal agency SBIR/STTR programs. Each was intended to determine the subject program's contribution to the national economy. Collectively, they answer the question: What resulted from the Air Force and Navy's SBIR/STTR investment of \$6.25 billion in small business research and development (R&D) during the 2000-2013 period? The research team attempted to contact all of the companies with Phase II awards, a total of 4,524 awards for the Air Force and 2,734 for the Navy, to learn about sales of new products and services based on technology emerging from the SBIR/STTR research, as well as other important economic results. Conclusive information was obtained on the outcomes of around 95 percent of these awards. Companies reported that 58 percent of the Air Force awards and 64 percent of the Navy awards resulted in commercialization, with sales totaling \$14.7 billion for the Air Force and \$14.2 billion for the Navy. These sales figures were processed using the national IMPLAN model to estimate the overall impacts on the U.S. economy. The result for the Air Force program was an estimated \$47.9 billion in total economic output, along with creation of an annual average of 16,751 jobs. The comparable numbers for the Navy were \$44 billion in total economic output and 14,973 average jobs per year.

INTRODUCTION

Federal SBIR and related STTR programs are the principal source of funding for small technology firms in the United States.¹ Through these competitive R&D programs, the U.S. government currently awards approximately \$2.5 billion per year to the nation's small businesses to stimulate innovation and generate new technologies of strategic national significance.

SBIR programs originated with legislation in 1982. They were created expressly to harness the innovativeness of U.S. small business—both to help the federal government address high-priority technology needs as well as to stimulate the national economy. This was part of a larger effort in the United States during the early 1980s to counter a perceived loss of national economic competitiveness.

The enabling legislation for these programs, the Small Business Innovation Development Act of 1982,² was based on the conviction that technological innovation creates jobs, increases competitiveness, and fosters economic growth. It also was predicated on the belief that small businesses are the principal source of innovation in the United States.

The 1982 Small Business Innovation Development Act was designed to achieve three major economic objectives:

- Spur technological innovation in the United States;
- Help meet federal government R&D needs;
- Increase private sector commercialization of innovations resulting from federally funded investments.³

By May 2017, approximately \$44 billion had been expended by the federal government on its SBIR and STTR programs in the 35 years since passage of the enabling legislation (GAO 2017). This enormous investment of taxpayer dollars raises an obvious question: How successful have these programs been in meeting their underlying economic objectives?

A significant body of research has been conducted to evaluate the relative success of the SBIR/STTR programs. Most of this research falls into two major categories: (1)

¹ SBIR and STTR programs are similar; however, STTR programs require small businesses to collaborate with not-for-profit research institutions, such as universities, and STTR programs receive significantly less funding than SBIR programs. See www.sbir.gov.

² Text available at the following URL: <http://history.nih.gov/research/downloads/PL97-219.pdf>.

³ A fourth objective was added as the bill was being finalized: To encourage participation by minority and disadvantaged persons. That objective is not addressed in this analysis.

survey research commissioned by the federal government, and (2) research by university-based social scientists, many of whom have productively mined the large body of data gathered by the federal government surveys.

An impressive number of federally commissioned surveys have been conducted to determine whether the SBIR programs are meeting their economic objectives. These studies have particularly focused on how well the programs have resulted in commercialization of SBIR-funded innovations. They include the seminal study by the General Accounting Office (GAO)⁴ in 1992 (GAO 1992), an unpublished study by the DoD in 1997 (GAO 1998), and an ongoing series of reports issued by the National Academies of Sciences, Engineering and Medicine (NAS) and its operating arm, the National Research Council (NRC), beginning in 2008 (National Academies 2016a, 2016b, 2015a, 2015b; National Research Council 2014, 2009a, 2009b, 2009c, 2008a, 2008b, 2008c).

When Congress reauthorized SBIR in 1986, it directed the GAO to conduct studies to determine the effectiveness of this federal R&D initiative. In 1990, the GAO conducted a survey of 1,337 companies focusing on results from their 2,090 Phase II awards. The survey pool consisted of all Phase II awards made by the federal government up through 1987. The GAO explicitly asked companies about sales of new products and services as well as additional developmental funding received related to these Phase II awards. It received responses for 1,457 of these awards, with the results published in 1992 (GAO 1992). Companies reported that they had generated sales or additional developmental funding for nearly half of the projects—700, or 48 percent of the total. The GAO report included an in-depth breakdown of the commercialization results for these successful awards.

In 1996, the DoD commissioned a study of its own SBIR program. This study surveyed all 2,828 DoD Phase II awards from 1984 through 1992, receiving 1,364 responses (GAO 1998). Responding companies reported that 653 projects had resulted in sales or additional R&D funding—48 percent of the total, the same percentage as the earlier GAO study. Like the GAO study, the DoD study included an in-depth analysis of the successful awards—for example, breaking commercialization results down by the total number of SBIR awards that companies had received and by their sales to the public sector versus the private sector.

When Congress reauthorized SBIR funding in 2000, it asked the NRC to assess the effectiveness of what was at that point a nearly twenty-year-old initiative. In response, the NRC examined the SBIR programs of the five major funding agencies: DoD, NIH, NASA, the Department of Energy, and the National Science Foundation. Together, these agencies account for approximately 96 percent of all SBIR/STTR funding.

⁴ The GAO changed its name to Government Accountability Office in 2004.

The NRC studies built on the foundations of the prior GAO and DoD studies and were designed to assess the degree to which federal SBIR/STTR R&D funding had resulted in commercialization, the value of this R&D to the agencies' missions, and its overall economic and other benefits. The first round of NRC studies, which appeared in the latter-2000s (National Research Council 2009a, 2009b, 2009c, 2008a, 2008b, 2008c), was followed by a second round resulting from Congress's reauthorization of SBIR in 2011 (National Research Council 2014; National Academies 2016a, 2016b, 2015a, 2015b).

Like their GAO and DoD predecessors, the NRC/NAS studies focused on SBIR/STTR Phase II awards. However, they were more detailed and granular, and looked at specific agency outcomes. Like the GAO and DoD studies, the NRC/NAS studies generated a voluminous and convincing body of evidence that the SBIR/STTR programs are indeed meeting their objectives and achieving a relatively high level of commercialization of new technology.

University-based social scientists also have extensively examined the commercialization success of the SBIR programs, usually employing statistical or econometric analyses. Some have attempted to measure SBIR program success using surrogate indicators or proxies. These include a study of SBIR program success using patenting as a proxy (Giga *et al.* 2016); one that employed Kauffman Foundation survey data to examine several key indicators of success, including patent output, growth in the number of employees, and success in attracting venture capital (Galope 2016); and analyses of SBIR program success using as proxies either new firm formation (Qian and Haynes 2014) or growth in the number of employees (Link and Scott 2012).

Other researchers have examined the importance of various determining or contributing factors to SBIR company success, such as the business background and gender of the company founder (Andersen, Bray, and Link 2017); the commercial complexity of the technology being developed (Scott and Link 2017); the maturity of the firm, whether nascent or established (Gicheva and Link 2016); prior R&D experience with the technology being funded, the firm size, the size of the award, the principal investigator's gender, and a university connection (Link and Wright 2015); private equity investment in the firm (Link, Ruhm, and Siegel 2014); and university involvement in the SBIR project (Siegel and Wessner 2012). Most of this research has relied on the volumes of publicly available data generated by the NRC/NAS surveys.

This past research has provided many valuable insights into both the specific factors correlated with SBIR company success as well as the relative effectiveness of the federal SBIR programs in meeting their objectives—particularly the objectives of spurring technological innovation and increasing private sector commercialization of new technologies resulting from federal R&D investments.

However, a significant shortcoming of most of the research summarized above is its reliance on relatively small sample sizes. In fact, only the 1992 GAO study had a sample consisting of over 50 percent of the awards (GAO 1992). For most of the studies, the sample size was significantly smaller.

For example, in its first series of studies, the NRC randomly selected 6,410 Phase II awards out of the more than 11,000 issued by the five major agencies from 1992 to 2001 (National Research Council 2009a, 2009b, 2009c, 2008a, 2008b, 2008c). Ultimately, however, information was only obtained on 1,916 of these awards, which is 30 percent of the random sample but less than 17 percent of the total Phase II awards. Random sampling is a well-established way of surveying large populations and can be very effective. However, the effectiveness of this approach is greatly undermined by low response rates.

The second series of NRC/NAS studies used a methodology almost identical to that deployed in the first series in order to ensure continuity for comparative purposes. These later studies also used relatively small sample sizes and achieved low response rates varying from 16-22 percent of the total population of SBIR awards. This is significant because the NRC/NAS studies have been heavily relied on by many analysts, including the social scientists cited above, in analyzing SBIR program success and the factors contributing to company success or failure.

Relatively small sample sizes and low response rates introduce multiple sources of potential bias. For example, are responding companies more likely to be those with positive results? We don't know because there is no information on the outcomes of the vast majority of Phase II projects. If the most successful companies are the most likely to respond, then the survey results will be heavily skewed toward overstatement of the success of SBIR programs or of the factors believed to contribute to company success.

On the other hand, low response rates may miss the most successful companies, biasing the results in the opposite direction. Companies with the largest cumulative SBIR-related sales tend to be those with the greatest elapsed time since the SBIR project's completion. Unfortunately, it is more difficult to get information on the outcomes of these older projects. The involved companies may have been acquired by large corporations that are unwilling to participate in the survey. Or, they may have changed their names or locations, making it difficult to contact them. Finally, company personnel may no longer be knowledgeable about the results from much earlier SBIR projects.

The studies described in this paper largely avoid the above potential biases in two important ways: (1) they surveyed the entire populations of Air Force and Navy SBIR/STTR Phase II awardees during the time period covered, not a partial sample; and (2) both studies had very high effective response rates of around 95 percent. In short, these studies obtained conclusive information on the commercialization

levels and other economic outcomes for most of the Air Force and Navy SBIR/STTR Phase II projects.

In addition, while the GAO, DoD, and NRC studies—and the academic researchers that subsequently drew on these studies—looked at commercialization results, they did not attempt to assess the *overall impacts* of the SBIR programs on the national economy. Neither has any other previous research. The Air Force and Navy studies reported here do assess these impacts. Using the well-established national IMPLAN model, they estimate the overall economic impacts of these agency SBIR programs in two ways: (1) the impacts directly related to the SBIR/STTR Phase II awards themselves, and (2) the impacts related to the subsequent commercialization of the innovations developed with these awards. The impacts assessed include total economic output, employment, labor income, value added, and tax revenues.

These Air Force and Navy studies are the first-ever comprehensive analyses of the economic impacts of entire federal SBIR/STTR programs. The only antecedent in this regard was a limited economic-impact study undertaken by NASA. In 2014, NASA reported on the economic impact of its SBIR Phase I and Phase II awards for a single fiscal year, 2012 (NASA 2014). However, NASA only estimated the economic impacts resulting from the immediate R&D expenditures of its SBIR funds by the recipient small businesses. Consequently, the study greatly understates the economic impact of NASA's SBIR program.

The present paper examines the economic impacts resulting not only from the infusion of Air Force and Navy SBIR/STTR funding into small businesses throughout the United States, but also from the innovations generated with this funding. It provides a comprehensive answer to the guiding question: What resulted from the Air Force and Navy's SBIR/STTR investments of \$6.25 billion in small business R&D during the 2000-2013 period?

THE AIR FORCE AND NAVY SBIR/STTR PROGRAMS IN CONTEXT

Each of the eleven federal agencies with an extramural R&D budget exceeding \$100 million is required to allocate a small portion of its R&D budget—3.2 percent in FY 17—to SBIR. In addition, the five federal agencies with extramural R&D budgets exceeding \$1 billion (the Department of Defense, Department of Energy, Department of Health and Human Services, NASA, and National Science Foundation) are required to expend 0.45 percent (FY 17) of their extramural R&D budgets on STTR.

Each agency determines its own R&D topics, issues solicitations, accepts proposals from small businesses (defined as for-profit entities with not more than 500 employees), establishes evaluation processes for these proposals, and makes

awards on a competitive basis. The Small Business Administration (SBA) functions as the overall coordinating agency for both SBIR and STTR.

There are three phases to SBIR/STTR programs. *Phase I* funds short-term (typically six-month) feasibility studies of proposed innovations. These awards normally do not exceed \$150,000. Assuming that a company establishes the scientific and technical merit as well as the commercial potential of its proposed innovation, it can compete for follow-on Phase II funding. *Phase II* funds the further development, testing, and/or evaluation (such as by creation of a prototype) of the proposed innovation. Phase II awards normally do not exceed \$1 million and are typically for a two-year R&D effort. *Phase III* involves the commercialization of the technologies developed during the previous phases, or their transition to government acquisition programs. No additional SBIR/STTR funding is available for this phase, but some federal agencies provide supplemental, non-SBIR/STTR funding for further development of promising innovations, when they meet critical U.S. government technology needs.

Approximately \$2.4 billion is awarded annually through the federal SBIR/STTR programs. DoD is the largest participant, awarding approximately \$1.2 billion annually. Within DoD, the Air Force and Navy have the largest individual programs. Their SBIR/STTR programs account for approximately 57 percent of the DoD total and 28 percent of the entire federal SBIR budget.⁵

As a result of their commanding size and funding of innovations in virtually all technology fields (including advanced materials, communications, electronics, energy and power, medical technologies, and software), the Air Force and Navy SBIR/STTR programs offer a good case study of the economic outcomes and impacts of the entire federal SBIR/STTR enterprise.

METHODOLOGY

The Air Force and Navy SBIR/STTR economic-impact studies were undertaken sequentially during the 2014-2016 period. Each study included three major phases: data gathering, data analysis, and final report generation. During the *data gathering* phase, the research team attempted to contact all companies that had completed Air Force or Navy SBIR/STTR Phase II contracts within the 2000-2013 fiscal year (FY) time period. Companies were asked to divulge the total sales of new products and services and other economic results directly related to these SBIR/STTR contracts. During the subsequent *data analysis* phase, the research team analyzed the information gathered and used IMPLAN economic-impact assessment software to estimate the total economic impacts resulting from (1) the initial Phase II funding for R&D, and (2) subsequent sales of new products and services derived from the

⁵ <https://www.sbir.gov/analytics-dashboard>

innovations generated by the R&D. The *final report generation* phase extended over several months for each study and involved reducing a large body of data to an easy-to-follow presentation of results. The first two phases are described in more detail below.

Data Gathering

To undertake these studies, TechLink first assembled essential information on all Air Force and Navy SBIR/STTR Phase II contracts that were completed during the FY 2000-2013 period. Information on the Phase II contracts came from the Air Force and Navy SBIR/STTR awards databases.⁶ A total of 4,524 Phase II contracts were included in the Air Force study and 2,734 contracts in the Navy study.

The essential information on each Phase II contract was entered into a custom database that was developed for these studies, to facilitate data gathering and analysis. Essential Phase II contract information included the company name and location, the contract number and award amount, the start and completion dates of the award, names and contact information for the principal investigator and company executive at the time of the award, and award titles and abstracts, which provided background information on the technology being developed.

A team of TechLink economic research specialists used the Phase II information and databases to attempt to contact each of the companies involved. They attempted to interview, by email and telephone, all relevant SBIR/STTR award recipient companies—1,750 in the Air Force study, and 1,199 in the Navy study—concerning the outcomes of their Phase II contracts. The number of contracts in each study exceeds the number of companies because a sizeable subset of companies had two or more SBIR/STTR Phase II contracts.

Survey Questions. Companies were asked a series of questions that focused on the economic outcomes and impacts related to their SBIR/STTR Phase II contracts. They were assured that their responses would be treated as confidential information and that, in order to conceal their identities, their responses would be aggregated with those of other companies and submitted to the DoD program managers without any company names. Basic questions included the following:

- 1) Did your company develop any new products or services based on your SBIR/STTR Phase II contract(s)? If so, what were the total cumulative sales of these new products or services for each contract?⁷
- 2) Of the total sales for each Phase II contract, what was the dollar value of sales to the U.S. military, either directly or through a prime contractor?

⁶ The Air Force data was downloaded directly from www.afsbirsttr.af.mil. The Navy provided the data for the Navy study.

⁷ Companies were not asked to report their sales by year because this would have greatly increased the burden of responding to the survey and, consequently, lowered the response rate.

- 3) Did the Phase II contract(s) lead to any follow-on R&D contracts for further development of the technology or technologies resulting from Phase II? If so, what was the total dollar value of these contracts?
- 4) Did you license any of the technologies developed with Phase II funding to another company? If so, what were the total royalties received from each licensee? What is the name of the licensee, so we can follow up to ask it about its sales?
- 5) Did you create a spin-out company to commercialize any of the technologies developed with SBIR/STTR Phase II funding? If so, what is the name of the company, so we can ask it about its sales?
- 6) Did you receive any significant subsequent investment funding, such as venture capital or angel funding, directly related to the technology developed or commercialized? If so, what was the total amount of these investments?
- 7) Was your company acquired as a direct result of the technology or technologies developed with SBIR/STTR Phase II funding? If so, what was the acquisition amount?

Response Rate. The effective response rate for both the Air Force and Navy studies was around 95 percent. For the Air Force study, the research team was able to obtain definitive information on the outcomes of 4,346 contracts out of the total of 4,524 contracts. Only 64 of the Air Force Phase II recipient companies, with a combined total of 120 contracts, openly refused to participate or were non-responsive, despite multiple efforts to secure the necessary information. An additional 32 companies, with a combined total of 58 contracts, could not be contacted because they had ceased to operate as corporate entities. These companies had gone out of business, changed their names, or been acquired by other companies and had left no trails that could be followed.

For the Navy study, companies surveyed provided definitive information on the outcomes of 2,379 contracts out of the total of 2,734 contracts. Supplementing this, the research team was able to obtain authoritative secondary information on the outcomes of 219 additional contracts from other official sources.⁸ Table 1 summarizes the survey results for each agency and provides the totals for both programs.

⁸ These other official sources included Company Commercialization Reports (CCRs) and the Federal Procurement Data System (FPDS, www.fpds.gov). Companies are required to submit a CCR with every SBIR or STTR proposal submitted to the DoD. CCRs are intended to provide a record of prior Phase II projects and the sales and investment resulting from innovations developed under these projects. The FPDS is a database of government contracts. It is managed by the Federal Procurement Data Center, part of the U.S. General Services Administration, and contains detailed information on all government contracts exceeding \$3,000.

Table 1. Survey Response Data

Survey Parameters and Responses	Air Force	Navy	Both Programs
Total Companies	1,750	1,199	2,949
Company Declined	64	100	164
Out of Business	32	68	100
Company Response Rate	95%	86%	91%
Total Awards	4,524	2,734	7,258
Data Acquired	4,346	2,598	6,944
No Data	178	136	314
Effective Response Rate on Awards	96%	95%	96%

Together, the two surveys received data from 91 percent of the nearly 3,000 participating companies. Of those non-responsive, 164 declined to participate and 100 were unreachable. Data were gathered for 6,944 of the 7,258 total awards, for an effective response rate of 96 percent, leaving only 4 percent of the total outcomes unknown.

The high response rate on both studies is attributable to several factors, including official letters from the Air Force and Navy SBIR program managers explaining the purpose and importance of these studies; strong assurances that company-specific information would be kept confidential, with only aggregated data being provided to the Air Force and Navy; extensive research to find current contact information for recipient companies or to track down individuals knowledgeable about the economic results from specific SBIR/STTR projects; dogged persistence by the research team in seeking information from companies; and the conciseness of the survey.

NAICS Code Assignments. Once the company surveys were complete, the research team next assigned to each of the Air Force and Navy Phase II contracts the appropriate 6-digit North American Industry Classification System (NAICS) codes. These codes were specific to the R&D or commercial activity. This task was essential to enable analysis of the overall economic impacts. NAICS is the U.S. government’s standard industry classification system. It is a comprehensive production-oriented system that groups companies and divisions of companies into industries based on the activities in which they are primarily engaged. NAICS recognizes 1,065 different industries in the United States and assigns a unique code to each industry.

NAICS codes are one of the most important inputs to the economic-impact model, IMPLAN (described below), because they are used to accurately determine the economic multipliers specific to the particular industrial activity. For analysis of the economic impacts resulting from the actual SBIR/STTR Phase II R&D activities, all companies in the Air Force study were assigned to NAICS code 541712: Research

and Development in the Physical, Engineering, and Life Sciences (except Biotechnology).⁹ In the Navy study, greater precision was employed, and contracts were assigned one of the following three primary R&D NAICS codes, 541712: Research and Development in the Physical, Engineering, and Life Sciences (except Biotechnology); 541720: Research and Development in the Social Sciences and Humanities; or 541711: Research and Development in Biotechnology.

Companies that had commercialized the results of their SBIR/STTR R&D activities were assigned additional NAICS codes for analysis of sales of the specific products or services. Companies with multiple SBIR/STTR contracts frequently were assigned multiple NAICS codes.

The research team entered company sales, other economic data, and NAICS code information into the custom database developed for these studies. The database greatly facilitated data entry from the multiple researchers gathering company information. In addition, it provided a mechanism for quickly querying and analyzing the data as well as for generating the final datasets for economic-impact modeling.

TechLink subsequently submitted the final datasets to the Business Research Division (BRD) at the Leeds School of Business, University of Colorado Boulder, which specializes in conducting economic-impact studies. The datasets included—for each Air Force or Navy SBIR/STTR contract that had achieved sales—a code number to identify this contract (but conceal the company's name), the 6-digit NAICS code for the corresponding product or service, and the total sales figures.

The sales category included all sales of new products and services directly related to the technologies developed with the SBIR/STTR funding, including military sales; follow-on R&D contracts to further develop these technologies for specific applications (defined as sales of R&D services); royalties from licensees of the technologies developed with the SBIR/STTR funding; licensee sales of the licensed SBIR/STTR-developed technologies, when this information could be obtained; and sales by spin-out companies of the SBIR/STTR-developed technologies, when this information was available.

Data Analysis

The BRD employed IMPLAN, a widely used economic-impact analysis software program, to estimate the economic multiplier effects of the R&D activity and subsequent sales resulting from the SBIR/STTR Phase II contracts. Basically, IMPLAN models how an initial economic activity creates secondary effects that ripple through a region's economy—the national economy in the case of the Air Force and Navy studies. These secondary effects include the *indirect effects*

⁹ This was the approach used by NASA (NASA 2014).

resulting from inter-industry purchases to support the R&D activities and the subsequent sales, and the *induced effects* resulting from household spending by the associated labor force.

More than 1,500 entities in academia, the private sector, and government use IMPLAN to model economic impacts. It is employed to determine economic impacts on regions ranging in size from zip-code area to county, state, and national levels (www.implan.com).

The multipliers used by IMPLAN are specific to industry sectors and regions. IMPLAN uses NAICS codes to distinguish between 536 industry sectors recognized by the U.S. Department of Commerce. Each sector has a unique multiplier because of the unique aspects of its supply chain, labor force, wage structure, and other factors. IMPLAN is regularly updated using data collected by various federal government agencies.

In these studies, the BRD converted the NAICS codes provided by TechLink to the 536-sector IMPLAN input-output model, then applied this model to (1) the SBIR/STTR Phase II R&D expenditures, and (2) the total sales of products and services attributable to the innovations developed through SBIR/STTR. Using IMPLAN, the BRD was able to estimate the sum of the direct and secondary effects or impacts of both the R&D activities and the sales. The overall purpose of this modeling exercise was to estimate the total economic contribution of the R&D activities and sales to the U.S. economy, including total economic output, value added, employment, labor income, and tax revenues.

While IMPLAN provides for analysis of events occurring across multiple years, the companies reported their sales as an aggregated lump sum, with no indication of when these sales occurred. However, IMPLAN requires that the sales be assigned to a specific year. In both the Air Force and Navy studies, all of the sales figures were assumed to be in 2013 dollars, even though the majority of sales occurred prior to 2013, with some dating back to the early 2000s. Use of 2013 as the reference year represents a conservative approach because it does not consider the relatively higher value of the earlier sales figures due to inflation: a dollar in 2013 was worth 25 percent less than a dollar in 2000.¹⁰

¹⁰ Per the U.S. Bureau of Labor Statistics Consumer Price Index (CPI) Inflation Calculator, available online at http://www.bls.gov/data/inflation_calculator.htm.

SURVEY RESULTS

Sales from SBIR/STTR Phase II contracts

Well over half of the Air Force and Navy SBIR/STTR Phase II contracts resulted in sales of products or services. A total of 58 percent of the Air Force contracts resulted in sales, while 64 percent of the Navy contracts did so. Ultimately, these commercialization levels will become higher as additional companies bring their SBIR/STTR-funded innovations to market.

Table 2. Sales and Commercialization Rates

Awards and Sales	Air Force	Navy	Both Programs
Total Awards	4,524	2,734	7,258
Awards with Sales	2,631	1,753	4,384
Rate of Commercialization	58%	64%	60%
Cumulative Sales (billions)	\$ 14.7	\$ 14.2	\$ 28.9
Average Sales per Commercialized Award	\$ 5,584,103	\$ 8,085,568	\$ 6,584,347
Average Sales Per Award	\$ 3,247,519	\$ 5,184,345	\$ 3,977,098

Total cumulative sales from the Air Force contracts were nearly \$14.7 billion, while those from the Navy were nearly \$14.2 billion. This equates to average sales among commercialized awards of approximately \$5.6 million in the Air Force program and \$8.1 million in the Navy program. These sales figures are more than 6 times the average contract amount of \$882,084 for the Air Force and 10 times the average contract amount of \$827,177 for the Navy. The average sales per contract, when considering all of the Phase II awards, including those without commercialization success, was slightly over \$3.2 million for the Air Force and nearly \$5.2 million for the Navy. Together, the awards from both programs produced average sales per award of \$4 million. These figures demonstrate that both the Air Force and Navy SBIR/STTR programs have achieved substantial commercialization success.

While the returns calculated for the Navy program are significantly higher than those for the Air Force, the two should be considered independently. This is due to differences in the way these agencies reported their awards information. The Air Force survey included information from all companies receiving Phase II awards. The Navy, however, omitted a portion of Phase II awards considered incomplete, or only partially funded.

Table 3 shows the total sales from the Air Force and Navy SBIR/STTR Phase II contracts, broken down by sales category. As this table shows, *commercial (civilian) product and service sales* were slightly over \$6.3 billion for the Air Force (43 percent of the total sales) and nearly \$3 billion for the Navy (21 percent of the total).

Military product and service sales were nearly \$4.4 billion for the Air Force (30 percent of the total sales) and nearly \$7 billion for the Navy (49 percent of the total). These relatively high levels of military sales indicate that both programs are achieving their objective of developing new technology to support the U.S. defense mission.

Table 3. Sales from SBIR/STTR Awards by Category (millions)

Sales Type	Air Force	Navy	Both Programs
Total Sales	\$ 14,692	\$ 14,174	\$ 28,866
Commercial Sales	\$ 6,329	\$ 2,992	\$ 9,321
Military Sales	\$ 4,386	\$ 6,960	\$ 11,346
Follow-on R&D	\$ 3,545	\$ 3,489	\$ 7,034
Royalties	\$ 60	\$ 136	\$ 196
Sales by Licensees	\$ 268	\$ 382	\$ 650
Sales by Spinouts	\$ 104	\$ 215	\$ 319

Follow-on R&D contracts, to further develop the technologies generated with SBIR/STTR funding, totaled slightly over \$3.5 billion for the Air Force (24 percent of the total sales) and nearly \$3.5 billion for the Navy (25 percent of the total). This R&D funding came from both the government and private sectors. *Royalties* resulting from licensee sales of the technologies developed with Phase II funding were around \$60 million for the Air Force and \$136 million for the Navy. *Sales by licensees* were reported to be \$268 million for the Air Force program, and \$382 million for the Navy. *Sales by spin-out companies* were reported to be \$104 million for the Air Force and \$215 million for the Navy. Together, the last three categories accounted for only 3 percent of the total Air Force SBIR/STTR project sales and 5 percent of the Navy sales.

The most productive Air Force Phase II contract generated nearly \$1.5 billion in commercial product sales. A total of 23 Air Force Phase II contracts had sales exceeding \$100 million; 220 had sales exceeding \$10 million; and 1,151 had sales of more than \$1 million. The most successful Navy award generated \$1.2 billion in product sales. Twenty-three Navy awardees reported sales of at least \$100 million; 244 had sales exceeding \$10 million; and 919 had sales of at least \$1 million.

Sales Figures Understate the Reality. For several reasons, total sales figures obtained by these two surveys are probably significantly smaller than the actual results:

- *Non-responding companies.* Sales information was not available from a significant number of companies. As previously noted, 264 companies with a total of 314 SBIR/STTR Phase II contracts did not participate in the study—164 because they declined to participate and another 100 that were

uncontactable because they had ceased to operate. Many of the companies that declined are believed to have substantial sales. For example, a sizeable number are large corporations that acquired Phase II recipient companies because of the commercial strength of the technologies developed with Air Force or Navy SBIR/STTR funding.

- *Licensee sales information generally unavailable.* The total sales figures also underreport the reality because they do not include most of the licensee sales. Companies reported that they had licensed a total of 310 technologies—180 in the Air Force study and 130 in the Navy study. However, the TechLink team was able to obtain sales information for only 27 percent of these licensed technologies in the Air Force study and 29 percent in the Navy study. Many companies declined to identify their licensees or to divulge what they knew of licensee sales. In addition, most licensees did not feel obligated to participate in these studies and were not responsive to requests for information on their sales.
- *Sales information for spin-out companies generally unavailable.* Similarly, the total sales figures do not include most of the sales by companies spun out of the Phase II recipient companies. These spinouts were created specifically to commercialize the technologies developed with SBIR/STTR funding, so they were very likely making sales. The TechLink team was able to obtain sales information for only 22 percent of these companies in the Air Force study and 33 percent in the Navy study. As in the case of licensees, most of the spin-out companies did not feel obligated to participate in this study and were not responsive to requests for information on their sales.
- *Licensee underreporting of sales and underpayment of royalties.* Another reason why sales are believed to be substantially larger than were reported is that underreporting is common in the licensing world. Historic royalty audit data from a well-established accounting and intellectual property management company reveals that over 80 percent of licensees underreport and underpay royalties to their licensors (Steward and Byrd 2007).
- *Inflation.* Finally, inflation contributes to an under-valuation of earlier sales in these studies. All sales data are expressed in 2013 dollars, as previously mentioned. There were no adjustments for inflation. Companies reported aggregate sales figures, and the timing of sales by year is not known. Aggregation of company sales values does not preserve the relatively higher value of sales that occurred *earlier* in the 2000-2013 study period. As mentioned, a dollar in 2013 was worth 25 percent less than a dollar in 2000, and 16 percent less than a dollar in 2005.¹¹

For all of the above reasons, the total sales figures reported in this survey are conservative and substantially understate the actual total sales resulting from Air

¹¹ U.S. Bureau of Labor Statistics Consumer Price Index (CPI) Inflation Calculator, available online at http://www.bls.gov/data/inflation_calculator.htm

Force and Navy SBIR/STTR Phase II contracts completed during the FY 2000-2013 period.

Other Economic Outcomes and Impacts

In addition to sales, the companies in the study reported other significant economic outcomes and impacts. The *total outside investment funding* (including venture capital and angel funding) directly related to the innovations developed with SBIR/STTR Phase II contracts was reported to be approximately \$2.5 billion—\$1.9 billion in the Air Force study and \$646 million in the Navy study. The *number of companies that were acquired* primarily because of these technologies was 316—225 in the Air Force study and 91 in the Navy study. The *total acquisition value* was reported to be around \$8.6 billion—\$6.8 billion in the Air Force study and \$1.8 billion in the Navy study. However, the acquisition figure certainly understates the actual value. A large majority of acquired companies stated that the terms of acquisition prevented them from disclosing the acquisition amount.

Finally, companies reported that they had *licensed 310 technologies to other companies* and *created 174 spin-out companies* specifically to commercialize technologies developed with Phase II funding. These other economic outcomes and impacts are summarized in Table 4 and broken out by Air Force and Navy:

Table 4. Other Economic Outcomes

Economic Outcome	Air Force	Navy	Both Programs
Total Outside Investment Funding (billions)	\$ 1.872	\$ 646	\$ 2.518
Number of Companies Acquired	225	91	316
Total Acquisition Value of Acquired Firms (billions)	\$ 6.768	\$ 1.795	\$ 8.563
Number of Technologies Licensed to Other Firms	180	130	310
Number of Spinout Companies Created	125	49	174

ECONOMIC-IMPACT ANALYSIS

Upon receiving the company sales and 6-digit NAICS code data from TechLink, the BRD at the University of Colorado Boulder used the national IMPLAN input-output model to determine the economic impacts. This was undertaken in two stages: (1) IMPLAN analysis of the economic impacts resulting from the Phase II award funding, and (2) IMPLAN analysis of the sales of the innovations resulting from this R&D. The estimated impacts are explained below in terms of *output, employment, labor income, value added, and tax revenues*. As previously noted, all dollar figures are reported in 2013 dollars.

Output

Output is the total value of all goods or services (including intermediate goods and services) produced during a given time period, whether used for further production or consumed. The concept of national output is an integral part of macroeconomics. Output is one of the values most frequently cited following the completion of economic-impact studies.

Impacts from SBIR/STTR Phase II R&D Activity. As Table 5 shows, the expenditure of \$6.25 billion in Phase II award funding generated an estimated \$16.61 billion in total output—\$10.51 billion in the Air Force study and \$6.10 billion in the Navy study.

Table 5: Economic Impacts of Phase II R&D Activity (billions)

Impact Type	Air Force	Navy	Both Programs
Direct	\$ 3.99	\$ 2.26	\$ 6.25
Indirect	\$ 2.85	\$ 1.65	\$ 4.50
Induced	\$ 3.67	\$ 2.19	\$ 5.86
Total	\$ 10.51	\$ 6.10	\$ 16.61
Multiplier	2.63	2.70	2.66

Of the total impact amount, around \$4.5 billion was generated as the result of the *indirect effect* (firms purchasing from each other), and \$5.86 billion was generated from the *induced effect*, the result of households spending payroll on goods and services economy-wide. The Air Force program stimulated \$2.85 billion in economic impact through the indirect effect and \$3.67 billion from the induced effect. The Navy program’s comparable numbers were \$1.65 billion (indirect effect) and \$2.19 billion (induced effect).

Dividing the total economy-wide output of \$16.61 billion by the value of the Phase II contracts, \$6.25 billion, yields an output multiplier of 2.66. That is, every dollar of Air Force and Navy SBIR/STTR Phase II R&D funding spent stimulated an *additional* \$1.66 in economic activity within the U.S. economy. The individual SBIR/STTR program multipliers were 2.63 and 2.70 for the Air Force and Navy, respectively.

Impacts from Sales of SBIR/STTR Phase II Innovations. In addition to the economic output from Phase II R&D expenditures, this study examined the output from the subsequent sales of the resultant innovations. Table 6 shows the estimated impacts of these sales of products and services on national output.

Table 6. Economic Impact of Company Sales (billions)

Impact Type	Air Force	Navy	Both Programs
Direct	\$ 14.69	\$ 14.17	\$ 28.86
Indirect	\$ 11.60	\$ 11.77	\$ 23.37
Induced	\$ 11.07	\$ 12.23	\$ 23.30
Total	\$ 37.36	\$ 38.17	\$ 75.53
Multiplier	2.54	2.69	2.62

According to the national IMPLAN model, the \$28.86 billion in direct sales of new products and services reported by companies generated an additional \$46.7 billion in sales economy-wide. Of this amount, around \$23.37 billion was due to the *indirect* effect, and \$23.3 billion was due to the *induced* effect. The total economy-wide output from sales of the SBIR/STTR Phase II-developed technology was \$75.53 billion. By individual program, the indirect effects were an estimated \$11.6 billion (Air Force) and \$11.77 billion (Navy). The induced effects were \$11.07 billion (Air Force) and \$12.23 billion (Navy). Of the total estimated impact of \$75.53 billion, \$37.36 was attributed to the Air Force program and \$38.17 billion was attributed to the Navy program.

Dividing total economy-wide output (\$75.53 billion) by the direct sales of products and services related to the SBIR/STTR Phase II contracts, a total of \$28.86 billion, yields an output multiplier of 2.62. For every dollar in sales directly attributable to the SBIR/STTR Phase II contracts, an *additional* \$1.62 in sales was generated economy-wide. The multipliers of the individual programs were 2.54 and 2.69 for the Air Force and Navy, respectively.

Value Added

Value added is the difference between an industry's or company's output and the cost of intermediate inputs. Expressed differently, it is the difference between a product's sale price and its production cost. This measure recognizes that companies buy goods and services from other companies in order to create products of greater value than the sum of the goods and services used to make these products. This increase in value resulting from the production process is the value added. As estimated by IMPLAN, value added is equal to the total sales (plus or minus inventory adjustments) minus the cost of the goods and services purchased to produce the products sold. The main difference between output and value added is that output includes the value of intermediate goods and services, while value added does not. Many economists prefer value added as an economic measure

because, at the macroeconomic scale, measures of output multiple-count the value of inputs.

Value Added Impacts from Phase II R&D Funding. According to the national IMPLAN model, the initial \$6.25 billion in R&D contracts generated \$9.23 billion in value added economy-wide. Of this total, \$3.23 billion came from the direct effect, \$2.78 billion from the indirect effect, and \$3.22 billion from the induced effect. The share of value added attributable to the Air Force SBIR/STTR program was \$5.88 billion; for the Navy program, it was \$3.35 billion. (See Table 7).

Table 7: Value Added Impact of Phase II R&D Activity (billions)

Impact Type	Air Force	Navy	Both Programs
Direct	\$ 2.07	\$ 1.16	\$ 3.23
Indirect	\$ 1.78	\$ 1.00	\$ 2.78
Induced	\$ 2.03	\$ 1.19	\$ 3.22
Total	\$ 5.88	\$ 3.35	\$ 9.23

Value Added Impacts from Sales of SBIR/STTR Phase II Innovations. Subsequent IMPLAN analysis showed that the \$28.86 billion in sales reported by companies generated \$37.71 billion in value added economy-wide: a direct effect of \$13.20 billion, an indirect effect of \$11.74 billion, and an induced effect of \$12.77 billion. As Table 8 shows, the Air Force SBIR/STTR program contributed \$18.85 billion of the value added and the Navy program contributed \$18.86 billion.

Table 8: Value Added Impact of Company Sales (billions)

Impact Type	Air Force	Navy	Both Programs
Direct	\$ 6.79	\$ 6.41	\$ 13.20
Indirect	\$ 5.95	\$ 5.79	\$ 11.74
Induced	\$ 6.11	\$ 6.66	\$ 12.77
Total	\$ 18.85	\$ 18.86	\$ 37.71

Employment

Employment in this analysis refers to the number of jobs created or sustained by an economic activity. It is a measure of the number of workers (either full-time or part-time) expressed in job years (one full-time position for a year).

Employment Impacts from SBIR/STTR Phase II R&D Activity. The national IMPLAN model estimated that 26,355 jobs were directly sustained economy-wide

by these agencies' \$6.25 billion in Phase II R&D activity. Indirect effects were responsible for an additional 27,882 jobs, and induced effects for 37,303 jobs. The IMPLAN model estimates that, altogether, 91,540 jobs nationwide resulted from the direct, indirect, and induced effects of the Air Force SBIR/STTR Phase II R&D activity. The Air Force program supported 17,978 direct jobs, 17,806 indirect jobs, and 23,931 induced jobs. The Navy program supported 8,377 direct jobs, 10,076 indirect jobs, and 13,372 induced jobs. (See Table 9).

Table 9: Employment Impact of Phase II R&D Activity (job-years)

Impact Type	Air Force	Navy	Both Programs
Direct	17,978	8,377	26,355
Indirect	17,806	10,076	27,882
Induced	23,931	13,372	37,303
Total	59,715	31,825	91,540

Employment Impacts from Sales of SBIR/STTR Phase II innovations. According to the national IMPLAN model, the \$28.86 billion in sales directly sustained an estimated 97,070 jobs economy-wide. Indirect effects were responsible for an additional 108,670 jobs, and induced effects for 146,858 jobs. The IMPLAN model estimates that, altogether, 352,598 jobs nationwide resulted from the direct, indirect, and induced effects of the sales of SBIR/STTR Phase II innovations. The Air Force program was responsible for 47,359 direct jobs, 55,312 indirect jobs, and 72,124 induced jobs. The Navy program was responsible for 49,711 direct jobs, 53,358 indirect jobs, and 74,734 induced jobs. (See Table 10).

Table 10: Employment Impact of Company Sales (job-years)

Impact Type	Air Force	Navy	Both Programs
Direct	47,359	49,711	97,070
Indirect	55,312	53,358	108,670
Induced	72,124	74,734	146,858
Total	174,795	177,802	352,598

Labor Income

Labor income consists of employee compensation (wage and salary payments, including benefits) paid to workers as well as proprietor income (income received by self-employed individuals).

Labor Income Impacts from SBIR/STTR Phase II R&D Activity. The national IMPLAN model estimated that direct labor income directly associated with Phase II

R&D activity was \$2.51 billion: \$1.67 billion for the Air Force and \$870 million for the Navy. This works out to approximately \$91,045 and \$103,812 per job, respectively.

Table 11: Labor Income Impact of Phase II R&D Activity (billions)

Impact Type	Air Force	Navy	Both Programs
Direct	\$ 1.64	\$ 0.87	\$ 2.51
Indirect	\$ 1.06	\$ 0.63	\$ 1.69
Induced	\$ 1.15	\$ 0.68	\$ 1.83
Total	\$ 3.85	\$ 2.18	\$ 6.03

Indirect labor income was estimated at \$1.69 billion: \$1.06 billion for the Air Force and \$630 million for the Navy. These numbers work out to approximately \$59,609 and \$62,863 per job, respectively. Overall induced labor income was estimated at \$1.83 billion. By branch this was \$1.15 billion (\$48,163 per job) for the Air Force, and \$680 million (\$50,786 per job) for the Navy. Average wages for the indirect and induced jobs were substantially lower than those for the direct jobs because many were in lower-paid manufacturing and service sectors.

Together, the indirect and induced labor income amounted to \$3.52 billion. The total economy-wide labor income was an estimated \$6.03.

Labor Income Impacts from Sales of Air Force SBIR/STTR Phase II innovations.

According to the national IMPLAN model, the labor income directly associated with the \$28.86 billion in sales reported by companies was \$9.31 billion. The indirect labor income was estimated at \$7.22 billion, and the induced labor income was estimated to be \$7.27. The total economy-wide labor income resulting in 2013 from sales of Air Force and Navy SBIR/STTR Phase II innovations was \$23.8.

Table 12: Labor Income Impacts of Company Sales (billions)

Impact Type	Air Force	Navy	Both Programs
Direct	\$ 4.55	\$ 4.76	\$ 9.31
Indirect	\$ 3.59	\$ 3.63	\$ 7.22
Induced	\$ 3.47	\$ 3.80	\$ 7.27
Total	\$ 11.61	\$ 12.19	\$ 23.80

Tax Revenues

Tax revenues were estimated for the combined \$6.25 billion in Phase II R&D activity and \$28.86 billion in subsequent sales, including their associated economy-wide indirect and induced effects. These tax revenues included social insurance taxes (paid by employers, employees, and the self-employed), personal income taxes, motor vehicle licenses, property taxes, corporate profits taxes and dividends, and indirect business taxes (comprised mainly of excise and property taxes, fees, licenses, and sales taxes). Table 13 shows the total estimate of \$8.8 billion in overall tax collections.

Table 13: Estimated Tax Collections (billions)

Impact Type	Air Force	Navy	Both Programs
Direct	\$ 1.25	\$ 1.57	\$ 2.82
Indirect	\$ 1.24	\$ 1.48	\$ 2.72
Induced	\$ 1.41	\$ 1.85	\$ 3.26
Total	\$ 3.90	\$ 4.90	\$ 8.80

SUMMARY

In summary, the Air Force and Navy SBIR/STTR economic-impact studies provided a comprehensive answer to the question of what resulted from the federal government's investment of \$6.25 billion in small business R&D in these two innovation programs during the 2000-2013 period. Overall, 60 percent of the Phase II contracts—4,384 out of 7,258—resulted in sales. Collectively, companies reported approximately \$28.86 billion in total sales, of which \$11.4 billion were to the U.S. military or to defense contractors. Other significant economic outcomes included outside investments related to the SBIR/STTR innovations of around \$2.5 billion; 316 company acquisitions, with a total acquisition value of well over \$8.6 billion (most companies declined to disclose acquisition amounts); 310 technologies licensed to other companies; and a total of 174 new spin-out companies.

IMPLAN economic-impact assessment software estimated the total economy-wide sales (output) to be around \$92.14 billion. Value added, representing new wealth creation in the economy, was estimated at \$46.94 billion and labor income at \$29.83 billion. Employment impacts included 444,137 total job years, or an average of 31,724 jobs per year. These total impacts are summarized in Table 14.

Table 14: Estimated Total Impacts from the Air Force and Navy Programs

Impact Type	Employment (job years)	Employment (per year)	Labor Income (billions)	Labor Income (per job)	Value Added (billions)	Output (billions)
Direct	123,425	8,816	\$ 11.82	\$ 95,767	\$ 16.43	\$ 35.11
Indirect	136,552	9,754	\$ 8.91	\$ 65,250	\$ 14.52	\$ 27.87
Induced	184,161	13,154	\$ 9.10	\$ 49,413	\$ 15.99	\$ 29.16
Total	444,137	31,724	\$ 29.83	\$ 67,164	\$ 46.94	\$ 92.14

Note: Totals may not tally due to rounding

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