# Solving the Surveyor's Dilemma:

## Estimating Future Outcomes from Innovation Programs – the case of the Air Force and Navy SBIR/STTR programs

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## EXECUTIVE SUMMARY

Between 2014 and 2016, the Air Force and Navy separately commissioned large-scale surveys of their SBIR/STTR program participants to generate a more informed view of program outcomes and impacts**.** IMPLAN economic modeling software was applied to the survey results to estimate overall impacts on the U.S. economy.

These were the first comprehensive economic-impact surveys of any federal agency SBIR program. The surveys provided conclusive information on the outcomes of well over 90% of the Phase II award recipients in these two Department of Defense (DoD) programs. They revealed that both programs had impressive economic impact ROIs: 12:1 for the Air Force and 19:1 for the Navy.

The surveys generated a wealth of data and the resulting reports were well received [Air Force, 2014; Navy, 2016]. But they failed to address what we call the Surveyor's Dilemma: the fact that these surveys reported on sales and other outcomes *that had already taken place*.

We argue that a substantial portion of these programs' impacts lies in the future, as new technology from SBIR/STTR projects that has not

**Key Findings:** Surveys substantially understate outcomes from SBIR/STTR programs because they do not account for future activity from already funded projects. According to this analysis of recent surveys of the Air Force and Navy SBIR/STTR programs:

- For projects with products that have already reached the market, we conservatively estimate that 45% of the total product sales will occur in the future, meaning that these total product sales will eventually be 83% greater than the totals reported at the time of the surveys.
- For projects that have not yet generated product sales, we conservatively estimate that an additional 10% will eventually result in commercial products, increasing the number of projects with product sales by 24%.
- With the addition of the missing future sales, the total economic impact from the Air Force and Navy SBIR/STTR programs will eventually be 51% greater than was reported in the two economic-impact surveys.
- For the Air Force and Navy SBIR/STTR economic-impact surveys, the missing impacts include:
  - ✓$18 billion in product sales
  - ✓$47 billion in total economic output
  - ✓220,000 job-years
- This new analysis shows that every dollar invested in Air Force and Navy SBIR/STTR Phase II awards will return $22 in economic activity.

yet reached the market does so, and as products that have already reached the market continue to generate revenues across the entire product cycle. In other words, the surveys significantly understate the actual impact of these SBIR/STTR programs.

This paper provides a conservative estimate of the extent of that understatement. We show that for projects generating new technology-based products that have already reached the market, sales continue to grow across the entire time period covered by the survey (which reached back to projects that had been completed as early as 2000).

The survey data confirm what one would expect—that SBIR/STTR–enabled products yield increasingly higher revenues the longer they have been on the market. Measured by award start date, aggregate sales among 16-year-old awards were five times those among three-year-old awards.[1] This indicates the extent to which awards completed in years close to the survey deployment date could expect to generate additional future revenue.

The data also indicate that the rate of award commercialization—the percentage of awards in each age group that yield products and services with positive sales—was higher for each elapsed year, until year 11. In fact, at the time of the survey, 16-year-old awards were nearly twice as likely as 3-year old awards to be commercialized (35% vs. 18%).

Using these data points, we were able to estimate eventual total product sales for Air Force and Navy SBIR/STTR projects after the date of the surveys. The surveys reported $16.8 billion in total product sales for the years analyzed. Our estimates identified a further $13.9 billion in future product sales not captured by the reports, for eventual total product sales of nearly $31 billion—an increase of 83%. (The missing future sales represent 45% of the nearly $31 billion in estimated total product sales.)

We also estimated the overall economic impacts of the new numbers, using the multipliers implied by the previous studies' IMPLAN output provided by the University of Colorado, Boulder, which conducted the IMPLAN modeling for the Air Force and Navy SBIR/STTR economic-impact studies. First, we applied the estimated rate of increase in sales to the overall sales numbers reported in the two surveys.[2] The increases were added to the reported direct impacts. The indirect and induced impacts, as well as changes in employment and labor income, were then calculated using ratios derived from the original IMPLAN analyses.

[1] These conclusions followed statistical techniques that reduced the impact of positive outliers.
[2] This covered all reported sales, including those by spinoff companies and licensees, and omitted further investments in research and development.

The resulting estimates of the major IMPLAN output categories—employment (job-years), labor income, total output—as well as calculated "annual" jobs, were approximately 50% higher than previous estimates.

These hitherto hidden outcomes should be included when estimating the impact of the SBIR/STTR programs on the U.S. economy and returns on the federal government's investment. Looking at program ROI, this analysis shows that the investment of $6.25 billion in the Air Force and Navy SBIR/STTR programs generated total output of $139 billion, an ROI of 22:1, as well as a total of 663,500 job-years.

## INTRODUCTION

Programs to encourage the commercialization of innovative technologies are an increasingly valuable tool in the policymaker's toolkit for encouraging economic growth. Small companies generate more patents and hire more engineers and scientists than major corporations. Further, the corporate behemoths of the future will emerge from the ranks of today's small businesses. The firms that today dominate the stock market—Apple, Google, Facebook and Amazon—were all founded since 1980. Other less well-known but important tech firms are also recent creations. Illumina, for example, which powers most genetic screening worldwide, was founded in 1998.

The national SBIR/STTR programs (started in 1983) are the premier mechanisms through which the federal government funds research and development (R&D) by U.S. small businesses. These programs, primarily operating through the five largest research agencies (DoD, NIH, NSF, NASA, and DOE), disburse about $2 billion annually to fund around 4,000 small business R&D projects. Funding is typically $150,000 for a feasibility phase (Phase I) and $1.5 million for a research phase (Phase II).[3] These awards are highly competitive: only around 15% of applications recieve Phase I awards, although the success rate increases to around 50% for Phase II awards.

It is relatively easy to track the amount of federal government support provided by SBIR/STTR programs, in the form of awards made and funding disbursed. But finding out what resulted from the projects they supported, and the long-term impact of that support, is a different and much more difficult matter.

Efforts to evaluate program outcomes have largely relied on case studies of successful projects and, more recently, on large-scale surveys of awardee companies. Prior research is well summarized in reports by the National Academies of Sciences, Engineering, and Medicine [NAS 2016]. The National Academies broke new ground in evaluating the nation's SBIR/STTR programs and in deploying large-scale surveys to gather data on outcomes [NAS 2004-2016]. The National Academies surveyed awards at the five major funding agencies.

Subsequently, TechLink was commissioned by DoD to undertake more intensive surveys of the Air Force and Navy SBIR/STTR programs. The TechLink surveys focused on Air Force and Navy Phase II awards that ended during the 2000-2013 period. Together, these two surveys obtained approximately 6,700 responses (at one response per project), accounting for nearly 93% of all 7,216 Phase II projects funded by Navy and Air Force during this time period. IMPLAN economic-impact assessment software was applied by the University of Colorado, Boulder, to the large datasets from these two surveys to estimate the total economic impacts. What

[3] Actual amounts vary by agency

resulted were the first-ever comprehensive economic-impact studies of any federal SBIR/STTR programs.

In addition to providing conclusive information on the outcomes of nearly 93% of the Air Force and Navy SBIR/STTR Phase II projects completed during the 2000-2013 study period, the two economic-impact studies enabled the research team to estimate the future sales of these 7,216 projects. Using the contract start date for each R&D project, the research team calculated the elapsed time between the granting of a Phase II award and the time of the survey. Then, by applying statistical analysis of the sales results for all of the projects for each elapsed year of the study period, the research team was able to obtain a well-informed estimate of the likely future sales of products emerging from the projects under review. The approach described in this paper provides at least a preliminary solution to the Surveyor's Dilemma: the fact that surveys capture only outcomes that have already taken place.

## THE SURVEYOR'S DILEMMA

Surveys are powerful tools for exploring outcomes in programs like SBIR/STTR. They allow researchers to probe deeply into program processes (how well the program worked for recipients), and to gather data about outcomes that only the awardees can provide. Currently, they are a primary source of data about program outcomes, providing the data on which both the National Academies and TechLink reports were based.

At the time of these surveys, approximately half of all projects had resulted in a successful technology (measured by product sales and/or R&D sales to further develop the technology for specialized applications). The TechLink surveys found that companies reported total combined sales related to SBIR/STTR awards of about $29 billion – an average of $3.8 million per award. These outcomes were the basis for estimates of overall economic impact from the Navy and Air Force SBIR/STTR programs: TechLink estimated that the overall impact on economic output was about $92 billion.

These are impressive results. But are they really a complete picture of the programs' commercial outcomes? The Surveyor's Dilemma emerges directly from the intrinsic nature of surveys: they collect outcomes data *at a single point in time* and are necessarily retrospective in nature. But outcomes—especially from innovation-support programs—may take years or even decades to fully roll out.

There is a considerable literature on technological diffusion, and a more recent and smaller literature on the speed to market for innovative products. Along with the many case studies completed for the National Academies reports on SBIR/STTR [NAS 2014-2016], there is convincing evidence that for some innovative products, there is a long pre-revenue gap before the new product reaches the market. While we are accustomed to the almost-instant deployment of apps and software from Silicon Valley, most products usually take much longer, emerging after an exhaustive process of R&D, prototyping, product design, market testing and design improvement, and then eventual product launch. For products in some especially slow-cycle sectors like materials or therapeutics, a new product can take 20 years to reach the market.

This, then, is the first part of the surveyor's dilemma: A survey taken at a single point in time does not capture outcomes from products that reach the market *after* the survey has been completed. Innovative products with long product development cycles are especially prone to this kind of underestimate. We will show that the TechLink surveys captured only about 80% of the eventual saleable products facilitated by the select Phase II awards, because the remaining 20% will come to market after these surveys were conducted. Including them will increase the number of projects with product sales by about 24%.

The second part of the surveyor's dilemma is even more important. All products have a natural life cycle: they reach the market, gain traction over time, achieve a sales peak, experience sales decline, and eventually become obsolete. This is an entirely normal trajectory for any product, but it poses a second challenge for the surveyor. Because surveys are administered at a single point in time, they capture products that are at all points along the product cycle: some that are nearing obsolescence, some that are mature and near peak sales, some that are still gaining traction, and others that have barely reached the market. Thus, a snapshot taken at a single point in time will understate total outcomes for the entire collective product cycle. The understatement will be small for products reaching the end of their life in the marketplace, but may be very large for products at earlier stages of the cycle. Our analysis of the projects covered by the TechLink surveys conservatively estimates that 45% of the total eventual sales are missed because the surveys only capture past sales. Including these future sales will increase total product sales by an estimated 83%.

These two issues—the exclusion of products that have not yet reached the market, and the underestimation of outcomes for products that are already in the marketplace—together constitute the Surveyor's Dilemma for accurately assessing outcomes from innovation programs like SBIR. The question, then, is how to solve this dilemma.

## USING THE PAST TO ESTIMATE FUTURE OUTCOMES

The TechLink studies provide a valuable opportunity to address the Surveyor's Dilemma. The more than 6,700 responses are enough to statistically estimate both the missing future sales from products that have not yet reached the marketplace and the missing future sales from products already on the market.

Conceptually, the solution is embedded in the problem: We know that for a period after the completion of SBIR/STTR contracts in any given year, both the percentage of projects that reach the market and the sales generated by those projects in the market continue to grow. In fact, they probably continue to grow for a long time. In fact, some SBIR projects do not reach the market until 20 years after the award date. Indeed, the National Academies profiled such a project in its first report on NSF.[4]

But for typical projects, the commercialization and sales period is shorter. So, we would expect that as we look at more-recent projects on a year-by-year basis, a declining percentage of contracts will have resulted in products that reached the market—fewer for projects that ended in 2012 than in 2010, fewer for 2010 than for 2008, and so on. Total sales will decline as well, with an inverse ratio between newness of the project and the size of the sales.

These declining curves provide us with a solid basis for estimating future outcomes. Using sales data from older projects, we can estimate the sales that more recent projects are likely to make in the future.

These projections allow us to account for the missing future sales and address the Surveyor's Dilemma by estimating the (1) number of products that will eventually reach the market, (2) the sales that these products will eventually generate, and (3) the total amount of sales that products already in the market will accrue over time. In the process, we will achieve a much more complete estimate of the total impact of the Air Force and Navy SBIR/STTR programs.

## ESTIMATING THE PERCENTAGE OF PROJECTS THAT WILL EVENTUALLY REACH THE MARKET

Generating the first dollar in sales is a major achievement for a new technology development project. Huge technical barriers usually need to be overcome, at least one customer must be identified and acquired, and a saleable product (as opposed to a prototype) must be developed and delivered. Overcoming these and other barriers takes time. The percentage of projects with new marketable technologies increases gradually, until all the SBIR-funded projects that are going to reach the market eventually do.

The first step in estimating the number of awards in any given annual cohort that will eventually reach the marketplace involves categorizing the already-available information. Aggregate data from the existing TechLink surveys revealed the percentage of Phase II awards, clustered by start date, that lead to sales of products or services.

[4] See SAM Inc. case study, National Research Council 2008

It would be convenient if a review of data in the Air Force and Navy SBIR/STTR surveys generated a smooth curve showing progressively greater market penetration with the increase in elapsed time since the contract ended. However, prevailing conditions both in the wider economy and in the DoD acquisitions marketplace change from year to year, and this is reflected in somewhat erratic movements around the trend. Further, the nature of the technology being developed plays a major role in the speed of market penetration. For example, new software can enter the market rapidly while medical technology is exceedingly slow to commercialize.

**Table 1. Projects and total sales by elapsed year (EY)**

| EY | Projects surveyed | Reporting sales >$1,000 | % reporting sales |
|---|---|---|---|
| 3 | 148 | 26 | 17.6 |
| 4 | 406 | 93 | 22.9 |
| 5 | 584 | 138 | 23.6 |
| 6 | 725 | 192 | 26.5 |
| 7 | 643 | 186 | 28.9 |
| 8 | 700 | 205 | 29.3 |
| 9 | 623 | 183 | 29.4 |
| 10 | 712 | 221 | 31.0 |
| 11 | 600 | 219 | 36.5 |
| 12 | 495 | 167 | 33.7 |
| 13 | 435 | 149 | 34.3 |
| 14 | 357 | 117 | 32.8 |
| 15 | 378 | 124 | 32.8 |
| 16 | 410 | 142 | 34.6 |
| Total | 7216 | 2162 | 30.0 |

Source: TechLink Air Force and Navy surveys

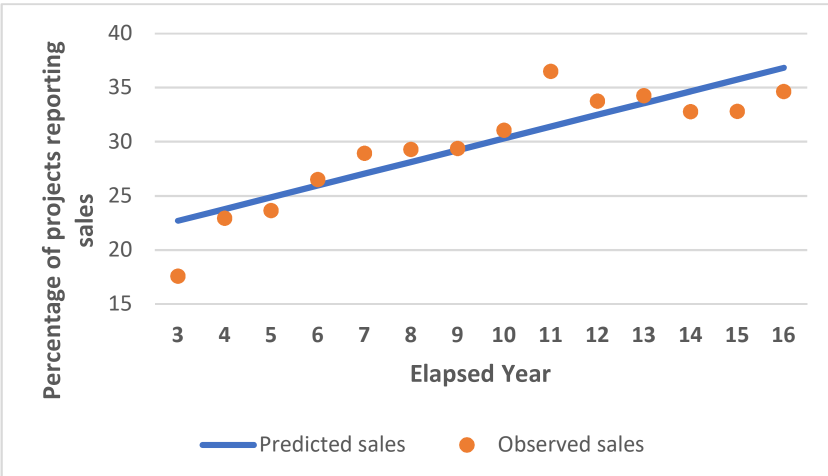
To smooth out the trend and also to add data points, we adopted a two-track approach. First, we aggregated the data from all the records in the Air Force and Navy surveys, including the 6,700 responses. To ensure compatibility, we labeled each award based on the number of years between the start date of the award and the year the survey was administered (2014 for Air Force and 2016 for Navy]. We then excluded projects from elapsed years (EYs) 1 and 2, as only a handful had yet reached the market, and also from years beyond EY 16, based on the sharp drop-off in the number of responses for those years. We then calculated the percentage of awards that reached the market in each year. The results, shown in Table 1, distribute 7,216 awards by EY. [5]

A linear regression analysis was then conducted of the percentage of firms with sales for EYs 3-16, with elapsed year (EY) as the fixed (X) variable, and the percentage data as the random (Y) variable. The analysis produced a linear, increasing trend, significant at $p < 0.0001$, showing increasing sales over the time period. Confidence limits (CLs) for mean predicted values were calculated, but only the 95% CLs are shown on the plot (80% CLs virtually overlapped with the

[5] The TechLink survey of all DOD awards currently in progress plans to extend the timeframe back to 1995 and the scope of the survey to all DOD components. This will make it easier to identify the impact of macroeconomic variables on eventual commercialization. The new data will also allow further exploration of the hypothesis that changes in DoD policy further encouraged commercialization in more recent years.

95% CLs). Residuals did not show any trend, indicating that the assumptions of linear regression were satisfied. Despite some variability in the data (see below), the slope is an unbiased, quantitative indicator of increasing post-project sales over the range of years in this analysis. The trend explained about 75% of the variation in the data ($r^2 = 0.752$).

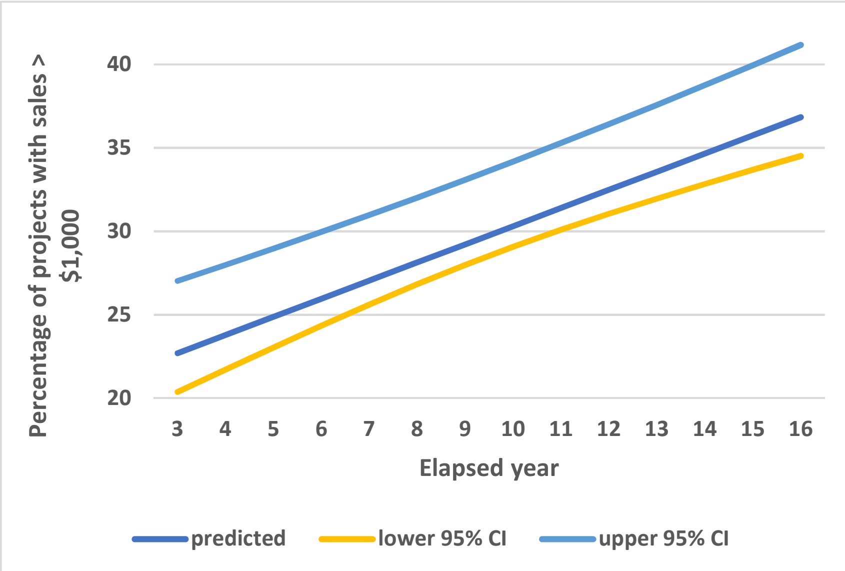
**Figure 1. Percentage of projects reporting sales**




Source: TechLink surveys

Figure 1 shows some variation round the trend, as expected. However, it also shows that the trend is positive, i.e., that the percentage of SBIR/STTR projects that reach the market continue to grow year after year from EY 3 through EY 16. Projects at EY 16 are predicted to reach the market at a rate that is 14 percentage points higher than EY 3. Confidence levels for these results are shown in Figure 2.

**Figure 2. Predicted rate of market access, showing confidence levels**




These predicted outcomes were then applied to the select years of Air Force and Navy SBIR Phase II recipients. Based on the predicted market entry rates, we estimate that an additional 521 projects will be commercialized after sixteen years (an increase of 24.1%). As a result, we expect 37.2% of all awards to eventually produce a product generating sales (up from 30.0%).

## ESTIMATING FUTURE SALES FOR PROJECTS THAT HAVE ALREADY REACHED THE MARKET

SBIR/STTR projects that reach the market continue to grow their sales over time (in some cases long after the date of the survey) and, consequently, projects completed relatively recently have almost all of their projected sales in front of them. However, these future sales are not included in the results captured by the TechLink surveys (or, indeed, any other surveys). To estimate these future sales, we began by combining results from the Air Force and Navy surveys. We then calculated the total sales for all projects that reported at least $1,000 in total sales.[6] Table 2 shows total reported sales by EY. These represent just product sales and do not include follow-on R&D contracts, which can be considered sales of R&D services by the involved companies.

[6] Projects with less than $1,000 in sales were excluded from the analysis, in part, because this group included many projects that reported a nominal $1 or other low dollar figure to indicate that they had higher sales but that they were unwilling to release their actual sales figures—i.e., the reported results were likely not accurate.

Preliminary analysis indicated that the sales data were approximately log-normally distributed (many records with low sales tailing off to a few records with very high sales), so these data were $\log_{10}$ transformed before analysis. A linear regression analysis was conducted, with elapsed year as the fixed (X) variable, and the transformed sales data as the random (Y) variable. The analysis produced a significant ($p \ll 0.0001$) positive slope representing the trend of increasing sales over the time period.

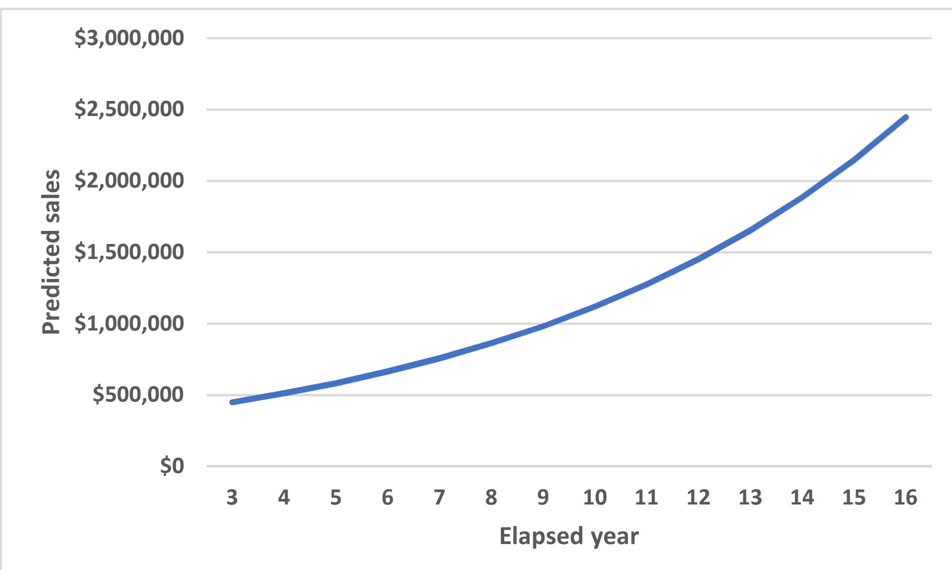
**Table 2. Projects and reported sales by elapsed year (EY)**

| EY | Projects surveyed | Reporting sales >$1,000 | Total reported sales |
|---|---|---|---|
| 3 | 148 | 26 | $ 45,789,382 |
| 4 | 406 | 93 | $ 249,157,436 |
| 5 | 584 | 138 | $ 146,999,014 |
| 6 | 725 | 192 | $ 634,693,701 |
| 7 | 643 | 186 | $ 423,393,514 |
| 8 | 700 | 205 | $ 1,090,776,806 |
| 9 | 623 | 183 | $ 716,905,005 |
| 10 | 712 | 221 | $ 792,801,582 |
| 11 | 600 | 219 | $ 1,450,258,117 |
| 12 | 495 | 167 | $ 1,582,418,731 |
| 13 | 435 | 149 | $ 2,090,223,543 |
| 14 | 357 | 117 | $ 1,996,392,562 |
| 15 | 378 | 124 | $ 2,383,928,309 |
| 16 | 410 | 142 | $ 3,211,561,632 |
| Total | 7,216 | 2,162 | $ 16,815,299,334 |

Source: TechLink surveys

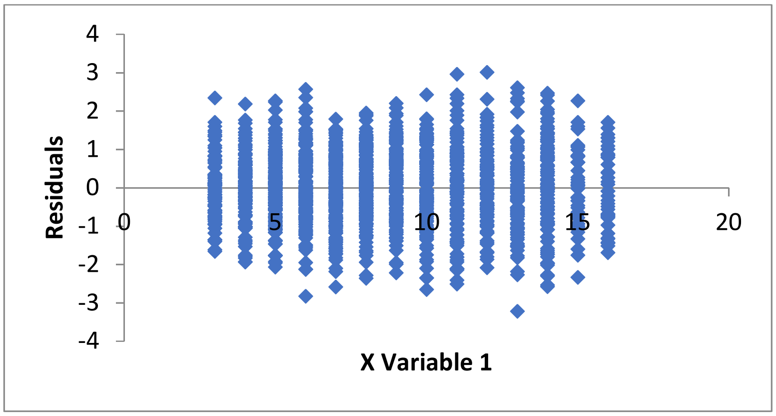
Between EY 3 and EY 16 (the start and end points for this analysis), we find that, overall, there is a positive relationship between the number of elapsed years since the end of the award and the total sales reported for the project. Based on this analysis we can predict future total sales for projects by elapsed year, as described in Figure 3.

**Figure 3. Predicted sales by elapsed year, estimated from regression model**



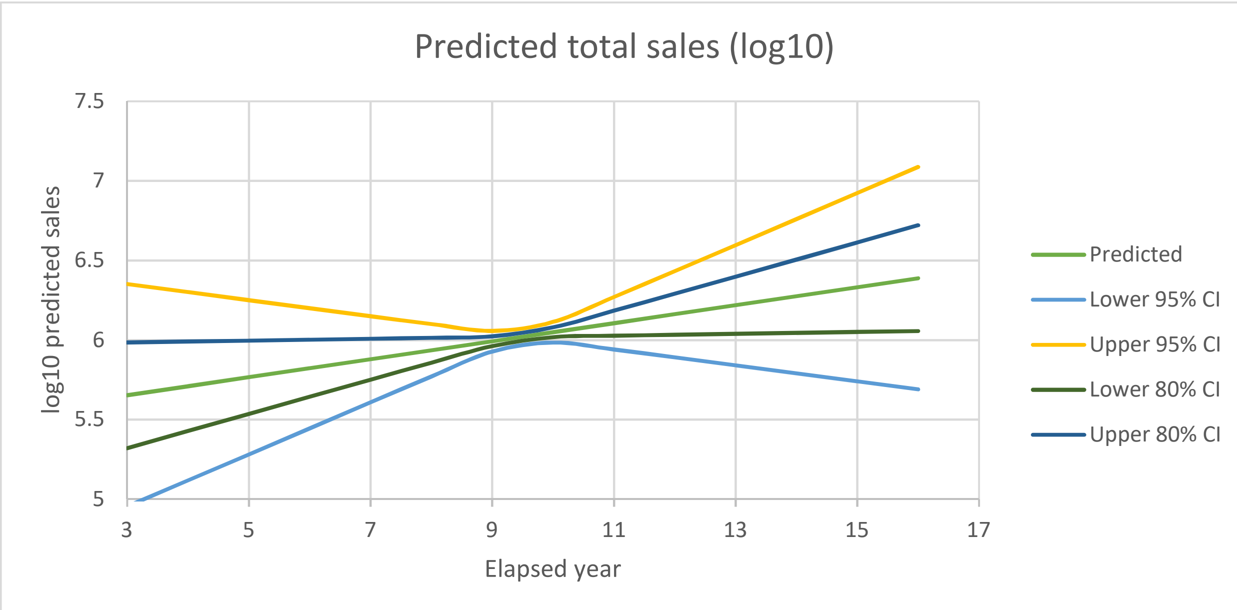
As expected, reported sales are highly variable, and this variability means that the regression explained only a small proportion of the variation. The adjusted $r^2$ was 0.043, meaning that the trend accounted for only 4.3% of the total variation. This is unsurprising. A large number of small positive outcomes and a few very large successes define the universe of SBIR outcomes. Graphic analysis of the residuals, i.e., the de-trended sales data, shows (1) linearity, and (2) an approximation to a normal frequency distribution, both requirements of linear regression (see Figure 4).

**Figure 4. Variable 1 residual plot**




Confidence limits (CL) for the mean sales at each elapsed year were computed at 80% and 95% levels of confidence. Predicted sales and confidence limits were plotted in logarithmic units, and back-transformed so they could be tabulated in dollar units. The CL were reasonably narrow at the center of the distribution, i.e., elapsed years 7-10, but increased toward the extremes (see Figure 5).

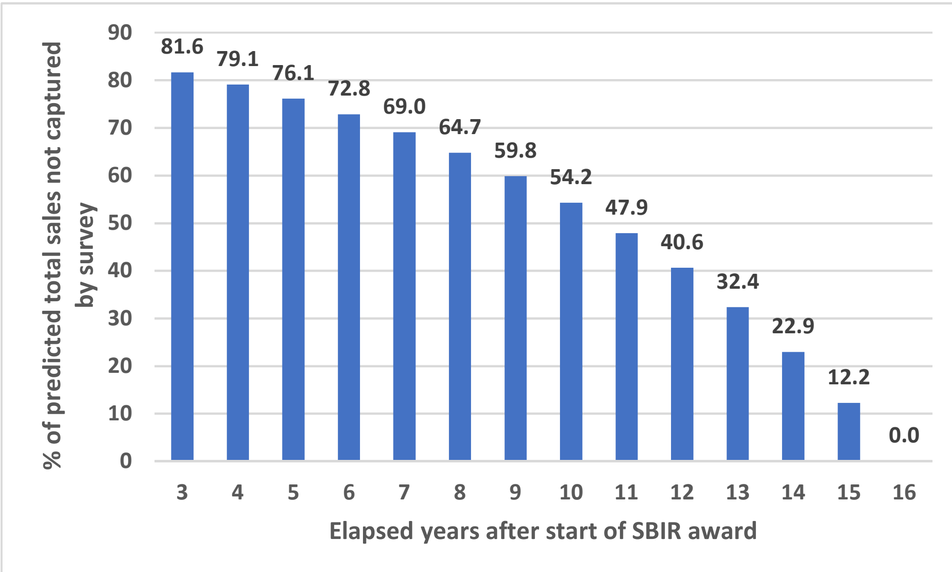
**Figure 5. Predicted sales (log) showing confidence levels**




Of course, total sales do not suddenly come to a crashing halt at the end of EY 16. For some projects, sales will continue, and total sales will continue to increase as more elapsed years are added to the model.[7] A survey inevitably misses outcomes achieved after the date of the survey. As Figure 6 shows, these missed outcomes include more than half of the sales from projects surveyed even 10 years after the project was initiated.

[7] The current DoD-wide survey, in which TechLink is surveying all SBIR projects that were initiated during the 1995-2012 period, will add additional years. For now, though, data limitations require us to use EY 16 as the end-point.

**Figure 6. Percentage of total estimated sales not captured by survey (estimated from regression model)**




Source: TechLink data; authors' calculations

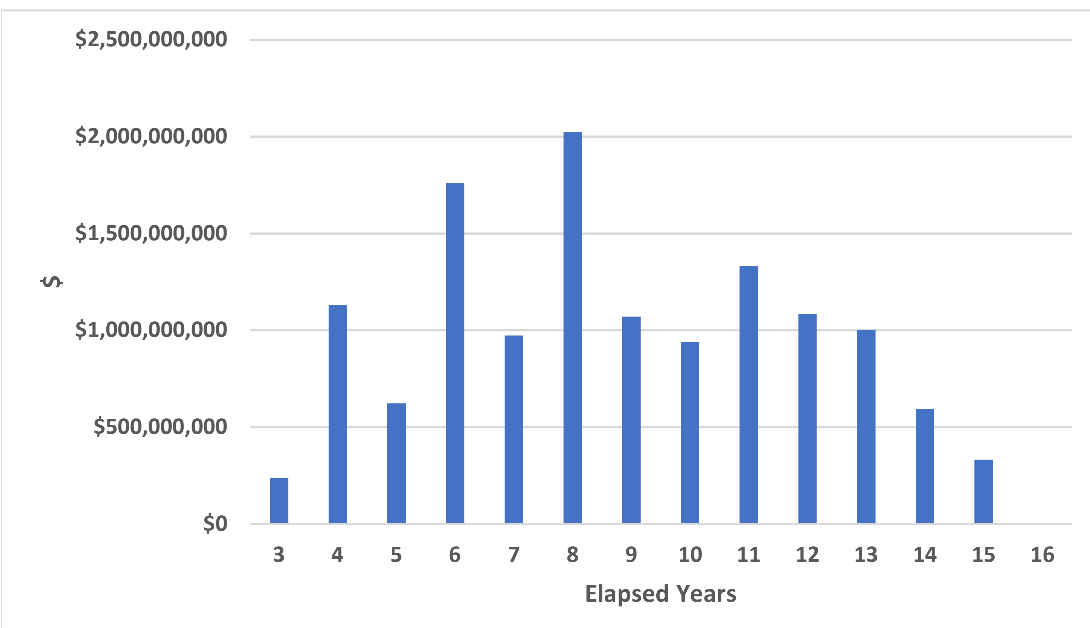
These missed outcomes translate directly into dollars. However, SBIR/STTR program outcomes are heavily influenced by the impact of outliers—projects that generate hundreds of millions or even more than a billion dollars in total sales. Efforts to calculate the year-on-year growth in sales using average sales would simply ensure that outliers dominated the resulting model.

In the section above we used a statistically appropriate methodology to sharply limit the impact of big winners. Using logs, we estimated the rate of change of sales over time. However, we now also need to account for the huge impact of outliers on total program outcomes. These outliers represent the economic "home runs" that all R&D or investment programs aspire to achieve. Consequently, when estimating total impacts, we need to use total sales by year as our base metric, which is then adjusted by applying the percentages shown in Figure 6 above to estimate missing sales by elapsed year. The resulting estimated future sales among contracts in each elapsed year are calculated in Table 3 and charted in Figure 7.

**Table 3. Estimate of sales not captured by survey ("Future Sales")**

| Elapsed Year | Reported Sales ($MM) | Total Predicted Sales ($MM) | Estimated Future Sales ($MM) |
|---|---|---|---|
| 3 | 46 | 249 | 203 |
| 4 | 249 | 1,190 | 941 |
| 5 | 147 | 616 | 469 |
| 6 | 635 | 2,336 | 1,701 |
| 7 | 423 | 1,368 | 945 |
| 8 | 1,091 | 3,094 | 2,003 |
| 9 | 717 | 1,785 | 1,068 |
| 10 | 793 | 1,733 | 940 |
| 11 | 1,450 | 2,782 | 1,332 |
| 12 | 1,582 | 2,665 | 1,082 |
| 13 | 2,090 | 3,090 | 1,000 |
| 14 | 1,996 | 2,591 | 594 |
| 15 | 2,384 | 2,716 | 332 |
| 16 | 3,212 | 3,212 | - |
| EY 3 - 16 | 16,815 | 29,425 | 12,610 |

**Figure 7. Total estimated sales not captured by survey ("future sales")**




Source: TechLink survey data; author calculations

Several points in Figure 7 are worth noting. First, total additional sales grow during EYs 3-11, as sales continue for many projects during this period. Additional sales for EY 3 are small because only a few of these projects report reaching the market. EYs 4, 6, and 8 appear to be positive outlier years, which reflects the reality that some contracts ending for these years happened to generate very positive results. Given the highly skewed nature of outcomes for small innovative firms generally, this is not surprising: a relative handful of projects generate a large share of total results, and a number of these big winners can be clustered in a single year. Variable outcomes are to be expected. Projects generating substantial revenues in EYs 4, 6, and 8 can be expected to generate further substantial revenues thereafter.

By EY 11, most projects have matured, so additional sales are no longer rising at the same rate, and the growth in total additional sales tails off through EY 16 as more and more projects become obsolete.

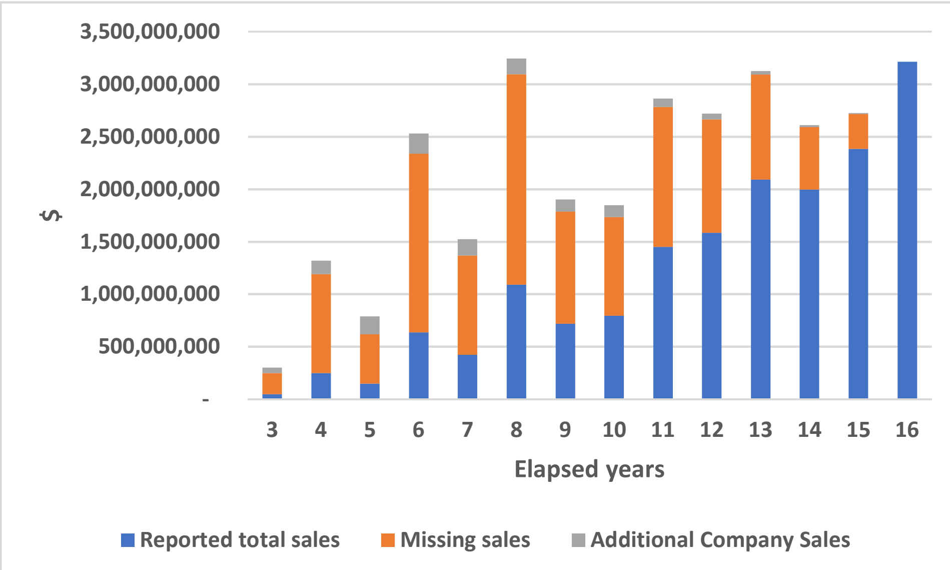
Total estimated future sales are substantial. The Air Force and Navy surveys identified $16.8 billion in total sales for EYs 3-16 inclusive.[8] The total estimated future sales for projects already in the market (and not captured by the surveys) is $13.9 billion. Thus, our best estimate is that the Air Force and Navy SBIR/STTR Phase II projects will eventually generate nearly $31 billion in total sales. That $13.9 billion increase represents 45% of the eventual total.

## SALES FROM PROJECTS EXPECTED TO REACH THE MARKET

We can now use the two estimates above—how many additional projects are expected to reach the market, and eventual predicted total sales per project—to estimate future sales for projects that reach the market after the date of the survey. The estimated 521 additional projects expected to achieve product sales are distributed by EY. As we have developed a value for predicted sales by EY, these two estimates can be combined to predict total sales for projects eventually expected to reach the market. The resulting estimate of these sales is $1.3 billion. The total growth in overall sales is illustrated in Figure 8.

[8] See TechLink 2014 and TechLink 2016 respectively for their estimated economic impact from sales of SBIR/STTR-supported technologies at Air Force and Navy.

**Figure 8. Reported sales, additional predicted sales, and sales from new projects predicted to reach the market**




For each elapsed year, the blue portion illustrates the aggregate sales amount as reported in the surveys. The orange portion is the predicted future sales for projects with products already on the market. The grey portion is future sales expected from project that had not yet reached the market at the time of the survey.

The future sales represented here, totaling $13.9 billion, amounts to an 83% increase over the total sales of $16.8 billion directly captured by the surveys.

## IMPLICATIONS FOR ECONOMIC IMPACT ANALYSIS

Higher sales translate into a bigger economic impact through the associated sales that ripple through the economy. The IMPLAN economic impact modeling tools used in the previous studies demonstrate how direct sales stimulate both indirect and induced impacts. Higher sales, then, are a change in *direct* effects, which stimlute increases in *indirect* effects (through changes in inter-industry transactions) and *induced* effects (through changes in household spending).[9]

With the data developed using the IMPLAN model and reported in the Air Force and Navy economic-impact studies, we can estimate the total effects of future sales on the region's

[9] See Box 1 below for a summary explanation of the IMPLAN methodology.

economy. Table 4 shows these estimates, generated by extrapolating the multipliers used in the previous studies to the new, larger estimated sales figures.

The higher projected total sales figures translate directly into higher employment, labor income, and total output. However, the overall program inputs (Phase II award expenditures) have remained the same. While total sales have increased, the original investment has not.

**Table 4. Reported, estimated, and total sales: SBIR program economic impacts**

| Impact Type | Prior Study Data | Multipliers | Additional Estimated Effects | Phase II Award Expenditures | New Total of Impact Estimates |
|---|---|---|---|---|---|
| **Output ($B)** | | | | | |
| **Direct** | 28.86 | | 18.09 | 6.25 | 53.20 |
| **Indirect** | 23.37 | 0.81 | 14.65 | 4.50 | 42.52 |
| **Induced** | 23.30 | 0.81 | 14.60 | 5.86 | 43.76 |
| **Total** | 75.53 | 2.62 | 47.34 | 16.61 | 139.48 |
| **Employment (job years)** | | | | | |
| **Direct** | 96,070 | | 60,213 | 26,355 | 182,638 |
| **Indirect** | 108,670 | 1.13 | 68,110 | 27,882 | 204,662 |
| **Induced** | 146,858 | 1.53 | 92,044 | 37,303 | 276,205 |
| **Total** | 351,598 | 3.66 | 220,367 | 91,540 | 663,505 |
| **Annual Jobs (countinuous jobs)** | | | | | |
| **Direct** | 6,934 | | 4,346 | 1,882 | 13,162 |
| **Indirect** | 6,762 | 0.98 | 4,238 | 1,992 | 12,992 |
| **Induced** | 10,490 | 1.51 | 6,575 | 2,664 | 19,729 |
| **Total** | 24,186 | 3.49 | 15,159 | 6,538 | 45,883 |
| **Labor Income ($B)** | | | | | |
| **Direct** | 9.21 | | 5.8 | 2.51 | 17.49 |
| **Indirect** | 7.22 | 0.78 | 4.53 | 1.69 | 13.44 |
| **Induced** | 7.27 | 0.79 | 4.56 | 1.83 | 13.66 |
| **Total** | 23.7 | 2.57 | 14.85 | 6.03 | 44.58 |

Source: TechLink surveys, IMPLAN economic model, author calculations[10]

The multipliers shown in Table 4 are derived from the aggregate total impacts reported in the previous TechLink studies. The "additional estimated effects" are all based on the estimated $18 billion in future sales (shown as $18.09 billion in direct output in the table). This expected increase in sales is the result of applying this study's calculated 83% increase to the overall amount of sales reported in all of the survey responses, regardless of elapsed year. The indirect and induced effects of future sales were estimated by applying the identified multipliers to this

[10] According to the Air Force and Navy reports, the direct amount of total combined sales (product sales along with further research funding) was $28.9 billion. Of this, $21.9 billion was product sales; the remainder was follow-on R&D. If that $21.9 billion is inflated by the 83% rate calculated in this analysis, additional product sales would be $18 billion.

$18 billion in additional direct sales. The concurrent increases in direct employment, annual jobs, and labor income were estimated using the previous ratios of these impacts to direct output, with the induced and indirect multipliers for impacts taken from the previous studies.

Table 5 below compares the original, aggregated impact estimates from the previous studies with those generated by the new methodology used in this paper. It shows that for all four of the major categories—output, jobs (job years), annual jobs, and labor income—the new estimates are 49-51% higher than those previously reported.

**Table 5. Total program impacts, adjusted for predicted sales**

| **Overall Increase in Economic Impacts** | | | | |
|---|---|---|---|---|
| | Reported | Estimated Increase | New Estimate | Rate of Increase |
| Total Output ($B) | 92.14 | 47.34 | 139.48 | 51% |
| Jobs | 443,138 | 220,367 | 663,505 | 50% |
| Annual Jobs | 30,724 | 15,159 | 45,883 | 49% |
| Labor Income ($B) | 29.73 | 14.85 | 44.58 | 50% |

Source: TechLink surveys, IMPLAN economic modeling, author calculations

These estimates of future economic impacts are very conservative for several reasons. First, the 83% rate of increase was based on projects from 3 to 16 years old at the time of the surveys. Applying that rate to projects from EYs 1 and 2 severely underestimates the earning potential of those projects. Moreover, these methods assumed the product life cycle ends at 16 years, but for a significant number of projects, sales will continue well beyond that.

Also, these future sales estimates are based only on product sales, which comprise only 76% of *total combined sales*. The remainder is $8 billion in follow-on R&D funding.  This measure is sure to increase over product life cycles as well, but our study does not estimate this change.

Other factors may further drive up program outcomes—for example, some companies working on classified projects refused to provide sales data, even though other sources indicated that these sales were substantial. And sales figures from companies that were acquired by large corporations (often because they had valuable contracts or technologies) were harder to obtain. Approximately three-fourths of the acquiring companies were not willing to provide sales data. Finally, spinout companies created by the SBIR recipient companies also were much less responsive to requests for sales figures. So, the estimates presented here significantly understate total sales.

Is there any reason to believe that these estimates of future sales are substantially mistaken? Projecting future sales for a single product or even market is notoriously difficult. The business world is littered with embarrassing evidence: Thomas Watson, president of IBM, said in 1943 that "I think there is a world market for maybe five computers." Daryl Zanuck of 20$^{th}$ Century

Fox predicted, about television, that "People will soon get tired of staring at a plywood box every night." And Ken Olsen, founder of Digital Equipment Corp. said, "There is no reason anyone would want a computer in their home."

But we are not projecting sales for a single project or even firm; we are estimating sales for a large number of firms and an even larger number of projects, and are relying on the evident truth that, collectively, they will accumulate SBIR-related sales over time. The question is whether our specific estimates are accurate—or rather, what level of confidence we should place in them. The statistical analysis performed above allows us to have confidence that our results are usable. Indeed, if there are errors, they are just as likely to increase our estimates for future sales as to reduce them.

The bottom line, then, is that we are reasonably confident in our analysis, and that the analysis itself results in a striking discovery: The eventual total sales from SBIR/STTR projects that have already reached the market will likely be more than 80% greater than the numbers captured directly by the surveys.

These hidden outcomes and impacts should be included when calculating the impact of SBIR/STTR programs on the U.S. economy, and also when estimating the return on investment from these programs. Looking at program ROI, this analysis shows that the investment of $6.25 billion in the Air Force and Navy SBIR/STTR programs generated total economic output of $139 billion, an economic ROI of 22:1, and a total of 663,500 job-years.

We believe that the methodology used in this paper for estimating future sales can be productively applied to other work aimed at assessing economic outcomes and impacts from SBIR/STTR and similar R&D programs. We expect this methodology and related estimates of future sales to continue to be refined by additional research.

As this paper has shown, much of the impact of these innovation programs lies in the future. New technology-based products that have already reached the market will continue to accumulate sales. And other innovative products still in development will eventually enter the marketplace. Failing to include these future sales badly understates the total impacts from these programs, and makes investment in these programs less attractive. The methodology used in this paper is believed to provide an effective solution to the Surveyor's Dilemma, as applied to innovation programs.

## BOX 1. THE IMPLAN MODEL – A BRIEF EXPLANATION

IMPLAN draws on a mathematical input-output framework originally developed by Wassily Leontief, the 1973 Nobel laureate in economics, to study the flow of money through a regional economy.  In the case of the SBIR/STTR programs, there are two inputs into the economy to consider: (1) the immediate injection of SBIR/STTR funding into the economy via SBIR/STTR award recipients; and (2) the sales and other revenues generated by SBIR/STTR firms as a result of SBIR/STTR awards. The higher sales identified in this paper affect only the latter.

Each of these components generates three kinds of economic impact:

- ***Direct effects*** represent the initial change in the industry in question (this category includes the direct expenditures of firms using SBIR/STTR award funding for R&D as well as the subsequent sales of products or services resulting from these firms' R&D efforts).
- ***Indirect effects*** are changes in inter-industry transactions when supplying industries respond to increased demands from the directly affected industries (sales by vendors who supply SBIR/STTR firms), estimated using IMPLAN's NAICS-based input-output model for the national and regional economies.
- ***Induced effects*** reflect changes in local spending that result from income changes in the directly and indirectly affected industry sectors (e.g., impacts from wage expenditures). These are household expenditures as workers spend their payroll checks on goods and services across a wide spectrum of the economy.

More detailed descriptions of the IMPLAN methodology can be found online at the IMPLAN web site, www.implan.com

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