

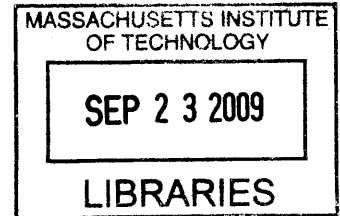
# A Study of Commercialization Factors in a Small Business Innovation Research (SBIR) Funded Company

by

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Submitted to the System Design and Management Program  
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# **A Study of Commercialization Factors in a Small Business Innovation Research (SBIR) Funded Company**

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Submitted to the System Design and Management Program  
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## **ABSTRACT**

A nation's ability to innovate is paramount for its success and survival among other nations. But capitalizing on these innovations and bringing them to the marketplace are what gives a nation its competitive edge and provide sustainable growth over time in this highly dynamic global economy. In the United States' complex innovation ecosystem, small businesses and entrepreneurs play a crucial role in innovating new technologies and commercializing them. Indeed many of the nation's large, successful and innovative firms started out as small entrepreneurial firms. Microsoft, Intel, AMD, FedEx, Qualcomm, Adobe are examples to these firms.

These small entrepreneurial firms with new ideas need to garner fair amount of funding before they can bring their ideas into the marketplace. However for entrepreneurial companies with science based innovative ideas, due to the unproven nature of these ideas and the lack of sufficient public information, there exist knowledge asymmetries. Therefore possibility of getting direct venture capital and/or angel investment becomes very slim for these firms unless the idea's commercial potential is obviously clear or a customer is already available. To address this early stage financing gap and to increase private sector commercialization of innovations, the Federal government offers funding through its three phase private-public partnership innovation program, called Small Business Innovation Research (SBIR) program.

The purpose of this study is to investigate the existence of any correlations between commercialization of SBIR funded projects, specifically Phase II programs, and various characteristics of the involved entities in attempt to enhance commercialization performance of an SBIR funded company. We hope that the results of this study will be practical in defining commercialization strategies to achieve faster and stronger capitalization on R&D investment for both the awarded company and the federal government and hence the tax payers.

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*To my wife Meltem and our daughter Ela*

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# 1. INTRODUCTION

A nation's ability to innovate is paramount for its success and survival among other nations. But capitalizing on these innovations and bringing them to the marketplace are what gives a nation its competitive edge and provide sustainable growth over time in this highly dynamic global economy. In the United States' complex innovation ecosystem, small businesses and entrepreneurs play a crucial role in innovating new technologies and commercializing them. Indeed many of the nation's large, successful and innovative firms started out as small entrepreneurial firms. Microsoft, Intel, AMD, FedEx, Qualcomm, Adobe are examples to these firms.

These small entrepreneurial firms with new ideas need to garner fair amount of funding<sup>1</sup> before they can bring their ideas into the marketplace. However for entrepreneurial companies with science based innovative ideas, due to the unproven nature of these ideas and the lack of sufficient public information, there exists knowledge asymmetries (Wessner, An Assessment of the Small Business Innovation Research Program, 2007), such that the commercial potential of the innovation is only known to the person who invented it and not to the potential investors. Therefore possibility of getting direct venture capital and/or angel investment becomes very slim for these firms unless the idea's commercial potential is obviously clear or a customer is already available. To address this early stage financing gap and to increase private sector commercialization of innovations, the Federal government offers funding through its three phase private-public partnership innovation program, called Small Business Innovation Research (SBIR) program. In addition to helping the small business firms pass the valley of death (Wessner, SBIR and Phase III Challenge of Commercialization, 2007), by providing early phase financing, the SBIR program also acts as a certification of promising new

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<sup>1</sup> Average investment by a venture capital firm is ~ and is changing over the past years. See Appendix for further information.

technologies, encourages further private sector investment and increases visibility of the company.

Since the inception of the SBIR program in 1982 the funding available to small businesses kept increasing steadily, and with this increase came a stronger emphasis on commercialization of SBIR funded technologies. To measure the commercialization activities and the track record of the participants, the SBIR program office developed several metrics. Commercialization achievement index (CAI) is one of these metrics calculated based on the company commercialization report that is compiled by the petitioning company. CAI is calculated based on companies' past commercialization performance and is used during award selection process to evaluate competing awards in terms of their potential for commercial application, and their expected benefits. Therefore weak commercialization performance undermines a company's potential for an award even though it may have a very strong technical case.

This increased emphasis on commercialization had a major impact on established SBIR companies. These are companies that have historically captured a high percentage of the awards but were focused on meeting the federal agency needs rather than bringing products to the market place even though commercialization is a natural and logical progression of SBIR program, as the companies only start making profits during this phase, and not while receiving SBIR funding.

The purpose of this study is to investigate the existence of any correlations between commercialization of SBIR funded projects, specifically Phase II programs, and various characteristics of the involved entities in attempt to enhance commercialization performance of an SBIR funded company. In this research we will focus on a privately owned small business applied research and development company that is deemed one of the nation's most successful<sup>2</sup> SBIR companies based on the number of Phase I and Phase II projects awarded by various Federal agencies. The data set compiled for this research

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<sup>2</sup> There are only five companies that were awarded more than 125 Phase-II projects, and the company we have selected is one of them. See the Appendix for Number of Phase-II programs per firm.

includes more than 250 Phase II programs from the commercialization report filed by this company. Due to privacy concerns the collected data as well as the name of the company will be kept anonymous.

We believe commercialization is vital for both sustainable growth of a small business company and its long term existence. Therefore our ultimate goal in this study is to try to increase the commercialization activities in these types of businesses especially in SBIR companies like the one we have studied in this research. We also hope that the results of this study will be practical in defining commercialization strategies to achieve faster and stronger capitalization on R&D investment for both the awarded company and the federal government and hence the tax payers.

## **1.1. Background**

The productivity slowdown in the United States in the early 1980s reduced the nation's ability to compete economically in the global economy especially in steel and auto manufacturing, and semiconductors industries. In light of this development, government initiated several public policies to stimulate innovation and commercialize new technologies. SBIR program was born as one of these public policy responses.

The SBIR program was created in 1982 by the Small Business Innovation Development Act under the Regan Administration. As one of the nation's several innovation programs, it is instituted to stimulate technological innovation among small private sector businesses while providing government agencies new, cost effective technical and scientific solutions to meet their diverse mission needs. This private public partnership program offers competition based awards to provide early stage financial support for high risk technologies with commercial potential.

The program is structured in three phases:

- **Phase I** awards are funded for approximately 6 months and are up to \$100,000<sup>3</sup>. This phase is considered as the start-up phase where the proof of concept study is performed. The award winner uses the funding to execute a feasibility study to establish the technical and commercial merits of the proposed idea. At the end of this phase the funding Federal agency evaluates the idea and assesses the quality of the firm, and makes the decision about consideration for further funding, which is Phase II. Past data suggests that approximately 15 percent of SBIR participants that apply receive a Phase I award (Wessner, An Assessment of the Small Business Innovation Research Program, 2007).

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<sup>3</sup> \$100,000 funding corresponds to around five hundred person hours in a small business company with considerable overhead costs.

- **Phase II** awards are up to \$750,000<sup>4</sup> and last for as many as 2 years. This is the research and development phase. Only the Phase I projects with most technical and commercial potential move to this phase. The award winner develops a prototype or a working model of his proposed concept. Concurrently, the program investigator evaluates the commercial potential, performs market research and identifies potential commercialization partners. Past data suggests that 40 percent of Phase I winners reach this step.
- **Phase III** is the step where the commercialization happens. In this phase the prototype developed in Phase II program transitions from a controlled environment such as a laboratory to marketplace. There is no SBIR funding in this phase and no time limitations. However data suggests that commercialization usually happens in the first two years after Phase II completion (Wessner, An Assessment of the Small Business Innovation Research Program, 2007). To commercialize their product the small businesses are usually expected to find additional funding thorough public or private sources. Depending on the state of the product that is being developed the company could follow the following steps:
  - Sell the product directly in the marketplace;
  - Spin off as a separate entity;
  - License their technology and collect royalties;
  - Pursue follow-up production contracts issued by Federal agency;
  - Seek for third party investment from venture funding or prime contractors or private firms for further development;
  - Apply for additional SBIR awards for related work;
  - Apply for non SBIR research funding and contracts.

The three-phase structure of the SBIR program is illustrated also in Figure 1. As this figure summarizes, in funding various high risk technical programs during Phase-I and

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<sup>4</sup> \$750,000 Phase-II funding corresponds to approximately three thousand person hours after overhead costs are included.

Phase-II of the SBIR program, the government expects to capitalize on its investment in the form of tax revenue as a result of increased employment.

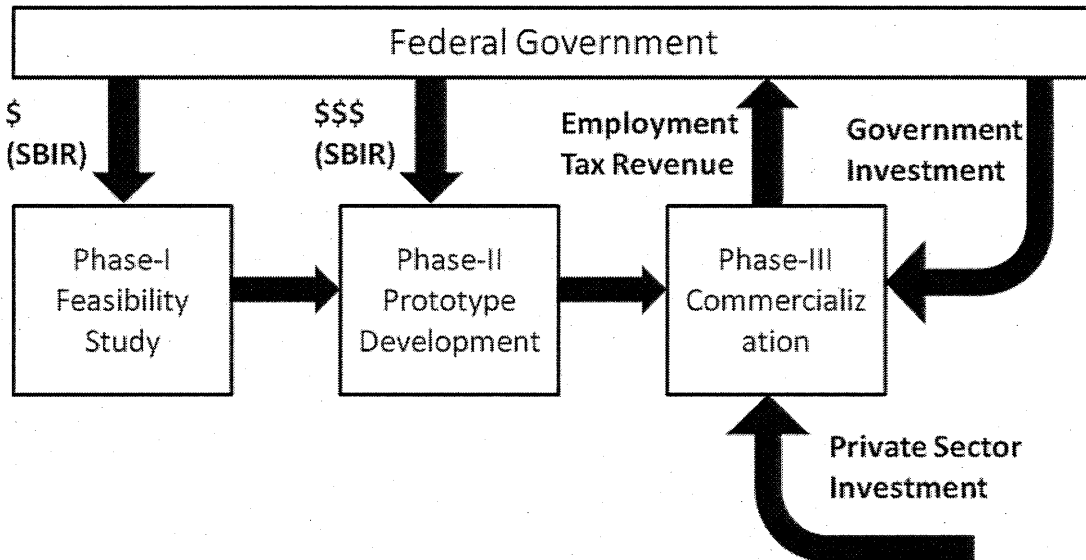


Figure 1: SBIR Program Structure

There is not a single recipe for successful transition from Phase II to commercialization, but usually if an idea has promising commercial potential, it attracts further investment to help the company bring their product into the marketplace.

However, entrepreneurs and small businesses must meet the following eligibility criteria to participate in the SBIR program:

- American-owned and independently operated;
- For-profit;
- Principal researcher employed by business;
- Company size limited to 500 employees.

The program currently mandates that all federal agencies with an external R&D budget over \$100 million annually set aside 2.5% of this money for awards to small businesses. This requirement occasionally makes the funding agencies perceive this set-aside money



as a tax on their budget (Wessner, An Assessment of the Small Business Innovation Research Program, 2007), which as a result reduces the effectiveness of the program. There are currently eleven federal agencies participating in this program, and they have disbursed over \$1.85 billion in year 2005. Of these eleven federal agencies, five are administering over 96 percent of the program's funds as of year 2005. They are the Department of Defense (DoD), the National Institute of Health (NIH), the Department of Energy (DoE), the National Aeronautics and Space Administration (NASA), and the National Science Foundation (NSF). These agencies support research using both grants and contracts.

The program goals have not changed since it started in 1982, and are fourfold (Wessner, An Assessment of the Small Business Innovation Research Program, 2007):

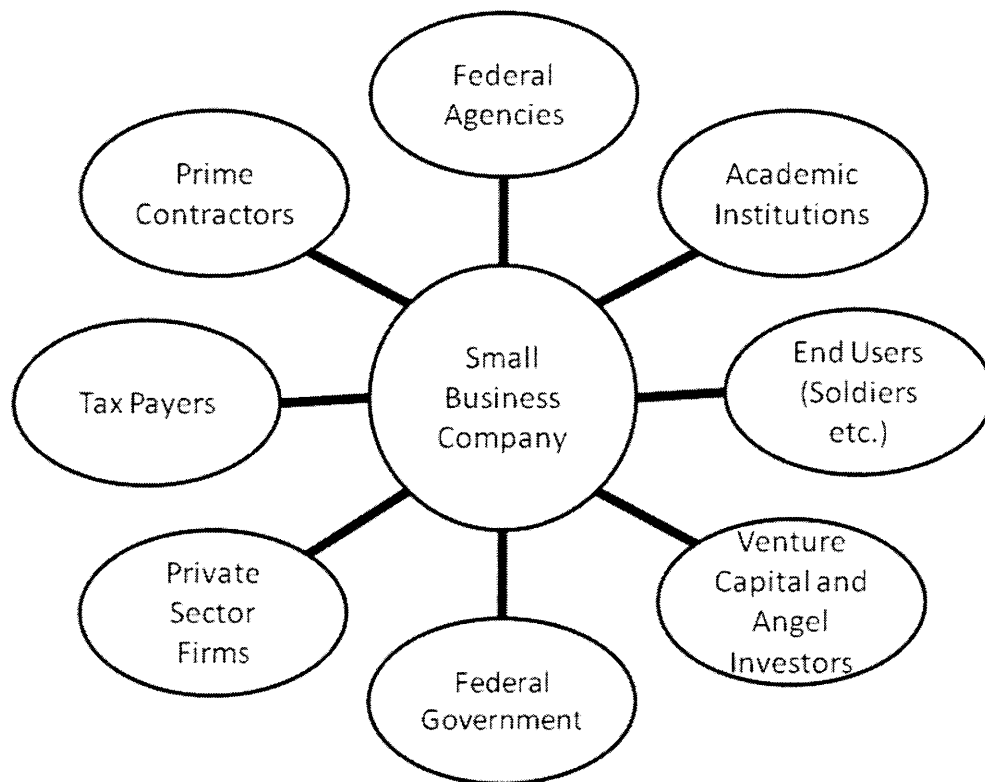
- 1) To stimulate technological innovation;
- 2) To use small business to meet Federal research and development needs;
- 3) To foster and encourage participation by minority and disadvantaged persons in technological innovation; and
- 4) To increase private sector commercialization of innovations derived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

This program is especially advantageous for entrepreneurial small businesses, as the funded firms retain the rights to intellectual property developed using SBIR award. There are no royalties owed to the federal government. However, the government retains royalty free use for a period.

The companies looking for funding from SBIR program go through a rigorous award selection process. While every agency uses a different approach for selecting the most promising idea, weight is put on the following points with descending order (U.S. Small Business Administration Technology Resources Network, 2007):

- The soundness, technical merit, and innovation of the proposed approach and its incremental progress toward topic or subtopic solution.
- The qualifications of the proposed principal/key investigators, supporting staff, and consultants. Qualifications include not only the ability to perform the research and development but also the ability to commercialize the results.
- The potential for commercial (government or private sector) application and the benefits expected to accrue from this commercialization

Being a public private partnership, SBIR program involves several stakeholders. While the dynamics of the SBIR ecosystem is fairly complex with interactions between several entities, a simplified stakeholder diagram is presented in Figure 2. The small business company is at the center of this ecosystem. Its primary stakeholders are the federal agency funding the program, prime contractors, private sector firms and academic institutions. The secondary ones are tax payers, venture capital firms, and federal government.



**Figure 2: SBIR Program Stakeholders**

## **1.2. Motivation and Significance of Problem**

There are two different motivations behind seeking a funding from SBIR program. First one is product oriented, where the small business identifies a federal agency need that aligns well with the company's competency, experience, and business model, and responds to the opportunity with the objective of commercialization at the end of program. The second one is more research oriented, where the small business focuses more on solving the federal agency's need, than commercializing. The major difference between the two is the difference in their priorities. The product-oriented approach gives priority to commercialization and puts the goal of meeting federal agency needs as secondary. Whereas research oriented approach gives priority to meeting federal agency needs and hopes commercialization follows.

Product oriented small business are usually composed of a small number of people, mainly focused on a product idea. Their ultimate goal in seeking funding from SBIR program is to capitalize on their science based high technology idea as soon as possible while protecting themselves from knowledge spillovers (Lerner, *The Government as Venture Capitalist: The Long-Run Impact of the SBIR Program*, 1999). Therefore the commercialization objective of the product oriented entrepreneurs and the SBIR program overlap extensively. While the SBIR funding from Phase I and Phase II programs can earn small businesses a fee in the order of 7% of the program money, they do not start making profits until after they commercialize their product ideas. Only after then these firms start realizing a return on investment. Therefore there is a very strong incentive for these companies to turn their ideas into products through commercialization.

On the other hand, research oriented small businesses are usually well-established companies with a long history of receiving SBIR funding. These companies' revenue streams depend heavily on SBIR funds and their priority is mainly keeping the customer [in this case the funding federal agency] happy by meeting their needs. While the work done by these firms achieve the number one objective of SBIR program: meeting federal

agency needs, these firms have historically underemphasized the commercialization objective of SBIR.

However, with the increased emphasis on commercialization during the award process, there is also a great incentive for these research-oriented firms to commercialize their product ideas.

In summary, both types of companies have strong incentives for commercialization:

- 1) Product oriented companies commercialize because this is where the money is;
- 2) Research oriented companies commercialize because otherwise they will be negatively evaluated by the funding federal agency during award selection process -unless they have an above average commercialization track record [kept by the federal agency - CAI]

Therefore, an investigation of correlations between commercialization and various SBIR program characteristics can reveal important facts that can then be used to develop successful commercialization strategies. In this study we will focus on only research oriented small business companies (#2).

### **1.3. Research Questions and Objectives**

This research study evaluates the correlation between the commercialization success rate and the following:

- 1) Experience<sup>5</sup> of the Principal Investigator;
- 2) Dollar amount of SBIR funding from Phase-I and Phase-II programs;
- 3) Dollar amount of investment received following the completion of the Phase-II program from sources other than funding federal agency;
- 4) Reuse of knowledge gained from another SBIR or non-SBIR funded project;
- 5) Presence of a commercialization partner such as prime government contractor or private sector firm at the beginning of the program.

The objectives of this study are summarized as follows:

- 1) To find correlation between commercialization success and various program characteristics;
- 2) To make recommendations based on these findings.

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<sup>5</sup> In terms of number of years.

#### **1.4. Literature Review**

While much research has been done on commercialization of privately funded high technology innovations, SBIR program, specifically commercialization of SBIR funded programs, has attracted little interest from academia. Therefore the amount and variety of publications on this topic are limited. The limitations on the collection and dissemination of this highly proprietary data by the SBIR program office further limited the access to research materials and discouraged any potential interest from academia.

For example, the paper “Bringing Science to Market: Commercializing from NIH SBIR Awards” (Link & Ruhm, 2008) focused specifically on the management of the overall SBIR program. It assessed the commercialization success of the SBIR program in general for projects funded by NIH. This study statistically analyzes the SBIR program relative to its stated objectives.

Another paper published on a relevant topic was “The effects of government-industry R&D programs on private R&D: the case of the Small Business Innovation Research program” (Wallsten, 2000). Scott Wallsten questioned the success of SBIR program in achieving its objectives, and tried to answer if SBIR program actually increases innovation activity.

The publication “When does Funding Research by Smaller Firms Bear Fruit?: Evidence from the SBIR Program” (Gans & Stern, 2003) is another study published on the topic. In this study, Gans & Stern quantitatively prove that project performance is highest for SBIR projects in industrial segment which receive the most venture financing.

Research so far focused mainly on the management of the SBIR program and policy recommendations to improve SBIR performance and it lacks the perspective from a single company point of view. Our study hopes to fill this gap by providing a more practical analysis of the SBIR program’s commercialization aspect. It differs from the

others in that it analyzes and examines commercialization in at one specific SBIR company.



## **1.5. Thesis Flow**

This study is organized in four chapters.

In Chapter 1 we outline the motivation behind this research, identify the research questions we will be answering and include a brief literature review on the commercialization of SBIR funded projects. In this chapter we also present a short background on SBIR program.

In Chapter 2 we review the methodology used to evaluate the research questions presented in Chapter 1. A short overview of the company from which we have collected the data, will be given, and the data set we used to find the correlation between commercialization and several program entities will be presented in detail. The key assumptions we have made regarding the data will be highlighted.

In Chapter 3 we will step through the study results and analysis. We will present the analysis procedure. We will regress several SBIR Phase II program parameters such as experience of the Principal Investigator, existence of pre funding and involvement of external commercialization partners from either private sector or from prime contractors on commercialization success of these programs, and we will present the correlation between these entities.

In Chapter 4 we present our findings, summarize the conclusions of this study and provide recommendations for future work.

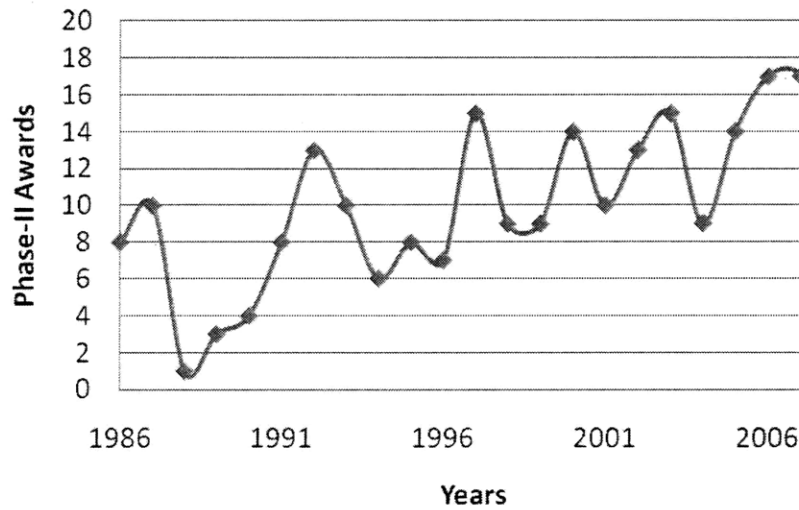
## **2. RESEARCH METHODOLOGY**

In this chapter we will present the methodology we have adopted during this research study. We will give background information about the participating company, and the principal investigators. Then we will introduce the dataset we have compiled using the company's commercialization report and the SBA Tech-Net database (DoD SBIR 09.1 Solicitation Instructions, 2009). Additionally we will explain the assumptions we made during dataset compilation. Finally we will explain the steps we followed in putting together the dataset.

### **2.1. Data Set**

The data collected and analyzed in this study is from a small business company that uses SBIR program funding for most of its commercialization activities. The company is headquartered in Massachusetts and has an employee count of approximately 150, composed of mainly scientists and engineers from various backgrounds. The company has been in the contract research and technology development business for over 35 years and serves both government and commercial customers. While the government funded projects was its number one source of income during the early phases, there is now a good balance between its commercial and government customers. Today SBIR funding accounts for around 45% of its revenues and is in a declining trend. This is due to increasing revenues realized from applied research performed for commercial customers using technologies developed under SBIR program and commercialization of SBIR programs in late eighties and early nineties. While these few early commercialization successes helped the company generate revenues even to this day, sustainable revenue growth is only achievable if the company can successfully commercialize more of the Phase-II programs it receives, because continuous revenue stream from these early commercialization hits will gradually diminish.

The dataset covers the Phase-II programs received by the company over the past twenty-five years, since the first time it was awarded a Phase-II funding from the SBIR program office in 1984. The total number of awards analyzed in this study is approximately two hundred and fifty. Only Phase-II awards are considered, as these are the ones that result in commercialization activities, receive investment and generate revenues. The distribution of the number of awards received over this period is presented in Figure 3. The award distribution reveals a strong positive overall trend with varying sizes of cyclic behaviors. This could mainly be associated to the increased number employees.



**Figure 3: Distribution of Number of Phase-II Awards Received by the Company since 1984**

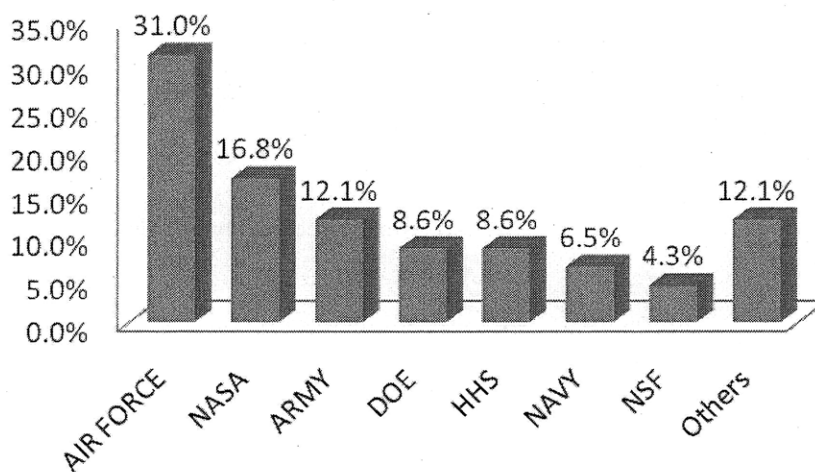
The two hundred and fifty Phase-II programs studied in this research were owned by approximately eighty different principal investigators. This means some investigators had more than one program.

These principal investigators had a diverse range of educational and professional backgrounds. The distribution of their backgrounds is presented in Table 1. An important point to note is that more than 80% of the Phase-II award winners had PhDs.

**Table 1: Distribution of Principal Investigator Background**

<b>Background</b>	<b>Percentage</b>
<b>Physics</b>	35%
<b>Chemistry</b>	30%
<b>Electrical Engineering</b>	8%
<b>Mechanical Engineering</b>	7%
<b>Aero/Astro</b>	5%
<b>Other</b>	15%

Similar to the principal investigator backgrounds, the U.S. federal agencies from which the awards were received were also diverse. U.S. Air Force funded projects constitute around 31% of the total, and represent the highest in the list almost twice as much as the immediate follower. The distribution of all agencies that funded the Phase-II programs over the past 25 years is presented in Figure 4.



**Figure 4: Distribution of Agencies for the Analyzed Phase-II Programs**

## **2.2. Procedures**

The dataset, that we used to investigate the correlations between the commercialization success and various program characteristics, was compiled from the following four different sources:

- 1) Company commercialization report;
- 2) U.S. Small Business Administration Tech-NET database<sup>6</sup>;
- 3) Company intranet;
- 4) Interviews with program investigators.

The company commercialization report is used to extract financial information regarding the company's commercialization activities over the time of interest, which starts the year the company is awarded its first Phase-II award. The report is proprietary, hence is not publicly available. [Explain further the Company Commercialization Report]. The two important key figures 1) Total sales amount and 2) Non-SBIR investment amount are calculated for each Phase-II program, using the data presented in the report.

Total sales amount is one of the key variables and we will use it to assess the commercialization success of the company during the analysis. This key variable is calculated as the sum of the following five sale sources as reported in the commercialization report:

- 1) Department of Defense and its prime contractors<sup>7</sup>;
- 2) Other Federal agencies;
- 3) Foreign countries (export);
- 4) Private sector;

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<sup>6</sup> Tech-Net is a web based search engine for researchers, scientists, state, federal and local government officials. It provides resources and information for and about small high technology businesses, and works as a bridge between these companies and potential investment sources.

<sup>7</sup> Examples to prime contractors are Raytheon, Boeing etc.

- 5) Anything other than the four above.

The report also includes additional investments other than the SBIR funding and breaks it down further into the following four categories:

- 1) Investment from Department of Defense;
- 2) Investment from other Federal Agencies;
- 3) Investment from Private sector<sup>8</sup>;
- 4) And investment from other sources;

The non-SBIR investment amount is calculated by summing the investment under these four categories for each Phase-II program in the report. This is also a key variable and it will be used to investigate the relationship to the commercialization success of the program.

As the data we are using in this study spans over 25 years, we normalized the sales and investment values by converting them into present value of money. In doing so, we used the Consumer Price Index (CPI) published by United States Dept of Labor, Bureau of Labor Statistics.

After the data in the commercialization report is extracted, we looked at U.S. Small Business Administration Tech-NET database to extract Phase-I and Phase-II program funding. We searched for the Phase-II programs the company was awarded and cross-referenced the topic numbers and identified the associated Phase-I and Phase-II funding. We call the total of these two as SBIR funding amount, another key variable; the effect of which we are investigating on the commercialization success of the program. The maximum funding awarded by SBIR program to companies for Phase I and II has remained constant since 1990, resulting in an erosion of value, and possibly affecting the

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<sup>8</sup> This includes venture capital and angel investments as well as prime contractor and private firm investments.

commercialization success, as some claim (Wessner, 2007). Through our investigation, we are hoping to also put this hypothesis to test.

Furthermore we have extracted the name of the principal investigator from the database. This information is then cross-referenced to PI information that is available from our third source, the Company Intranet to estimate the experience level. This is another key variable as our study investigates whether a correlation is evident between the experience of the PI and the commercialization success. Quantifying a professional's relevant experience to the program is neither straightforward nor easy. Hence we chose a consistent view and calculated experience as the number of years working as a professional (irrespective of whether the experience is relevant or not) since the graduation date of the last institution the PIs graduated from.

As the final step of the data collection phase, we have personally interviewed several principal investigators whose programs are included in the commercialization report. The interviews were conducted to gather qualitative data and to address the following specific questions:

1. If knowledge gained from another SBIR or non-SBIR funded project is utilized in their current projects.
2. If a commercialization partner such as prime contractor or private sector firm was identified at the beginning of the Phase II.

While we conducted the interviews for qualitative data, we chose to ask only questions that can be answered with a "yes" or "no" (i.e. dichotomous) to keep data reliability to a maximum.

At its final stage the completed dataset included the key information shown in Table 2.

Table 2: Collected Data and its Range

<b>Variable Name</b>	<b>Range</b>
<b>Phase-II Award Year</b>	1985 - 2005
<b>Total SBIR Funding</b>	\$200,000 to \$2,000,000
<b>Total Sales Amount</b>	\$0 to \$21,000,000
<b>Additional non-SBIR Investment</b>	\$0 to \$19,000,000
<b>PI Work Experience</b>	2 to 38 years
<b>Previous Knowledge Utilized<sup>9</sup></b>	Yes or No
<b>Presence of Commercialization Partners</b>	Yes or No

### **2.3. Assumptions**

#### **Assumption #1**

The effect of inflation on all monetary variables was taken into account during this study since the data set applies to two and a half decades of time. Instead of applying the CPI index for every individual year, we used the average (3.9%) over the same period as published by Dept. of Labor. The actual versus the average CPI index is presented in Figure 5.

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<sup>9</sup> Answer is yes or no (dichotomous).



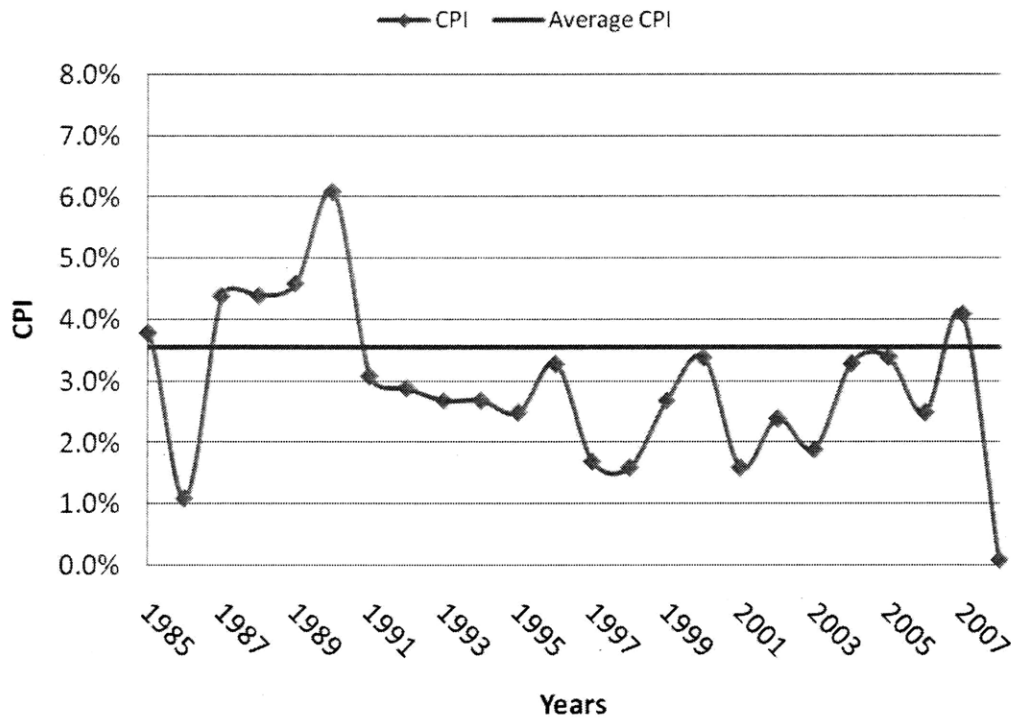


Figure 5: CPI and Average CPI from 1985 to 2007

## Assumption #2

In the company commercialization report, total sales amount for each program is listed as a lump sum instead of being broken down by the years in which the revenue was materialized. To normalize the effect of time on this key variable, we made the following assumptions in our calculations:

- All of the sales revenue is materialized within five years of Phase II completion. Five years is chosen as it usually represents an average life-cycle for a high-tech, cutting edge product
- The sales revenue is equally distributed among the assumed five years of commercialization.

- Sales revenue starts to materialize within three years after completion of Phase II program.

### **Assumption #3**

Approximately 2% of the data queried in Tech Net database did not return any results for SBIR funding. However, this data contained invaluable commercialization information and hence we didn't omit the whole record. Instead, we used the average SBIR funding for that specific year across all projects to estimate the missing SBIR funding amount.

### **Assumption #4**

Although the dataset covers up to and including year 2008, we have only considered data for projects up to 2006. We believe the commercialization data for more recent projects would be incomplete and that using such data would skew our results. Thus we omitted projects starting after 2005.

### **Assumption #5**

Considering the length of time our dataset covers, we were not able to interview every PI. Thus we have filled in the gaps of information with:

- Discussions with respective area managers;
- Interpolating from other projects based on similarity to other programs;
- Based on our self-assessment of the program.

### **3. ANALYSIS and STUDY RESULTS**

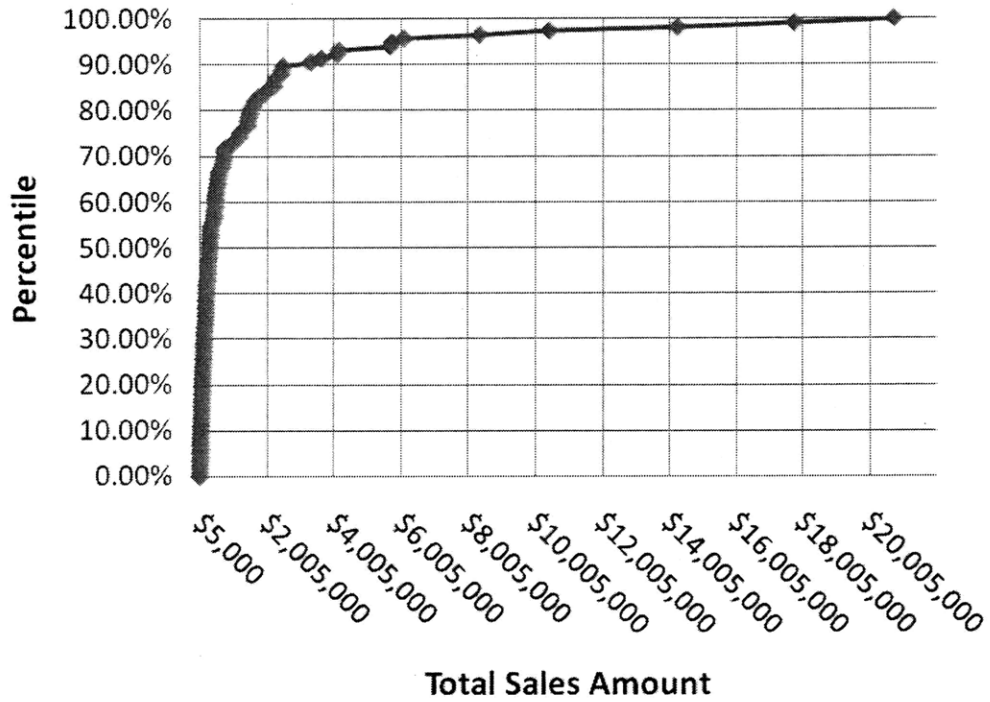
In the previous chapter we have laid down the groundwork for the data and presented the methodology. And in this chapter we will analyze the data set that we have collected and combined from several different resources and present the study results.

Throughout this chapter commercialization success will be our main metric, and we will evaluate the correlation between this metric and the following:

1. Experience of the Principal Investigator;
2. Dollar amount of SBIR funding from Phase-I and Phase-II programs;
3. Dollar amount of investment received following the completion of the Phase-II program from sources other than funding federal agency;
4. Reuse of knowledge gained from another SBIR or non-SBIR funded project
5. Presence of a commercialization partner such as prime government contractor or private sector firm at the beginning of the program.

Commercialization is an open ended concept and needs to be defined and quantified in the context of our analysis. We evaluate commercialization success based on the revenues generated following completion of Phase II program. To eliminate outliers, we defined a threshold of 10 percentile of the revenue stream. To calculate the sales amount that corresponds to 10 percentile threshold we plot the total sales revenue distribution, including the programs that have generated sales. The result is illustrated in Figure 6. This plot can be considered as the cumulative distribution function of the sales revenue where x-axis represents the sales revenue, and the y-axis represents the percentage of programs having sales revenue up to that point. Since the distribution is heavily skewed, a zoomed-in version is presented in Figure 7; showing that the 10 percentile point corresponds to approximately \$25,000 total sales amount. Throughout this study, we will only consider those programs with higher than \$25,000 total sales revenue as

commercially successful. Using this type of dollar threshold simplifies the evaluations by allowing us define the commercialization success as a dichotomous variable.



**Figure 6: Distribution of Sales Revenue – Cumulative Distribution Function**

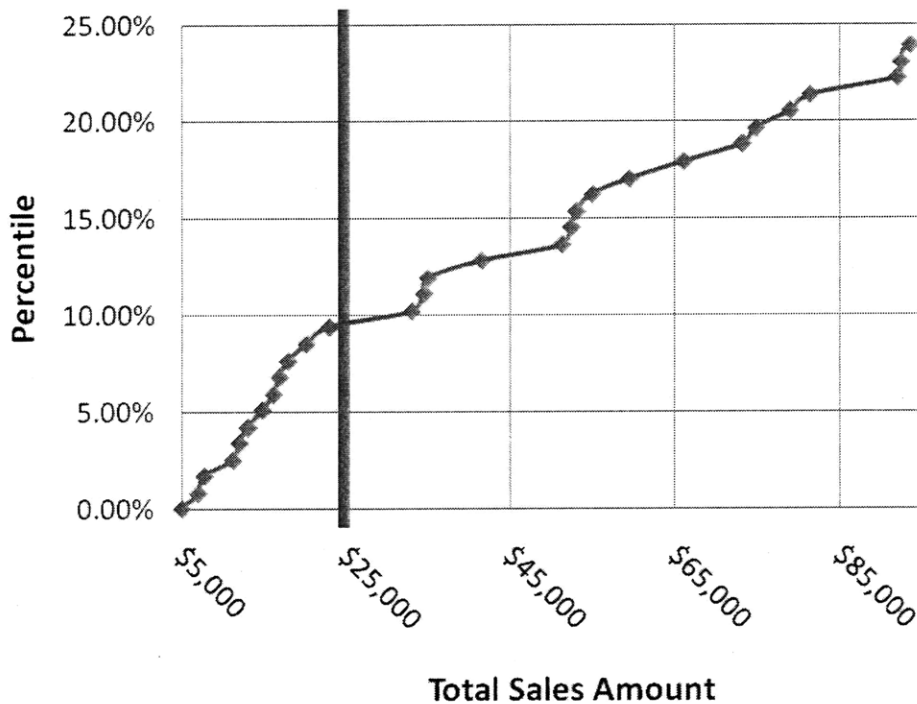
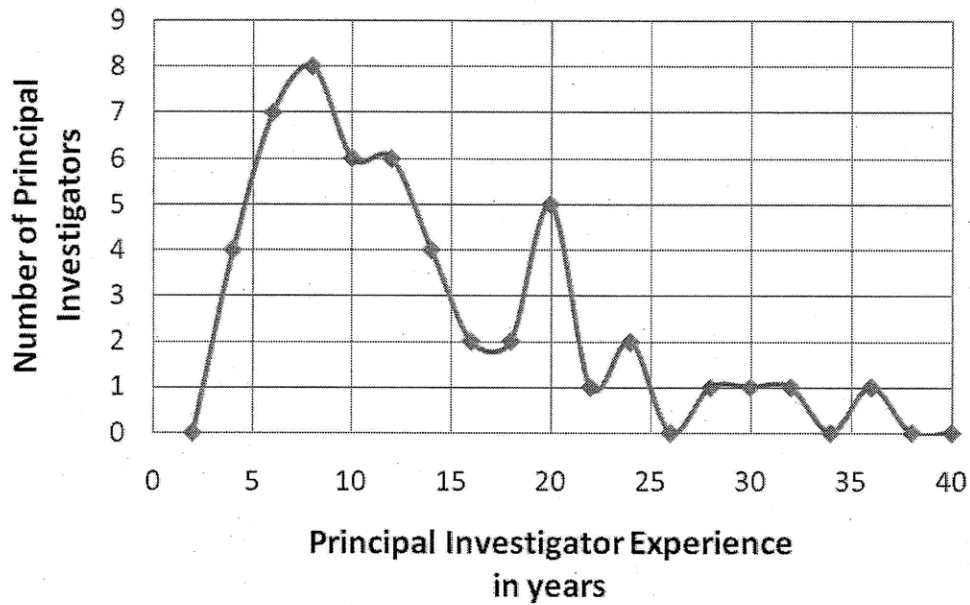


Figure 7: Distribution of Sales Revenue – Cumulative Distribution Function (Zoomed-In)

### Experience of Principal Investigator

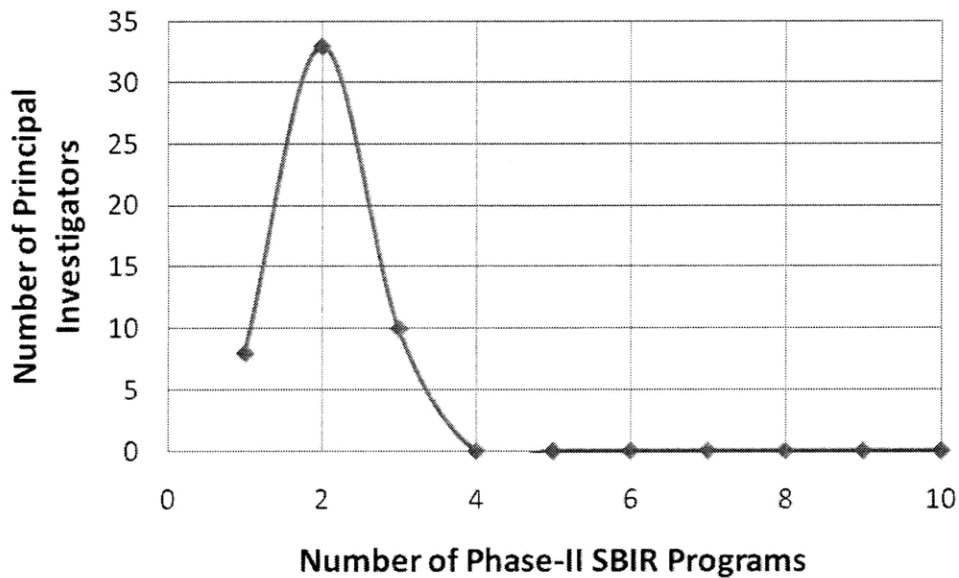
We calculated the experience of the principal investigator at the time Phase II was awarded for each commercially successful project to identify the existence of a correlation between principal investigator experience and commercialization success.

The resulting plot is presented below in Figure 8. While the experience distribution is skewed towards 8 years, there is no obvious correlation between the commercial success of a Phase II program and the experience level of its principal investigator. The skewing may be attributable to the fact that the company employed more people with this amount of experience.



**Figure 8: Relationship between Principal Investigator Experience and Commercialization**

Thus we shifted our focus to another possible parameter instead of principal investigator experience. We've looked at each individual principal investigator and calculated the number of Phase II programs he/she worked on before achieving the first commercially successful Phase II program. The resulting plot is presented in Figure 9. It is obvious from this analysis that the majority of principal investigators worked on at least one Phase II program before they achieved their first program with revenues of higher than \$25,000.



**Figure 9: Number of SBIR Ph-II Programs the Principal Investigator Works on Before Achieving Commercialization Success**

This result is expected since the principal investigator builds up not only technical knowledge from the first Phase II program, but also an understanding of the SBIR funding eco-system, expectations of Federal Agencies and develops contacts from the first one. Based on this finding we suggest developing a mentorship program to accelerate the acquisition of this knowledge and experience or compensate for lack of it.

### **SBIR funding from Phase-I and Phase-II programs**

The next parameter we looked into is the amount of SBIR funding from Phase I and II programs combined. For this analysis, we considered the whole data set and created a dichotomous variable for commercialization status where the number one (1) indicates commercially successful (total sales revenue  $\geq$  \$25,000) programs and number zero (0) indicates the opposite where revenues are less than \$25,000. We then plotted the amount of SBIR funding received for these programs. We used the present value of the funding amounts to be able to fairly compare programs. This plot is shown in Figure 10. It

suggests that for the data set under investigation, there is no evident correlation between the commercialization status of a Phase II program and the total amount of SBIR funding the program receives. However, this doesn't mean that there is no correlation at all. We would suggest expanding the data set to other companies and re-evaluating the correlation results.

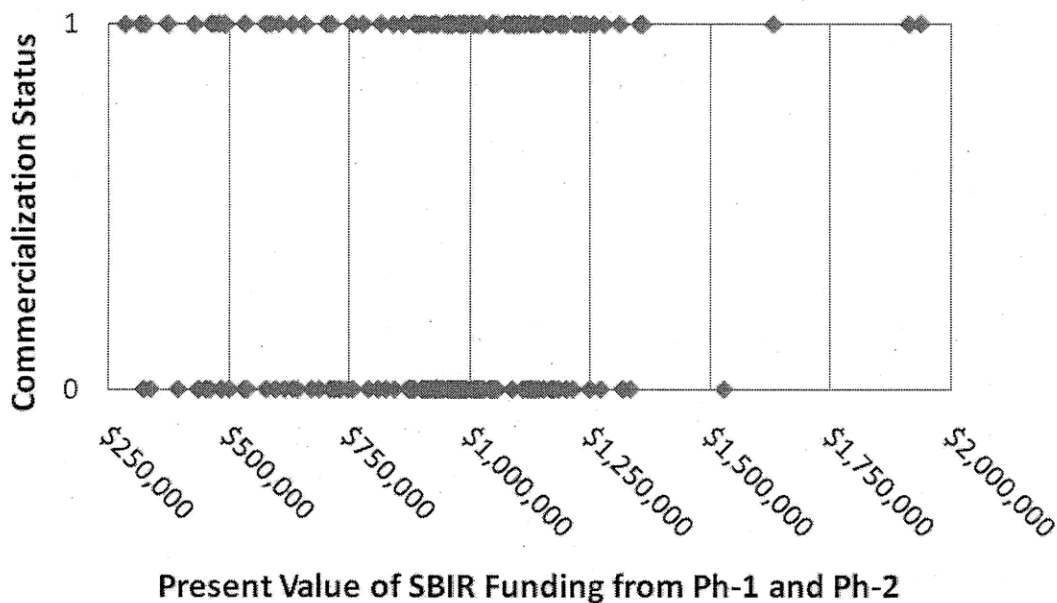


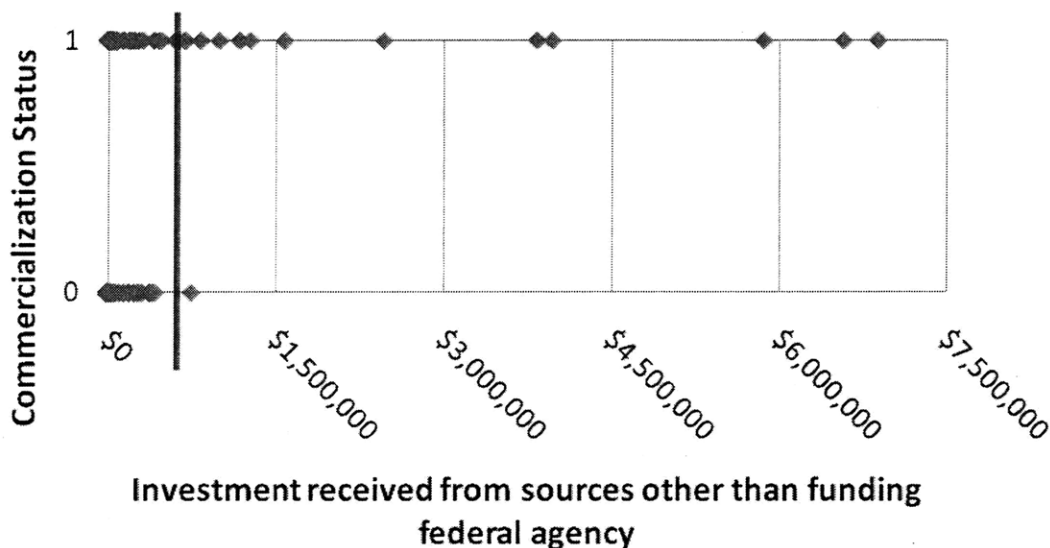
Figure 10: Relationship between SBIR Funding Amount and Commercialization

In this analysis, we used a monetary parameter, mainly because our data set consists of one company's data. However, a better metric that can be used for the analysis of an expanded data set with multiple companies would be man-hours. This would normalize the differences among rates charged by different companies, accounting for differences not only for direct labor and materials but also overhead and administrative costs.

### Investment received from sources other than funding federal agency



Another significant parameter we studied is the investment received from non-SBIR sources including from Department of Defense, other Federal Agencies, Private sector and other sources. For this analysis, we considered the whole data set and created a dichotomous variable for commercialization status where the number one (1) indicates commercially successful (total sales revenue  $\geq$  \$25,000) programs and number zero (0) indicates the opposite where revenues are less than \$25,000. We then plotted the net present value of investment received from all sources other than the funding federal agency for these programs. This plot is shown in Figure 11. As the Figure indicates, programs that attract an additional investment of over \$400,000 have a higher chance of achieving commercialization success.



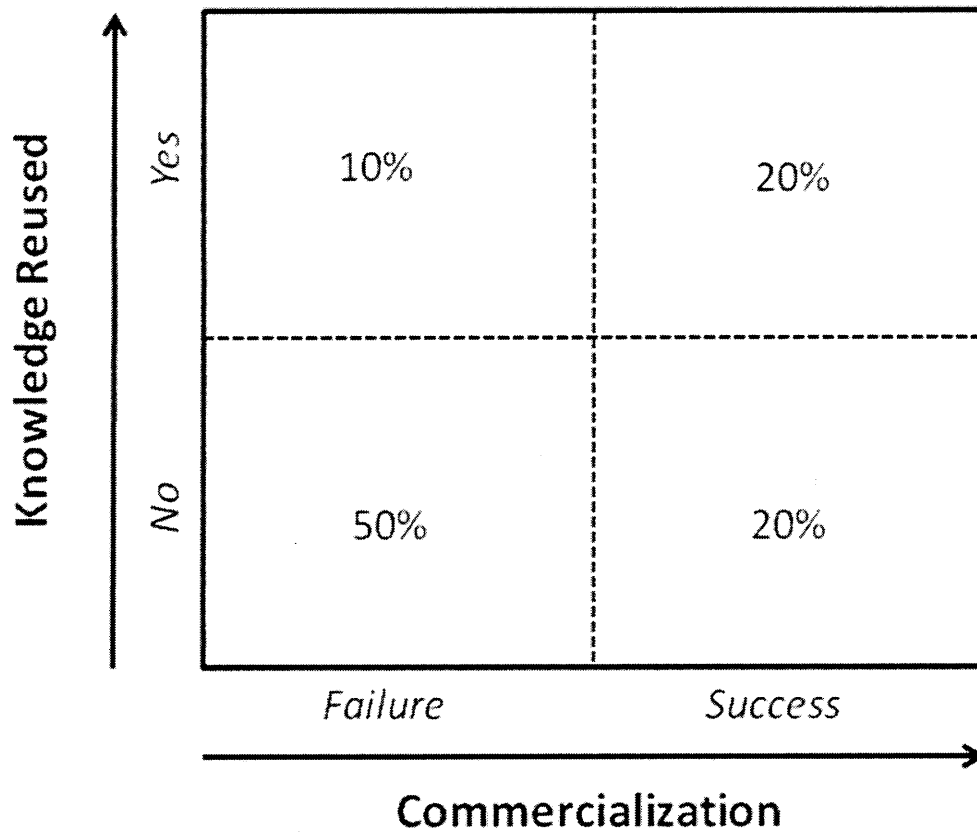
**Figure 11: Relationship between non-SBIR Investment and Commercialization**

However, whether the additional investment increases the chance of commercialization or if the commercialization potential of the project attracts additional investment cannot be deduced from the data set we have available. But commonsense and our finding suggest that additional investment backed up by a sound technical idea definitely increases commercialization. Therefore identifying potential users of the product allows us to find out the potential investment sources early in the program and develop the program with an emphasis on commercialization.

## **Reuse of knowledge gained from another SBIR or non-SBIR funded project**

Another factor we investigated in determining commercialization success is the possible reuse of knowledge gained from another SBIR or non-SBIR funded project. This factor is especially important since the main objective of any research and development project is the accumulation of particular knowledge to be used in an application or to be the basis of further research. Thus it's only logical to expect that reuse of knowledge should increase chances of commercialization.

We compiled our findings from our interviews about the reuse of knowledge gained from another SBIR or non-SBIR funded project in relation to commercialization success in Figure 12. Based on our findings, only 30% of the programs reused knowledge. While the statistical significance of this sample is a topic of discussion in itself, for the purposes of this study we will interpret the result as is.



**Figure 12: Relationship between Knowledge Reuse and Commercialization**

The results presented show that:

- 10% of projects in which knowledge was reused failed to commercialize, while 20% of projects in which knowledge was reused commercialized.
- 50% of projects in which knowledge was not reused failed to commercialize, while 20% of projects in which knowledge was not reused commercialized.

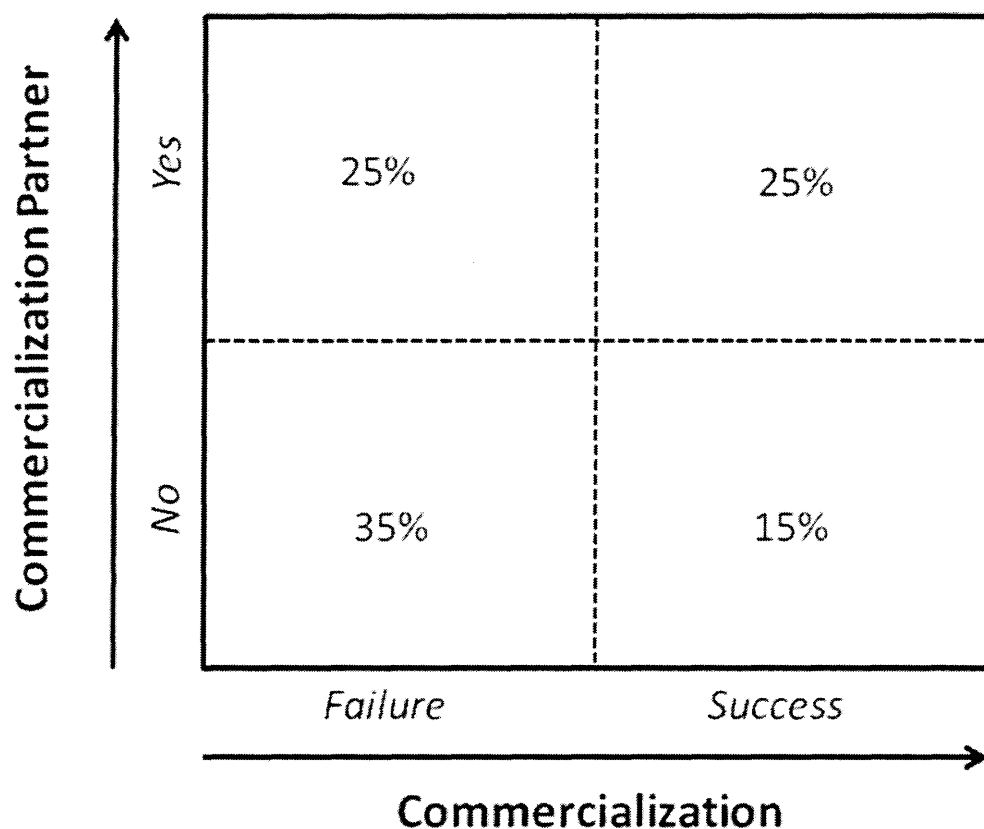
Out of the projects that knowledge was reused, two thirds commercialized, while this ratio was only one third for the projects that have not reused knowledge. While on the surface this would indicate a positive correlation, we would be cautious to do so due to the limited sample population of projects that reused knowledge.

Another important observation is the negative correlation between lack of knowledge reuse and commercialization. Of all the projects that we investigated, half did not reuse any knowledge and failed to commercialize.

### **Presence of a commercialization partner**

Another factor we investigated in determining commercialization success is the presence of a commercialization partner. Usually in projects of this nature the commercialization partner – if exists – either is directly linked to the user or has great familiarity with the end user. Most of the time, the end user is not the funding agency, funding agencies are merely enablers. Therefore having a commercialization partner enables a greater focus on customer needs and satisfaction rather than only on satisfying funding agencies' needs.

We present our findings about the presence of a commercialization partner in relation to commercialization success in Figure 13.



**Figure 13: Relationship between Commercialization Partner Presence and Commercialization**

The results presented show that:

- 60% of projects had a commercialization partner.
- 35% of projects with a partner failed to commercialize, while 25% of projects with a partner commercialized.
- 25% of projects without a partner failed to commercialize, while 15% of projects without a partner commercialized.

Of the projects that have commercialized 63% had a commercialization partner. This shows that the chances of commercialization increase if there is a partner with strong commercialization interest in the project. Also, 35% of all the projects didn't have a commercialization partner and they failed to commercialize. This strengthens our

argument that commercialization is positively correlated to having a commercialization partner helps.

## **4. CONCLUSIONS**

In this study we have evaluated the effects of the following factors on the commercialization success of a small business company competing for SBIR funding:

1. Experience of the Principal Investigator;
2. Dollar amount of SBIR funding from Phase-I and Phase-II programs;
3. Dollar amount of investment received following the completion of the Phase-II program from sources other than funding federal agency;
4. Reuse of knowledge gained from another SBIR or non-SBIR funded project
5. Presence of a commercialization partner such as prime government contractor or private sector firm at the beginning of the program.

Throughout this study we have defined an SBIR program as commercially successful if it had generated sales revenue greater than or equal to \$25,000 following the completion of the SBIR Phase-II program. The following chapter summarizes the findings of our study.

### **4.1. Conclusions**

#### **Experience of Principal Investigator**

There is no correlation between the experience of the principal investigator and the commercialization success of the program. Even though the results revealed some skew in the experience of investigator, this could very well be because of the fact that the company may have employed more people with this amount of experience during that time period.

However further investigation of the number of SBIR Ph-II programs the principal investigator worked on before achieving a commercialization success, showed that there is a strong correlation between this factor and commercialization success of the program.

The results revealed that for more than 65% of principal investigators who have successfully commercialized, it took at least one Phase II program before they achieved their success.

We tie this result to the fact that SBIR ecosystem with its large number of stakeholders is fairly complex, and it takes some time for the principal investigator to establish an understanding of this system, understand expectations of Federal Agencies and develop internal and external contacts. Based on this finding we suggest developing a mentorship program to accelerate the acquisition of this knowledge and experience or compensate for lack of it.

### **SBIR funding from Phase-I and Phase-II programs**

The investigation of effects of SBIR funding from Phase-I and Phase-II programs, on commercialization success of a program has revealed no correlation between them. However, this doesn't mean that the funding amount has no effect at all; it merely suggests that for the technologies the company is working on, the SBIR funding is large enough that it has no effect on commercialization. Further increase of the existing funding amount dramatically however could very well increase the commercialization percentage.

We would suggest expanding the data set to other companies and re-evaluating the correlation results using a better metric such as man-hours rather than monetary values in assessing the effects to normalize the differences among rates charged by different companies, accounting for differences not only for direct labor and materials but also overhead and administrative costs.

### **Investment received from sources other than funding federal agency**

We have found that investment received from sources other than funding federal agency has positive impact on commercialization such that programs that attract an additional



investment of over \$400,000 have a higher chance of achieving commercialization success.

However, whether the additional investment increases the chance of commercialization or if the commercialization potential of the project attracts additional investment cannot be deduced from the data set we have available. So we suggest conducting a further investigation using a larger dataset from several different SBIR companies.

### **Reuse of knowledge gained from another SBIR or non-SBIR funded project**

Study of relations between the reuse of knowledge gained from another SBIR or non-SBIR funded project and the commercialization success of that project did not reveal any strong correlation between these two. Among the projects that achieved commercialization, the percentage of the ones that reused knowledge is approximately same as the ones that have not, therefore a definite correlation cannot be deduced. However we believe there is a negative correlation between lack of knowledge reuse and commercialization. Of all the projects that we investigated, half did not reuse any knowledge and failed to commercialize.

### **Presence of a commercialization partner**

Another important finding was that the presence of a commercialization partner definitely helps. Given that the program is commercially successful, the chance of this project having a commercialization partner is twice higher than not having.

Due to the limitations in the data collected, however we would be cautious to say that it is directly a consequence of actually having a commercialization partner, there might be another underlying factor that affects the outcome.

## **4.2. Future Work**

In this study we have focused our efforts only on a single SBIR company. Due to the proprietary nature of the data needed for this research, access to this data was of uttermost concern. While we believe the projects conducted by this company represent a significant sample of the SBIR program population in general in terms of breath and depth of the program, we strongly believe further investigation with emphasis on more diversity with consideration of additional factors (variables) could prove useful for a wider target audience. The results of such a study can be used by;

- 1) **SBIR program office:** For guidance of funded companies in commercializing their technologies in minimum amount of time, with minimum amount of effort, and also gauging the effectiveness of the SBIR program as a whole in terms of satisfying one of the most important objectives - commercialization.
- 2) **SBIR companies petitioning for R&D funding:** For identifying the major drivers for commercialization of high technology ideas and understating their effect.
- 3) **Entrepreneurs:** In gauging possibilities of obtaining government funding for commercializing their product ideas.

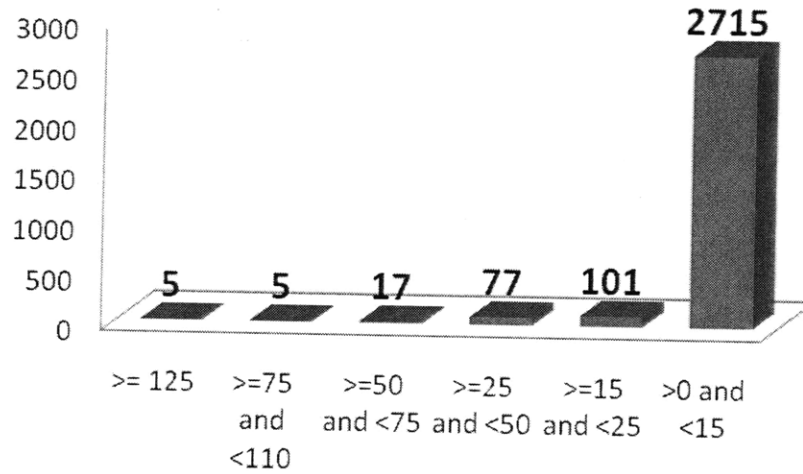
Such a study will no doubt require high concurrence from the government in terms of collecting the invaluable data in a format without affecting the competitive advantage of companies seeking SBIR funding – probably by either aggregating or anonymizing the data. This type of effort will require also identifying several more different variables. The decision on these variables will require revisiting the objectives of the study, and the expectations of the target audience.

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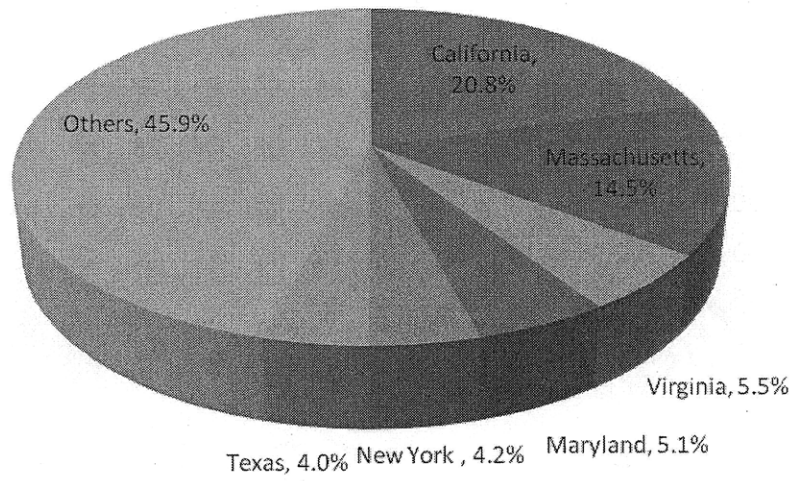
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## Appendix 1

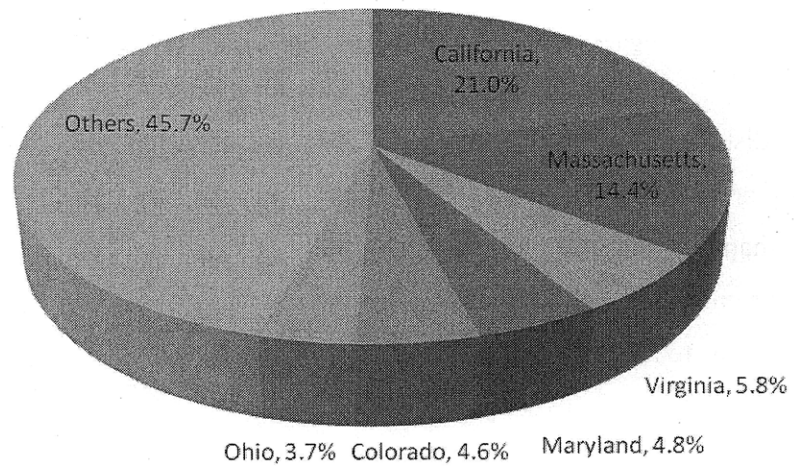


**Figure 14: Number of Phase-II Programs per Firm**

Geographical distribution of Phase-I and Phase-II awards received since the inception of the SBIR program until 2005, reveals that top two states; California and Massachusetts capture more than one third of the program budget. This could be associated to the fact that the close proximity of these states to high technology firms, venture capital and angel networks, as well as to highly innovative academic institutions.



**Figure 15: Geographical distribution of Phase-I SBIR Awards**



**Figure 16: Geographical distribution of Phase-II SBIR Awards**

## Appendix 2

Table 3: Excerpt from the compiled data-set

Ph-I Year	Ph-I Funding	Ph-II Year	Ph-II Funding	Total Funding (Present Value)	Agency	Total Sales	Total Investments	PI Experience	Commercialization Success	Knowledge Reused	Commercialization Partner
2006	\$99,986	2007	\$999,964	\$1,183,445	MDA	\$0	\$0	5	0	0	1
1986	\$50,000	1987	\$630,300	\$1,360,332	DARPA	\$1,436,586	\$0	7	1	1	1
1997	\$59,963	1999	\$486,960	\$750,769	Navy	\$0	\$66,364	19	0	0	0
1999	\$90,000	2000	\$224,990	\$398,205	EPA	\$0	\$3,907	5	0	1	0
2000	\$99,922	2001	\$700,000	\$1,025,873	DOE	\$0	\$17,250	6	0	0	0
2004	\$69,988	2005	\$224,877	\$328,625	EPA	\$122,704	\$0	10	1	0	0
2005	\$99,989	2006	\$749,954	\$932,890	OSD	\$0	\$0	15	0	0	0
2006	\$99,975	2007	\$999,945	\$1,172,355	MDA	\$0	\$0	16	0	0	0
2004	\$69,847	2005	\$599,797	\$759,689	NASA	\$0	\$0	13	0	1	0
2004	\$179,577	2006	\$888,309	\$1,166,135	HHS	\$140,450	\$54,683	14	1	0	0
2007	\$299,980	2008	\$594,244	\$915,371	NIH	\$0	\$0	16	0	0	0
2007	\$99,980	2008	\$749,888	\$876,554	AF	\$0	\$0	12	0	0	0
2005	\$99,851	2006	\$749,882	\$932,672	DOE	\$199,956	\$19,589	8	1	1	0
2005	\$69,923	2007	\$499,992	\$606,134	Navy	\$74,781	\$94	9	1	0	0