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# Probability of Small Business Innovation Research (SBIR) Commercialization as a result of Participating in the Navy's Transition Assistance Program

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**Probability of Small Business Innovation Research (SBIR)  
Commercialization as a result of Participating in the  
Navy's Transition Assistance Program**

By

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October 3, 2014

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Submitted by:  
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Under the Faculty Guidance of  
Ron Hira, Ph.D.

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of the Requirements for the Degree of  
Master of Science in Science, Technology and Public Policy

Department of Public Policy  
College of Liberal Arts  
Rochester Institute of Technology  
Rochester, NY  
October 3, 2014

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## Abstract

Commercialization (private sector or Non-SBIR federal funding) of federally sponsored innovations is a key congressionally mandated goal of the Small Business Innovation Research (SBIR) and Small Business Technology Transfer (STTR) programs. While much attention has focused on quantifying and assessing the commercial outputs of the SBIR program, limited research exists on the impact that business advisory support initiatives have on project commercialization. These programs, such as the Navy's Transition Assistance Program (TAP), seek to augment the business capacity of SBIR/STTR award recipients by providing information and resources focused on facilitating the commercialization process. I hypothesize that these programs increase the probability of commercialization success for participating SBIR Phase II projects. To test this hypothesis, I employed a logistic regression model exploring commercialization outcomes from participants and non-participants from the Navy's Transition Assistance Program (TAP). A dataset comprised of 993 Navy Phase II projects awarded between 2005 and 2008 was used to populate the model. The self-reported commercialization outcomes contained in the dataset include 537 Navy TAP projects, and a comparison group of 456 Navy Phase II projects who opted not to participate in the program during the years covered. The resulting analysis found that the odds of success given that a project participated in the Navy TAP ranged from 1.5 to 6.2 times the odds of success for a non-participating project, depending upon firm characteristics. It was also found that for every dollar invested in the Navy TAP, \$38 dollars in commercialization outcomes were generated. This research demonstrates that external business support can be an effective policy option for impacting the probability and magnitude of SBIR commercialization success.

## 1. Introduction

The Small Business Innovation Research (SBIR) program was established in 1982 to strengthen the role innovative small businesses play in conducting federally funded research. In addition to fostering innovation, the SBIR program sought to make use of, “small business to meet Federal research and development needs” (Small Business Development Act, 1982). In 1992, its sister program, the Small Business Technology Transfer (STTR) program was established, and required small businesses to partner with research institutions in an effort to bridge the gap between basic research and commercialization (Small Business Research and Development Enhancement Act, 1992). SBIR and STTR are three phased programs which require federal agencies to set-aside a portion of their extramural research and develop budgets for competitively awarded grants or contracts to small businesses. Federal agencies with extramural research and development budgets greater than \$100 million, are required to set-aside no less than 2.8 percent of those funds for the SBIR program, and agencies with extramural research and development budgets greater than \$1 billion are required to set-aside no less than .4 percent of those funds for the STTR program.<sup>1</sup>

Eleven federal agencies are required to participate in the SBIR program because they meet or exceed the extramural research and development budgetary threshold. Five of these agencies also meet the requirements for the STTR program (Department of Defense, Department of Energy, Department of Health and Human Services, National Aeronautics and Space Administration, and the National Science Foundation). For FY2011 the cumulative extramural research and development budget across the eleven participating agencies was approximately \$84.6 billion, and funds obligated from the SBIR/STTR programs were close to \$2.5 billion (SBA Annual Report, 2011). SBIR/STTR funds are provided to awardees during Phase I (feasibility study) and Phase II (research and development) of the program; however, SBIR funds are not allowed during Phase III, the commercialization phase. Although the responsibility of commercializing the federally sponsored research remains with the small business, in response to increasing congressional interest on commercial outputs of the program, federal agencies have sought to impact

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<sup>1</sup> Prior to the 2011 reauthorization of the program, the set-a-side was 2.5 percent for SBIR, and .3 percent for STTR. The reauthorization increases the SBIR set-a-side to 3.2 percent by FY 2017, and the STTR set-a-side to .45 by FY2016.

commercialization by developing and administering commercialization/transition assistance programs (henceforth referred to as commercialization assistance programs).

The birth of the SBIR concept traces back to the Research Applied to National Needs (RANN) program established in the 1970s at the National Science Foundation (NSF). The program sought to engage the private sector and shift NSF towards more applied research in an effort to stimulate innovation and economic benefit from federal research and development funding (Green & Lepkowski, 2006). The RANN program sought to address current and emerging societal concerns by identifying technical problems and soliciting solutions from the private sector (e.g. academia and industry), fund studies to demonstrate the feasibility of their solutions, and then transfer the developed ideas to the commercial sector (Green & Lepkowski, 2006). A component of the RANN program called for NSF to set-aside ten percent of the budget for small businesses, which in 1982 only shared in 3 percent of federal research and development funding (Small Business Research and Development Enhancement Act, 1992). This structure and small business set-aside lead to the creation in 1976, by Roland Tibbetts, administrative officer of RANN, of the SBIR program. In establishing the program Mr. Tibbetts sought to leverage the cutting edge capacity of small firms by testing as many high risk technical ideas as possible (SBIR/STTR Reauthorization Act Report, 2009). While the RANN program ended in the late 1980s, the SBIR program survived and became law with the passing of the Small Business Innovation Development Act of 1982. In establishing the program, Congress sought to leverage small innovative firms to stimulate technological innovations that met both agency and national economic needs (Small Business Development Act, 1982).

The national policy goal of leveraging federal research and development to champion economic growth was part of a broader movement taking place during the 1980s. Other pivotal pieces of legislation at the beginning of the decade included the Technology Innovation Act of 1980 (Stevenson-Wydler Act, 1980) and the Amendments to the Patent and Trademark Act (Bayh-Dole Act, 1980). These acts signaled a national policy shift towards the transfer of federal research and development to the private sector to stimulate economic growth (Research and Development: National Trends and International Comparisons, 2014). The Stevenson-Wydler Act addressed the transfer of technology from federal research labs to industry, while, the Bayh-Dole act provided for patent ownership to remain with recipients of federal research and development programs as

an incentive to encourage commercialization of the technology (Schacht, 2000). The focus on economic outcomes of federal research and development has continued to be stressed in subsequent reauthorizations and amendments of these acts, including the SBIR program.

Congress instructed federal agencies to factor a company's commercial potential when making awards as a component of the program's 1992 reauthorization (Small Business Research and Development Enhancement Act, 1992). This marked the first time commercial potential became a factor in award decisions. Congress sought to dissuade agencies from making awards to previous SBIR award winners who had failed to demonstrate successful commercialization of previously funded projects, while encouraging agencies to make more awards to firms with a commercialization track record--demonstrated through prior success commercializing SBIR research (LaFalce, 1992). When the program was reauthorized in 2000, Congress required small businesses to submit a commercialization plan as a part of their Phase II award application (Small Business Reauthorization Act, 2000). This provision, supported by the National Venture Capital Association and negotiated by the House Science Committee, sought to ensure that award winners were planning for commercialization by ensuring they had a strategy in place to penetrate federal or commercial markets (Udall, 1999). Taken together the 1992 and 2000 reauthorizations emphasized commercialization as an integral component of the program. As Congress has stressed the importance of economic outputs from federally sponsored research stemming from the SBIR/STTR program, federal agencies have sought resources and mechanisms to support small businesses through the commercialization process.

A survey of SBIR awardees found that a lack of market knowledge and marketing skills was the most frequently cited obstacle to commercialization, and that many SBIR firms needed business assistance to commercialize their technology (Cooper, 2003). According to the National Research Council (2008), "Agencies have begun to see that the technically sophisticated winners of Phase II awards are in many cases inexperienced business people with only a limited understanding of how to transition their work into the marketplace" (p. 213). Commercialization assistance programs are viewed by some program managers and outside observers as a mechanism to overcome this knowledge gap.

The Department of Energy first developed a commercialization assistance program in 1989 to help companies market their SBIR funded projects (General Accounting Office, 1995). Since

then, additional federal agencies have implemented individualized versions of commercialization assistance programs.<sup>2</sup> While each agency's SBIR commercialization assistance program is unique to their mission, they tend to share common traits: they are voluntary for award recipients, generally support business strategy development, seek to surface additional funding opportunities, and provide access to market information (National Research Council, 2008).

Federal agencies have had the legal authority to implement commercialization assistance programs since 1992. The Small Business Development Enhancement Act (1992) allowed federal agencies to contract with a vendor to provide commercialization support to Phase I recipients using resources from the agency SBIR set-aside. However, in the case of Phase II, the agency could not provide services using set-aside funds, but instead, could permit the individual awardees to procure services independently using a portion of their Phase II award funds. According to a General Accounting Office report (1995), the authority to authorize small businesses to seek independent support was criticized by SBIR program managers. Among their criticisms was the belief that significant administrative burdens would arise from case-by-case reviews of company requests for support (General Accounting Office, 1995). The Department of Energy, and subsequently the Navy, worked around these restrictions by investing non set-aside funds to establish commercialization assistance programs for Phase II awards.

In a 2007 hearing before the House Science and Technology Subcommittee on Technology and Innovation, SBIR program managers from the five largest participating agencies were asked to provide testimony regarding "what elements were needed to address financing and commercialization in the SBIR program" (Small Business Innovation Research Reauthorization on the 25th Program Anniversary, 2007). In a statement provided on behalf of the Department of Defense, Linda Oliver, acting director of small business programs, requested both an increase in the level of funding available for commercialization assistance and the authority, "to provide the assistance directly or through the Phase II contract" (Small Business Innovation Research Reauthorization on the 25th Program Anniversary, 2007). Oliver's testimony was the most specific in terms of a commercialization assistance policy recommendation. While the other agencies were

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<sup>2</sup> For example, the Navy Transition Assistance Program was created in 2000, and the National Institutes of Health Commercialization Assistance Program was created in 2004.

not specific in their recommendations they echoed the belief that assistance to awardees was important (Small Business Innovation Research Reauthorization on the 25th Program Anniversary, 2007).

While the research literature on the SBIR program has focused extensively on the commercial outputs of SBIR funded technologies (General Accounting Office, 1992; National Research Council, 2008; Lerner, 1999), little attention has focused on the complementary activities undertaken by agencies to facilitate commercialization of federally funded research. Despite the limited qualitative or quantitative evidence of the programs' effectiveness, new resources and authority for commercialization assistance programs were provided within the SBIR/STTR Reauthorization Act of 2011. The SBIR program was amended to allow federal agencies to provide commercialization assistance directly to an award recipient in an amount not to exceed \$10,000 per awardee (SBIR/STTR Reauthorization Act, 2011). The legislation also provided further flexibility and resources by allowing federal agencies to use up to 3 percent of their SBIR set-aside for administrative funding, including the implementation of commercialization initiatives (SBIR/STTR Reauthorization Act, 2011). As a result of these legislative changes, all participating agencies can implement commercialization assistance programs and finance them using funding from the SBIR set-aside.

Prior to this reauthorization, the implementation of commercialization assistance programs for Phase II award recipients were limited to agencies that had the will and resources to use administrative funding--non SBIR set-aside funds--to execute the programs. Given the continued emphasis on commercialization and, recently legislated penalties for small businesses that fail to meet minimum commercialization requirements (SBIR/STTR Reauthorization Act, 2011), this calculus may be changing. The 2011 Reauthorization established minimum benchmarks for multiple-award winners as it relates to transitioning from Phase I to Phase II, as well as, from Phase II to Phase III (commercialization). Firms that have received more than 20 awards during the previous five fiscal years must have a Phase I to Phase II transition ratio of at least .25. The commercialization benchmark (transition from Phase II to Phase III) applies to Phase I firms that have won at least 16 Phase II awards during the past 10 years. These firms must have obtained an average of \$100,000 from sales/investments per Phase II, or their SBIR projects must have resulted in a number of patents equal to at least 15 percent of the number of Phase II awards they won

during the 10 year period. Failure to meet these standards makes the firm ineligible for new Phase I awards for a period of one year ("Performance Benchmarks", 2013).

The impetus for adding these performance standards was motivated by a need to “refocus” the emphasis of the programs on Phase III commercialization. In explaining the need for the award limits, the House Small Business Committee felt that federal agencies found it easier to make Phase I and Phase II awards to a small set of firms rather than identifying a broader community of firms interested in commercializing federally funded research (Creating Jobs through Small Business Innovation Act Report, 2011). The report further reiterates that the primary, if not sole, purpose behind the SBIR and STTR programs is commercialization of federally funded research (Creating Jobs through Small Business Innovation Act Report, 2011). Despite this emphasis, using small businesses to meet Federal research and development needs remains as one of the legislated goals. So while commercialization is important, it is not the sole goal. However, given this renewed focus on commercialization, based upon hearings and my conversations with program managers, I anticipate more agencies will make use of the allowable amounts from the SBIR set-aside to establish commercialization assistance programs (Small Business Innovation Research Reauthorization on the 25th Program Anniversary, 2007).

This project is timely given the penalties for small firms who fail to meet the minimum commercialization benchmarks, congressional focus on commercialization, and the new resources and authority provided to federal agencies to support the commercialization process. Prior to this new authority the SBIR set-aside funding was restricted to Phase I and Phase II awards for small businesses. This new authority means that agencies can invest up to \$5,000 to support Phase I projects, and up to \$10,000 to support Phase II projects, approximately 3% and 1% of the recommended Phase I and Phase II award levels, respectively. Now that federal agencies can facilitate commercialization through commercialization assistance programs, using funding from the set-aside, they must weigh their interest in commercialization outcomes against those of seeding innovations through additional SBIR Phase I and Phase II awards. If the full amounts available for commercialization was applied to all award recipients, the total investment would have been slightly more than \$41 million for FY11, i.e. 1.6 percent of the FY11 SBIR and STTR budget.

The literature on the SBIR program thus far has treated commercialization outcomes as endogenous to the project. This thesis may indicate that commercialization outcomes are not solely endogenous to the firm, by demonstrating exogenous support (commercialization assistance programs) potentially enhances the probability of commercialization. Quantifying this effect will allow federal agencies to seed innovation by making awards to the most technically promising technologies, and augmenting their commercialization capacity through external commercialization assistance. This project quantifies the probability of commercialization given that a project participated in the Navy's commercialization assistance program. The findings will support policy makers by clarifying the tradeoffs between supporting commercialization assistance versus seeding new awards.

### **1.1. Navy Transition Assistance Program**

The Navy Transition Assistance Program (TAP) was established in 2000 by John Williams, the Navy SBIR Program Manager, and is implemented by a support contractor, Dawnbreaker, Inc.<sup>3</sup> The Navy invests approximately \$15,000 per small business participant, utilizing the department's administrative budget (National Research Council, 2007), to provide participants with access to expert business consulting, market research, Department of Defense transition planning, and marketing support during the 11-month Transition Assistance Program (Sullivan, 2013). The objective of the TAP is to provide information and points of contacts that help identify transition (commercialization) paths, prepare marketing materials that convey the business opportunity, and to provide access to technology evaluators and decision makers to surface funding opportunities (Servo, 2013). The Navy TAP culminates in a partner/investor event called the Navy Opportunity Forum. Small firm participation in the Navy Opportunity Forum is restricted to Phase II award winners that have completed the requirements of that year's Navy Transition Assistance Program. The 2013 Navy Opportunity Forum was attended by more than 1,200 representatives from federal acquisition programs, technology evaluators, decision makers from large DoD prime contractors, large technology firms, and private sector investors.<sup>4</sup>

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<sup>3</sup> I work for the support contractor, Dawnbreaker, Inc.

<sup>4</sup> <http://www.navyopportunityforum.com/>

The Navy requires all Phase II award recipients to attend a one-day Transition Assistance Program (TAP) meeting held annually during the month of July. During this kickoff event participants are exposed to information on the Navy SBIR program, successful commercialization strategies, intellectual property protection techniques, and information on the Transition Assistance Program. Following the event, participants have a two week period to opt into the TAP program.<sup>5</sup> Those opting into the program receive project level support, with the costs covered by the Navy. Participating firms are expected to invest the necessary time to complete program deliverables and attend the Navy Opportunity Forum (Servo, 2013). This time expenditure is not billable to their Navy SBIR and STTR contracts, which may serve as a deterrent for some, while ensuring participants have “skin in the game.”

Participant commitment is important because the Navy TAP is a collaborative partnership between the service contractor and the firm. TAP participants are provided a team composed of a business consultant, market research specialist, and graphic designer. The business consultant uses an iterative deliverable based approach while working with the participant. Their collaborative back and forth effort is focused on enhancing marketing capacity and collateral. The business consultant also provides transition and commercialization mentoring. They attempt to augment the participant’s knowledge by surfacing information to clarify market opportunities and facilitate transition and commercialization planning. The Dawnbreaker team takes the lead throughout this process, but the TAP participant is required to partake in the development of commercialization planning documents, review and participate in market research debriefs, and participate in at least 10 training webinars (topics range from: protection of intellectual property, working with prime contractors, to developing a compelling Phase III transition Plan). If TAP participants fall too far behind they are politely asked to withdraw from the program (Servo, 2013).

The TAP was explained by a program participant in testimony before the House Committee on Science, Space, and Technology as so:

Galois has benefited from participation in several SBIR support resources, and especially from those that focus on transition and commercialization. Prime among these is the Navy’s Transition Assistance Program, or TAP, which gave Galois substantial new and useful understanding and capability in commercialization. The program is voluntary for

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<sup>5</sup> <http://www.dawnbreaker.com/programs/navy-tap.php>

Navy Phase-II winners, and requires a commitment in time and money from the company to participate. Over a year's time and under advisor guidance, Galois learned or improved capabilities in how to evaluate a particular market, assess a venture partner, write a business plan, produce marketing collateral that is informative to defense industry primes, and present at an industry-focused conference. Each of these skills has been reused and deepened since that experience. Of particular note, the Dawnbreaker advisor provided baseline criteria for examining venture opportunities, which Galois applied immediately to the KSys opportunity. This information facilitated the development of that commercialization effort (McKinney, 2011, p. 11).

Participants who have completed the Transition Assistance Program have reported commercialization success. There were 693 projects presenting at a Navy Opportunity Forum between 2002 and 2007, 61 percent of them reported non-SBIR funding within 18 months of program completion. Those projects cumulative reported approximately \$1.15 billion in Phase III funding (Williams, 2010). The commercialization funding reported includes both sales in the commercial market as well as non-SBIR federal funding for additional development or to procure products or services resulting from the SBIR project. This definition reflects the dual goals of the SBIR program to meet both agency needs and contribute to economic growth (Small Business Research and Development Enhancement Act, 1992).

## **2. Literature Review**

### **2.1. SBIR and Commercialization Assistance as a Response to Market Failures**

Since markets only inefficiently allocate the pure public goods, like knowledge based innovations, government plays a role in the research and development market. Martin and Scott (2000) addressed this question while reviewing the economic literature of innovation based market failure. They found that the limited ability of innovative firms to capture the benefits of their research and development investments represented an innovation market failure resulting in suboptimal investment in innovation from a public perspective. It was once held that larger firms had a competitive advantage in the innovation market which allowed them to capture the benefits of their research and development, however, they found that this innovation market failure occurred irrespective of firm size.

Link (1999) offers additional support for the role information plays in a firm's decision to undertake research and development projects. While research and development market failures are often discussed in terms of appropriating returns, Link (1999) recognizes and discusses the inherit

risks in advanced research and development. He notes that private firms face both technical and market risks when determining their research and development investments. If firms view the probability of reaping a commercial reward for a given investment as too risky, given the level of knowledge needed to both develop the innovation and to market it, they will tend to under-invest in research and development (Link, 1999, p. 193; Link and Scott, 2001, p. 764).

Link and Scott (2001) continue to stress the importance of market based risks in research and development decisions. They identify technical and market based uncertainties when considering these investments. Firms are concerned if their technology will meet the technical specifications necessary to justify their investment, and even if they are confident that they can meet those specifications, uncertainty remains over market acceptance. These risks factor into the returns a private firm would expect from a given investment in R&D. Because of the technical and market uncertainties, firms tend not to invest in projects with potentially high societal returns, but lower prospects of private returns. Small firms receiving SBIR awards are faced with overcoming both the technical and market based uncertainties of the federally sponsored research.

Generating social benefits from federal research and development investments in the SBIR/STTR program is among the congressional goals. The SBIR/STTR program seeks to engage small businesses to meet federal research and development needs as well as generate commercial outcomes from those investments. While small firms in the SBIR program often possess the technical skillset to meet the innovative challenges associated with the development of advanced technologies, their ability to translate those technical developments into commercially viable, or acquisition ready (in the case of the Department of Defense), products and services are often lacking (National Research Council, 2008, p. 223). Federal program managers implementing external advisory services are seeking to overcome these deficiencies, and maximize the positive externalities and spillover effects of increased performance resulting from market based commercialization of the federally sponsored technology. Their interest in influencing the firm performance through external advisory support is closely linked to the market failure based rationale for public and private partnerships.

Storey (2003) provides a discussion on why policies exist to influence small and medium size firm performance through outside business advisory support services. He frames the discussion in terms of two market failures. The first market failure he discussed focused on

imperfect information while the second examined positive externalities. As a response to imperfect information, municipalities view small firms as ill-informed on the private benefits of external business advisory services which results in the firm purchasing a "sub-optimal quantity of advice" (p. 478), resulting in less than ideal performance. By offering commercialization assistance programs, federal agencies are bringing the private advisory services to the small business, seeking to overcome their underinvestment in support.

The second market failure perspective views the presence of socially beneficial outcomes of higher performance which may result from investments in advisory services. These social benefits will not occur without a subsidized approach because small firms will, "under-estimate the private benefits of obtaining external advice/consultancy" (Storey, 2003, p. 482). While small firms in the SBIR program often possess the technical skillset to meet the innovative challenges associated with the development of advanced technologies, their ability to translate those technical developments into commercially viable, or acquisition ready (in the case of the Department of Defense), products and services often lacks (National Research Council, 2008, p. 223). The SBIR/STTR program both seeks to diversify the federal research and development marketplace while also generating societal benefits, including economic growth. I believe these dual goals contributes to participating firm's under-estimating the benefits of securing private sector advisory support.

The SBIR/STTR topic generation process signals an innovation gap to the research and development marketplace. While successful winners of SBIR/STTR Phase I and Phase II awards demonstrate the technical capacity to overcome this challenge, they may be under the false impression that their technical development translates into commercial acceptance. This particular concern exists within the acquisition community, where the SBIR/STTR may also signal a potential customer. However, navigation of the complex federal acquisition marketplace requires business expertise that firms often do not possess (National Research Council, 2008, p. 224), but is necessary to maximize societal benefits from taxpayer funded research and development.

In summary, federal subsidizing of research and development seeks to address the underinvestment of private firms in a manner that maximizes societal benefits. In establishing the SBIR/STTR programs, Congress sought to harness the innovative capability of small businesses to both diversify the federal research and development service marketplace and generate societal

benefits. Maximizing the economic outcomes from the federal SBIR/STTR investments occur as firms commercialize (either in commercial markets or through the federal acquisition process) products and services which generate jobs, support advanced weapon systems, or drive down federal research and development costs through increased competition. While the small firms attracted to the SBIR/STTR programs may be technically advanced, they may lack the necessary business capacity to create these down-stream societal benefits. Storey (2003) found that small and medium firms tend to underinvest in the services which could augment their business capacity because they are unclear or underestimate the long-term benefits of those investments. To overcome this information failure, and to maximize the societal benefits from federal research and development funding, federal agencies have begun establishing external advisory support programs.

## **2.2. SBIR Commercialization Assistance Needs**

The need for commercialization assistance was briefly discussed by Ronald Cooper, innovation policy specialist at the United States Small Business Administration, while describing the rationale for, and the performance of, the SBIR program. Within his description and explanation of the SBIR/STTR programs, Cooper (2003) described a prospective program to enhance SBIR commercialization. He envisioned a two part program focusing on both the financial gap between Phase II and early-stage capital, as well as business development support (p. 148). In describing the need for additional assistance, he felt the firms often had "top quality technological innovations, [but] often require business assistance to move them to a point where private markets--venture and angel capital--are willing to invest in them" (p. 148). This chasm between early stage ideas and sufficient capital to transform those concepts into commercial products is often referred to as the "valley of death" (Figure 1).

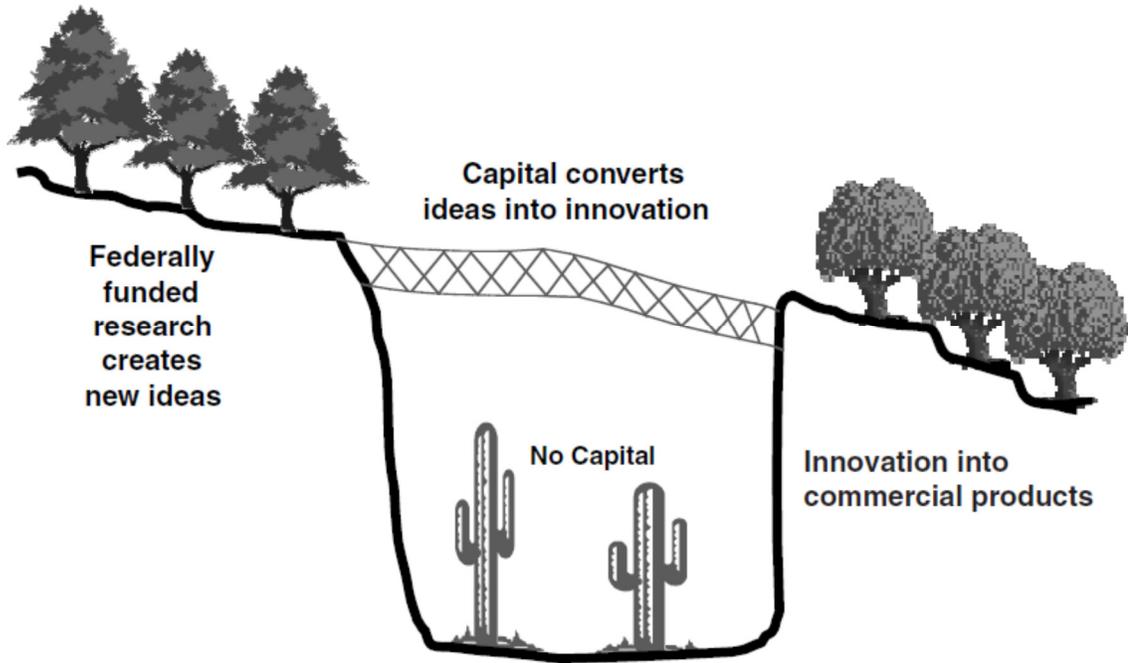
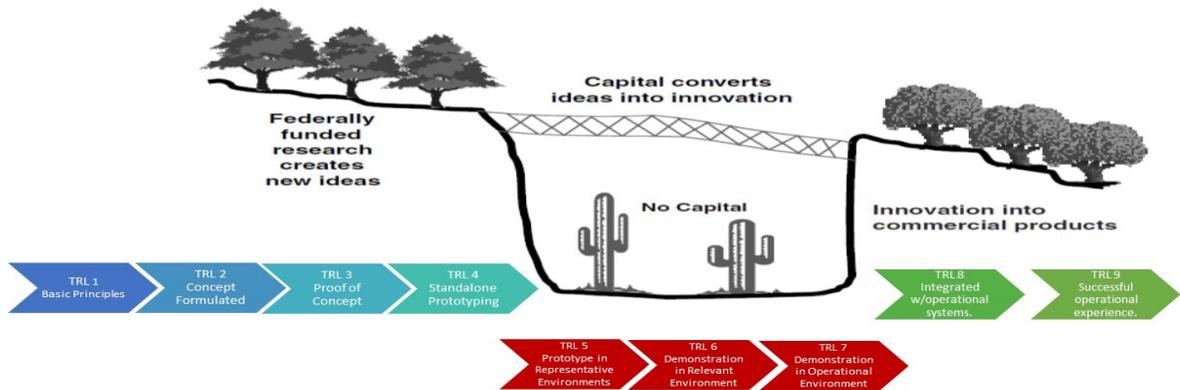


Figure 1 Diagram of the "Valley of Death" Source: (National Research Council, 2007, p. 8)

The “valley of death” is not restricted to transforming technological information into commercially available products, but also appears when SBIR/STTR firms seek to commercialize their innovations within the federal marketplace. While the SBIR/STTR programs provide early stage seed funding to create new technical ideas and support the prototype development of those ideas, the funding is often inadequate to reduce the technical risks to acceptable levels for the federal acquisition community. This gap is depicted in Figure 2.<sup>6</sup> The Navy TAP also supports firms in their efforts to overcome this valley of death by focusing on the business skills necessary to identify capital opportunities and convey their business case, in both the commercial and federal marketplaces.

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<sup>6</sup> Technology Readiness Levels originated with NASA and measure technical risk ([http://esto.nasa.gov/files/TRL\\_definitions.pdf](http://esto.nasa.gov/files/TRL_definitions.pdf)).



**Figure 2 SBIR/STTR Valley of Death Diagram**

Projects developed under SBIR/STTR Phase I and Phase II funding typically reach a technology readiness level (TRL) of 4 or 5; however, the acquisition arm of the Department of Defense will often view that technology as too risky to invest programmatic funds. The DoD program offices are more willing to invest additional development or demonstration funding when a project reaches a TRL of 7 or 8 (National Research Council, 2007, p. 58). Given this gap, SBIR/STTR firms must traverse this valley by identifying resources to continue the development of their technology and reduce risk if they are going to successfully transition their technology. The Navy TAP supports them in these efforts by providing them marketing collateral, business mentoring, and a partner/investor event that connects them to funding opportunities.

This technology transition process has been defined as a two-way long-term communication process (National Research Council, 2004, p. 1). Michael McGrath, Deputy Assistant Secretary of the Navy (Research, Development, Test, and Evaluation) identified five conditions that needed to be met for successful technology transition to the government: there must be a need, effective solution, business case, budgetary resources and acquisition mechanism (National Research Council, 2004, p. 27). Cooper (2003) and others (National Research Council, 2008) have observed that SBIR/STTR award winners have the technical capacity to develop theoretically effective solutions, however, communicating their business case and strategically

planning around the budgetary and acquisition environments could be enhanced. A survey of SBIR award winners confirmed a need for this additional support.

Under a grant from the U.S. Department of Agriculture, Palminteri (2001) developed and administered a survey to the population of SBIR Phase II award winners between FY94 and FY97 to assess the business support needs of firms in the program. The survey was administered to 2,575 firms across the eleven participating federal agencies and had a 24 percent response rate. The results of that research provide the logic underpinning many of the efforts federal agencies have undertaken to augment the business and marketing capacity of SBIR award recipients. Palminteri found that two thirds of respondents indicated that they needed some form of assistance. Although the census based approach does not result in a representative random sample, Palminteri did find that assistance varied by firm size, with smaller firms (1-5 employees) requiring more support for commercialization planning and marketing compared to firms with 50 or more employees. Palminteri also found that the need for marketing and commercialization related services, including support in partnering with other firms, were among the most frequently cited needs--irrespective of firm size, technology area, or sponsoring agency.

Transitioning innovative ideas into products and innovations is complex and challenging irrespective of the marketplace (federal acquisition or commercial). Firms face a challenge attracting the necessary capital to translate high risk early stage research into commercially viable products. This “valley of death” exists within the SBIR/STTR community, as the typical project is not developed to a sufficient level to signal a reduced risk to the marketplace (acquisition or commercial). The ability to market and convey the business case for these technologies plays a role in overcoming these challenges, but it has been found that many SBIR/STTR firms feel they need additional support in this area (Palminteri, 2001; National Research Council, 2008). Programs like the Navy TAP seek to provide this additional support.

### **2.3. Business Advisory Support as a Commercialization Need**

Technical assistance to small firms is not unique to the SBIR/STTR programs. Examining the rationale behind other programs can augment the understanding of programs focused on the SBIR/STTR community. One example stems from the Small Business Development Center

program. Chrisman and McMullan (2004) examine a potential knowledge gap while assessing the long-term impact of the Small Business Development Center. According to them, "in many cases there is a gap between the knowledge possessed by entrepreneurs and the knowledge required for successful venturing" (p. 232). In many ways the underlying rationale for outsider assistance is consistent with the knowledge gap perspective expressed in support of developing commercialization assistance programs (National Research Council, 2008, p. 223). Chrisman and McMullan (2004) research stemmed from a longitudinal survey of Pennsylvania based SBDC clients surveyed in 1994, 1996, 1998, and 2001. Utilizing a comparison group drawn from a 2000 study on general population survival rates for firms between 1992 and 1996, the authors measured the difference in firm survival rates and found that the SBDC supported ventures had a significantly higher survival rate.

Cumming and Fisher (2012) sought to measure the impact of publicly funded advisory services on small and medium sized enterprises targeted towards growth and innovation. The authors utilized a population of 228 firms that contacted the Ontario based Investment Network, a business advisory service focused on small firm growth. They found that 101 firms received advising from the program, but by using pre-entry program data on all 228 firms, the authors were able to econometrically control for self-selection. The program participants demonstrated a positive and significant difference in financial outcomes including sales and financing, based on regression analysis. Their ability to control for self-selection is important because entry into the federally funded commercialization assistance programs is voluntary. While controlling for self-selection is beyond the scope of this thesis, it should be considered in future research to compensate for the non-randomness of program participation.

These two studies provide both rational and sample approaches to evaluating business advisory services. Business advisory services have been provided because small firms often have a gap in their current knowledge and what is required for success. Through a comparison group design Chrisman and McMullan (2004) found that Small Business Development Centers supported firms had higher firm survival rates. Cumming and Fisher (2012) employed regression techniques to control for possible self-selection bias, although beyond the scope of this project, their approach can be illustrative for future projects.

#### **2.4. Assessing the SBIR Program**

The 2008 assessment of the SBIR program conducted by the National Research Council (2008) may be the most in-depth evaluation of the program. The National Research Council study sought to assess if the SBIR program has met congressional goals, with an emphasis on commercialization (National Research Council, 2008, p. 13). To complete the study, stakeholders from the five largest participating federal agencies (i.e., Department of Defense, Department of Energy, Health and Human Services, National Aeronautics and Aerospace Administration, and the National Science Foundation) were involved in case studies, symposiums, interviews, and surveys to determine how the program has functioned, and assess the program's performance.

The primary data source for the study was a survey that sought to, "understand both commercial and non-commercial aspects, including knowledge base impacts, of SBIR, and to gain insight into impacts of program management" (National Research Council, 2008, p. 229). The survey was administered in 2005 to SBIR Phase II award recipients between 1992 and 2001, using a 20 percent layered random sampling technique. The process started with a random sample of the entire award population, followed by a 20 percent random sample for each award year, with a final sample to ensure at least 20 percent of the agency's awards were included. The final result was a sample of 4,523 projects, of which, 1,916 responded to the survey, a 42 percent response rate.

The National Research Council study found that the SBIR program was, "sound in concept and effective in practice" (National Research Council, 2008, p. 54). More specific to this thesis, the study found that 47 percent of the projects reported sales related to their SBIR funded project, indicating some commercial success. While not addressed in detail, the report also touched on the agencies' implementation of commercialization assistance programs. While the study did not assess the outcomes of commercialization assistance programs, it showed federal agencies' interest in supporting the commercialization process. A key theme in the discussion on commercialization assistance programs was the take-away from interviews with, "awardees, agency staff, and commercialization contractors, [all of whom] indicate[d] that the business side of commercial activities is often where companies experience the most difficulty" (National Research Council, 2008, p. 223). This concept was reinforced by firms selected for case studies in the report, with seven out of the nine referencing participation in a support program specifying some level of value.

The Phase II survey used by the National Research Council was, in many ways, built on previous work by the General Accounting Office (GAO). The General Accounting Office (1992)

conducted one of the first studies to measure private sector commercialization of SBIR Phase II awardees. Utilizing a census approach, GAO administered a questionnaire to Phase II award recipients between 1984 and 1987. While their approach found there was private-sector commercialization of the federally sponsored research and development, measured through both sales and additional development funding, they could not measure the effectiveness of the program because they lacked “formal criteria by which to judge the results, once they [were] determined” (General Accounting Office, 1992, p. 16). The GAO study uncovered the presence of private-sector output, without indicating program effectiveness.

A central contribution from the GAO study has been the measurement of commercialization through sales and additional development funding. GAO defined sales to, "include all sales of product(s), process(es), service(s), or other sales to federal or private-sector customers, resulting from the technology associated with the project." They defined additional development funding to, "include funding from federal or private-sector sources, from the companies themselves, or from other related SBIR awards used for further development of the technology associated with the Phase II project" (General Accounting Office, 1992, p. 20). These metrics have continued to be implemented in subsequent studies as measures of SBIR awardee private-sector commercialization, and will be used in this study as a proxy for the dependent binary commercialization variable.

The National Research Council (2000) assessed the Department of Defense Fast Track Initiative, a program that provided interim funding to SBIR Phase I awardees during the period between Phase I and Phase II for projects that demonstrated third party matching funding (which was contingent on the project going to Phase II). These firms also received an expedited Phase II review process and were guaranteed Phase II selection given fulfillment of their Phase I technical goals and demonstration that the program was technically sufficient. To complete their assessment of the Fast Track program, the National Research Council developed and administered a survey instrument to a sample of Fast Track recipients and a control group. The project based survey covered 379 Phase II awards between 1992 and 1996. The survey resulted in a 72 percent response rate and was supplemented by 55 case studies. They found that the, "program was encouraging commercialization and attracting new firms to the program" (National Research Council, 2000, p. 24). While the study continued to use the GAO established measurements of commercialization

success: presence of sales or additional development funding; the fast track initiative departed from previous efforts by surveying a sample of Phase II award winners and comparing their actual and expected results with a matched control group.

The control group used in this methodology was matched on, "solicitation year, number of previous Phase II awards, size of the firm, geographic location, women or minority ownership, and technology area of the project" (National Research Council, 2000, p. 55). The factors used to match the control group offer insight into this project, and in a few aspects will be replicated during this study. While the National Research Council study utilized projects from other programs to develop its matched sample, this thesis will utilize Phase II awards that were eligible for the Navy TAP, but chose not to participate.

While the reviewed literature thus far has sought to demonstrate or assess the presence of near-term commercialization impact, Lerner (1999) sought to answer the question of the long-term impact of the SBIR program by applying an empirical framework to the GAO (1992) data-set. Lerner (1999) utilized a matched pair design to measure the long-term employment and sales growth of 1,435 firms over a 10 year period (p. 286). To conduct the research he used a subset of 541 SBIR firms from the GAO survey and matched them with two matched sets of similar firms--one based on industry and firm size, and the other based on location and firm size. Lerner found that the SBIR awardees enjoyed substantially greater employment and sales growth, although not uniform. The "superior growth of SBIR awardees was confined to firms based in ZIP codes with substantial venture capital activity" (Lerner, 1999, p. 290). Although Lerner utilized the GAO data set to analyze the long-term impact of SBIR in terms of employment and sales growth, the relationship of those outputs were more broadly attributed to the SBIR program without insight into the underlying drivers of commercialization.

#### **2.4.1. Commercialization Probability**

Link and Ruhm (2009) sought to isolate the variables that impact the probability of commercialization. Utilizing data on 405 NIH SBIR Phase II awardees from the National Research Council (National Research Council, 2008) assessment of the SBIR program, they estimated the probability of commercial success as a function of additional development funding and four control variables: knowledge base, owner demographics, NIH funding institute, and the presence

of university involvement. The authors found that the mean commercialization probability for NIH SBIR awardees was slightly more than 50 percent (.5111). The research of Link and Ruhm offers insight into a potential driver of commercialization of SBIR Phase II awards, specifically additional development funding. Utilizing their probit model, they identified the marginal benefit of additional development funding based on two subsets of NIH firms, those who reported additional development funding as part of the National Research Council study, and those who did not. They quantified the marginal effect of additional development funding, finding that it "correlates with a 35 percentage point increase in the probability of commercialization" (Link & Ruhm, 2009, p. 16). Their quantification of the contribution of control variable's impact on commercialization is informative for my research. They identified additional development as a key independent variable. While this project is focusing on participation in commercialization assistance programs, the general goal of these programs is to augment small firms' capacity to secure commercialization funding, which would include both sales and additional development funding. Based on the work of Link and Ruhm, to the extent that commercialization assistance programs are effective, one would expect an increased probability of commercialization for program participants.

While their work was specific to NIH, subsequent work by Link and Scott (2010) took a closer look at the probability of success across the federal agencies participating in the National Research Council (2008) study. They examined the probability of commercialization success of SBIR Phase II awardees across the five largest participating agencies. They framed their research as an effort to quantify the risk government incurs when it serves as an entrepreneur. Utilizing data collected as part of the National Research Council's assessment of the SBIR program, the authors developed an econometric model using data for each agency to quantify the level of risk the respective agencies incurred. Link and Scott (2010) found that the mean probability that companies would commercialize their SBIR research was, "somewhat less than .50, the probability of heads on the toss of a fair coin" (p. 599). If government as an entrepreneur accepts a 50 percent chance of failure when seeding an SBIR Phase II project, it would be reasonable to conclude that the development and funding of a commercialization assistance program would be focused on reducing that failure probability. While their research included a large number of control variables, participation in transition or commercialization assistance program was not among them. Their

work provides a framework for further understanding the role commercialization assistance programs can play as a risk mitigation strategy.

### **3. Research Design**

I hypothesize that the Navy's Transition Assistance Program (TAP) increases the probability of commercialization success for SBIR Phase II projects. To test my hypothesis I will apply a logistic regression model to the population of treated projects between 2005 and 2008,<sup>7</sup> and a comparison group of eligible projects that chose not to participate in the program during the same period. Previous outcome evaluations of the SBIR program have identified commercialization as a key indicator of program success, defining the measure as any non-SBIR sales or additional development funding received (General Accounting Office 1992, National Research Council, 2004, National Research Council 2008). A lack of market knowledge and marketing skills was a frequently cited commercialization obstacle by SBIR awardees (Cooper, 2003). Commercialization Assistance Programs, like the Navy's Transition Assistance Program, seek to overcome these obstacles by providing project level marketing, business strategy, and transition support. This research will seek to determine the effectiveness, measured by the odds of success between the treated and non-treated projects, of the Navy's Transition Assistance Program (TAP) by modeling a binary project level commercialization variable.

*H1: Navy Transition Assistance Program increases the probability of project commercialization.*

#### **3.1. Threats to Validity**

My research design limits the ability to generalize these findings beyond the Navy Transition Assistance Program (TAP). The design is a non-experimental design, and these projects may not be representative of the broader SBIR/STTR community. There are other programmatic

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<sup>7</sup> The Navy TAP is an 11-month program and provides firms the option of participating in the first or second year of their Phase II award. Choosing 2008 as the cutoff ensured that projects had exhausted their Navy TAP eligibility and would have completed the program by the time the dataset was assembled.

characteristics which limit the ability to broadly generalize these findings to commercialization assistance programs. Among these include differences in vendors, acquisition versus commercial focused support, program components, and per project support investments.

The voluntary nature of the Transition Assistance Program introduces the prospect of selection bias. Program participants may possess unobserved characteristics and motivations that may not be reflected across both the treated and comparison populations. While I recognize this possibility, accounting for potential selection bias is beyond the scope of this research. By not accounting for the potential of selection bias, findings cannot be solely attributable to the intervention, but must be given with the caveat that there may be unobserved factors inherent to the project or firm.

A possible threat to internal validity is the potential underreporting of commercialization outcomes between the treatment and comparison groups. While this is discussed later, I should note that the commercialization data is self-reported by the firms. A smaller percentage of the treated projects provided a commercialization update than the comparison group. To guard against mistakenly over reporting the impact of the treatment, a separate lower bound analysis will be employed.

### **3.1.1. Question of Causality**

While I have mentioned concerns over potential selection bias and the limitations of this dataset to address them, I feel it is important to discuss the potential impact of selection bias as it relates to causality and my results. While the results indicate that projects that participated in the Navy TAP feature higher odds of success compared to the non-participating counterparts, questions can be raised regarding the underlying projects. It is possible that projects entering the TAP have higher prospects for commercialization compared to those not entering the program. It is also possible that firms when deciding on which projects to enter into the program may chose not to enter projects they feel have miniscule opportunities for commercialization. Experimentally ascertaining the answer to the underlying nature of the projects entering the TAP versus those not entering the TAP is not feasible given the non-experimental development of this dataset. With that stated, I do not believe that the underlying projects entering the TAP are more commercializable than those not entering the program.

It is known, based on vendor experience that firms do make tradeoff decisions on which projects to enter into the program. As shared by Dr. Jenny Servo, president of Dawnbreaker,<sup>8</sup> when principal investigators have multiple eligible projects but lack the bandwidth to shepherd all their projects through the program, they are advised by Dawnbreaker to opt-in the project which requires the most support (personal communication, June 18, 2014). It is Dawnbreaker's belief that through the market research and under their business advisement they can add more clarity into avenues of commercialization for these more challenging projects. Also, from the perspective of the vendor, if a firm has a transition or commercialization path identified, they may be less willing to invest the necessary time to complete the program. The time commitment is a key factor why I do not believe participants are entering what they perceive as more commercializable projects.

I do not believe firms would knowingly enter projects they sensed to have higher commercialization prospects. The TAP requires nearly a 1-year time commitment to participate and complete the program. It is unclear to me why a firm would invest those resources to participate if they knew their projects were aligned for success. Although the services of the TAP are paid on behalf of the firm, the program is gated, and requires iterative activity between the firm and Dawnbreaker (vendor executing the TAP). As stated previously, the time commitment in the program ensures that participating firms have "skin in the game." The collaborative and continual development of program deliverables requires firm participants to invest their own resources—which cannot be billed to their contracts. This commitment was expressed by a TAP participant in congressional testimony, "The [TAP] program is voluntary for Navy Phase-II winners, and requires a commitment in time and money from the company to participate" (McKinney, 2011, p.11). I do not believe firms would invest these additional resources to participate if they felt their projects had a higher than average prospect for success. Based upon these factors and my interactions with a number of SBIR/STTR project participants, I do not believe the TAP is solely reflecting results of more commercializable projects.

### **3.2. Data Sources**

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<sup>8</sup> Dr. Servo executes the Navy TAP, and is my employer.

I utilized the Navy's public SBIR and STTR advanced search engine<sup>9</sup> to begin compiling the dataset. The database contains project data on Navy SBIR and STTR awards, including summary reports and information on Navy TAP participants. Through this database I was able to identify the population of Navy SBIR and STTR Phase II award winners for fiscal years 2005 through 2008, including the subpopulation of TAP program participants. These data were merged with the proprietary DoD commercialization database which contains project level, self-reported, commercialization data on SBIR and STTR Phase II awards. The two datasets were matched based on a one-on-one match of project contract number.

The DoD commercialization database captures cumulative SBIR project level commercialization data. The DoD requires SBIR Phase II award winners to update project outcomes on previous awards any time they apply for new DoD SBIR awards, one year after the start of their Phase II award, and at the completion of their Phase II. The DoD also requests annual updates following completion of the project (National Research Council, 2009, p. 120). While relying upon self-reported data may lead to certain bias's, like under/over reporting, I believe the DoD reporting requirements and the necessity for project updates to be digitally certified by firm officials minimizes any concerns. Evidence of the high level of compliance can be seen in Table 1, where 94.5 percent of the population of Navy Phase II projects during the fiscal years of interest provided an update to the DoD commercialization database.

Although the DoD commercialization database captures a high percentage of the projects, there is variation between the percentage of captured projects amongst the treatment and comparison groups. I will describe the sample selection process later but, it is important to note that the treatment group has a smaller number of projects providing updates than the comparison group (81 percent versus 89 percent, respectively). This could indicate an underreporting bias. I assume two possible scenarios: one, the projects followed a similar pattern of success but failed to report; or, two, they were unsuccessful and chose not to report their lack of commercialization. Scenario one would lead to understating of the interventions impact. Under the second scenario, the potential bias may result in the overstating of the interventions impact. To protect against overstating the impact, I will add a sensitivity model under the assumption that the treated projects

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<sup>9</sup> <https://www.navysbirsearch.com/>

who failed to report were unsuccessful. This model can be viewed as the lower bound of the intervention's impact.

### 3.3. Sample Selection

#### Population of Navy Phase II SBIR and STTR Awards

The population of Navy Phase II SBIR and STTR awards are defined as all projects captured in the DoD commercialization database with award start dates between fiscal years 2005 and 2008. There are 1,174 such projects (Table 1). These projects constitute the eligible population from which the treatment and comparison groups were selected.

**Table 1 Population of Navy Phase II Awards**

<b>Fiscal Year</b>	<b>Phase II Awards</b>	<b>Awards w/ CCR Update</b>	<b>Percentage Captured by CCR</b>
<b>2005</b>	312	286	91.7%
<b>2006</b>	251	240	95.6%
<b>2007</b>	262	254	96.9%
<b>2008</b>	349	340	97.4%
<b>Totals</b>	1174	1120	95.4%

#### 3.3.1. Treatment Group

The treatment group is defined as Navy TAP graduates who have provided an update to the DoD commercialization database during the month of, or after, program completion. As seen in Table 2, there were 664 TAP graduates between fiscal years 2005 and 2008. From this population, 537 (81 percent) provided a post-intervention update to the DoD commercialization database. The 127 projects who do not meet the defined criteria will be excluded from the base modeling. Excluding these projects may lead to an over (or under) stating of the programmatic impact.

**Table 2 Population of Navy Phase II Projects Considered for the Treatment Group (Projects that participated in the Transition Assistance Program (TAP))**

<b>Fiscal Year</b>	<b>Population of TAP Projects</b>	<b>TAP Projects w/ CCR Update</b>	<b>Percentage Captured by CCR</b>	<b>TAP w/ Post Intervention Update</b>	<b>Percentage of TAP in Treatment</b>	<b># of TAP excluded</b>
<b>2005</b>	181	173	95.6%	158	91%	15
<b>2006</b>	150	146	97.3%	120	82%	26
<b>2007</b>	148	147	99.3%	113	77%	34
<b>2008</b>	199	198	99.5%	146	74%	52
<b>Totals</b>	678	664	98%	537	81%	127

As stated previously, two assumptions may be made regarding the population of excluded projects. Under one scenario, I can assume they followed a similar pattern of success but failed to report, which would understate the programmatic impact. Alternatively, I can assume they were unsuccessful and chose not to report, which would overstate the programmatic impact. To protect against the latter, I will develop a sensitivity model under the second assumption to protect against overstating the programmatic impact. This subsequent model will serve as a lower bound for the programmatic impact.

### **3.3.2. Comparison Group**

The comparison group is defined as the untreated (chose not to participate in the Navy TAP) population of Navy Phase II awards captured by the DoD commercialization database. The comparison group population consists of 456 projects between fiscal years 2005 and 2008, as seen in Table 3. The possibility for spillover effects between the treatment and comparison groups exists. The Transition Assistance Program is a project level intervention, meaning, firms with multiple Phase II awards during the period of interest may have entered only a subset of those awards in the treatment.

**Table 3 Population of Navy Phase II Awards used for the Comparison Group**

<b>Fiscal Year</b>	<b>Population of Non-TAP Projects</b>	<b>Non-TAP Projects w/ CCR Update</b>	<b>Percentage Captured by CCR</b>
<b>2005</b>	139	113	81%
<b>2006</b>	105	94	90%
<b>2007</b>	115	107	93%
<b>2008</b>	151	142	94%
<b>Totals</b>	510	456	89%

Since I posit a positive impact from the treatment (participation in the Navy TAP), I would expect the model to quantify a probability of commercialization success higher for the treatment group than the comparison group. However, with the presence of firm spillovers, the programmatic impact may be understated--depending on the proportion of multiple project firms split across the treatment and comparison groups. I subset the larger model based on firm project characteristics to shed light on these potential spillover effects. While this sub-setting may indicate the presence of spillover and signal the direction of their impact, fully accounting for those effects are beyond the scope of this thesis, but it is worth noting for future research designs.

### **3.4. Dataset**

The resulting dataset contains 993 projects, 537 in the treatment and 456 in the comparison group. As seen in Table 4, the treatment group has a statistically significant higher percentage of projects reporting commercialization compared to the comparison group. The treatment group also has a statistically higher average Phase II award amount, a variable that will be included in the model as a control. Under the lower bound scenario, I assumed that the 127 projects that participated in the TAP, but failed to provide an update to the DoD commercialization database, were unsuccessful. Under this assumption the difference in commercialization percentages between the groups was reduced to 13 percentage points. The difference remains statistically significant. This data as well as the year by year commercialization percentages for the treatment and comparison groups can be seen in Table 4 and Table 5, respectively.

Table 4 Selected Descriptive Statistics for Treatment and Comparison Groups

	Treatment	Comparison	Difference
<b>Sample Size (n)</b>	537	456	81
<b>Number Commercialized</b>	390	212	178
<b>Commercialization Percentage</b>	73%	46%	26%*
<b>Total Commercialization</b>	\$806,245,836	\$465,414,980	\$340,830,856
<b>Commercialization Average</b>	\$1,501,389	\$1,020,647	\$480,742
<b>Phase II Award Average</b>	\$1,001,644	\$879,468	\$122,176*
<b>Phase II Sponsoring Component Project Distribution</b>			
<b>MARCOR</b>	4%	4%	
<b>NAVAIR</b>	41%	42%	
<b>NAVFAC</b>	0%	1%	
<b>NAVSEA</b>	24%	21%	
<b>NAVSUP</b>	0%	0%	
<b>NSMA</b>	1%	1%	
<b>ONR</b>	24%	25%	
<b>OSD</b>	0%	0%	
<b>SPAWAR</b>	6%	4%	
<b>SSP</b>	0%	1%	
<b>*Significant at .05 level.</b>			

**Table 5 Number of Projects and Commercialization Percentages by FY (Treatment and Comparison Groups)**

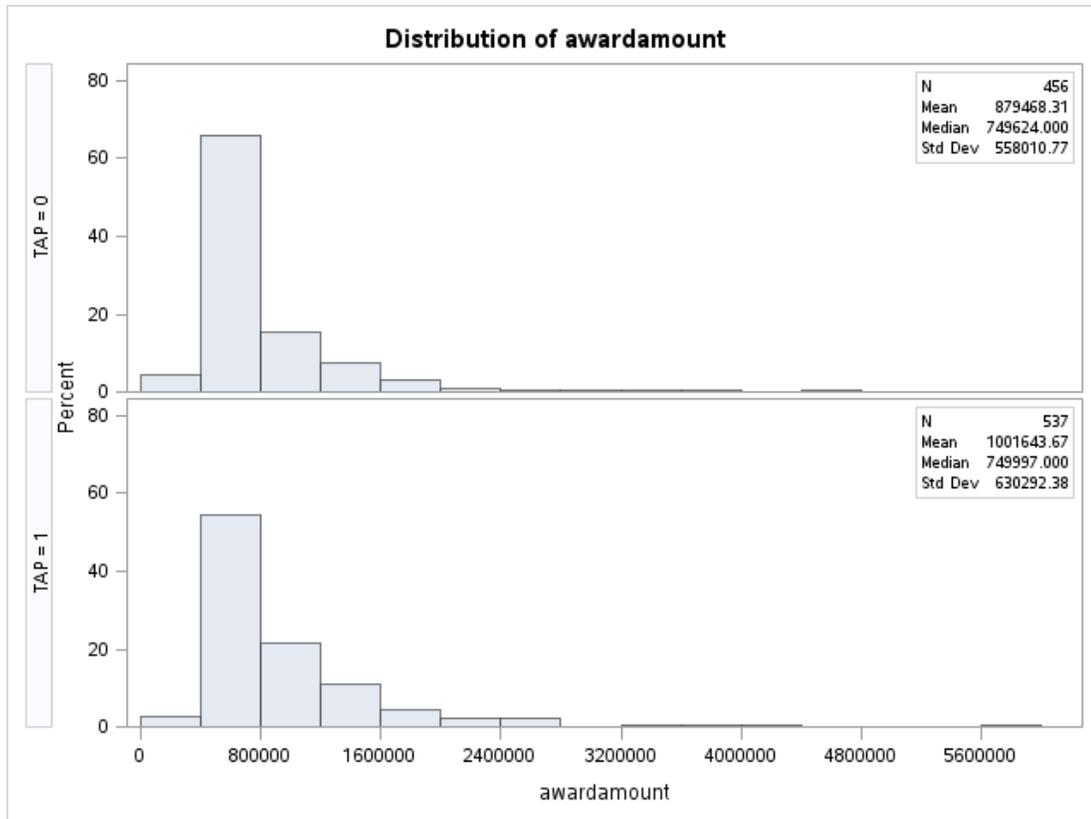
<b>Fiscal Year</b>	<b>Treatment</b>	<b>Commercialization Percentage</b>	<b>Comparison</b>	<b>Commercialization Percentage</b>
<b>2005</b>	158	77%	113	53%
<b>2006</b>	120	73%	94	52%
<b>2007</b>	113	73%	107	45%
<b>2008</b>	146	66%	142	39%
<b>Totals</b>	537	73%	456	46%

### **3.4.1. Descriptive Analysis of Dataset**

As seen in Table 4, the resulting dataset indicates differences in the means across a number of variables. This section takes a closer look at these variables and describes their role in the regression model.

### **3.4.2. Phase II Award Amount**

I believe projects receiving higher levels of funding are better positioned to develop their technology, which may in turn move them closer to a product, or make them more attractive to outside investors. Based on this belief, I hypothesize that the level of Phase II project funding has a positive impact on the probability of commercialization. The distribution of Phase II award amounts between the treatment and comparison groups can be seen in Figure 3.



**Figure 3 Phase II Award Amounts: Treatment versus Comparison**

As seen in the figure inset, the treatment group (TAP=1) has a median Phase II award amount of \$749,997 compared to a median award level of \$749,624 for the comparison cohort, a difference of a little more than \$300. This isn't surprising because, during the fiscal years covered, the SBIR policy guidelines provided a \$750,000 soft cap for Phase II awards. Processes were in place to allow agencies to exceed those aforementioned guidelines, which is reflected in the comparison of Phase II award averages.

The average Phase II award for treatment projects is slightly greater than \$1 million, compared to just under \$880 thousand for the comparison group. The differences between the two populations can be seen in the box plot presented in Figure 4. While both populations share the same median location, the third quartile and upper limits are more extended for the treatment group. The treatment group also contains a larger concentration of outliers on the higher end of the scale, including the two highest Phase II award projects, both receiving close to \$6 million.

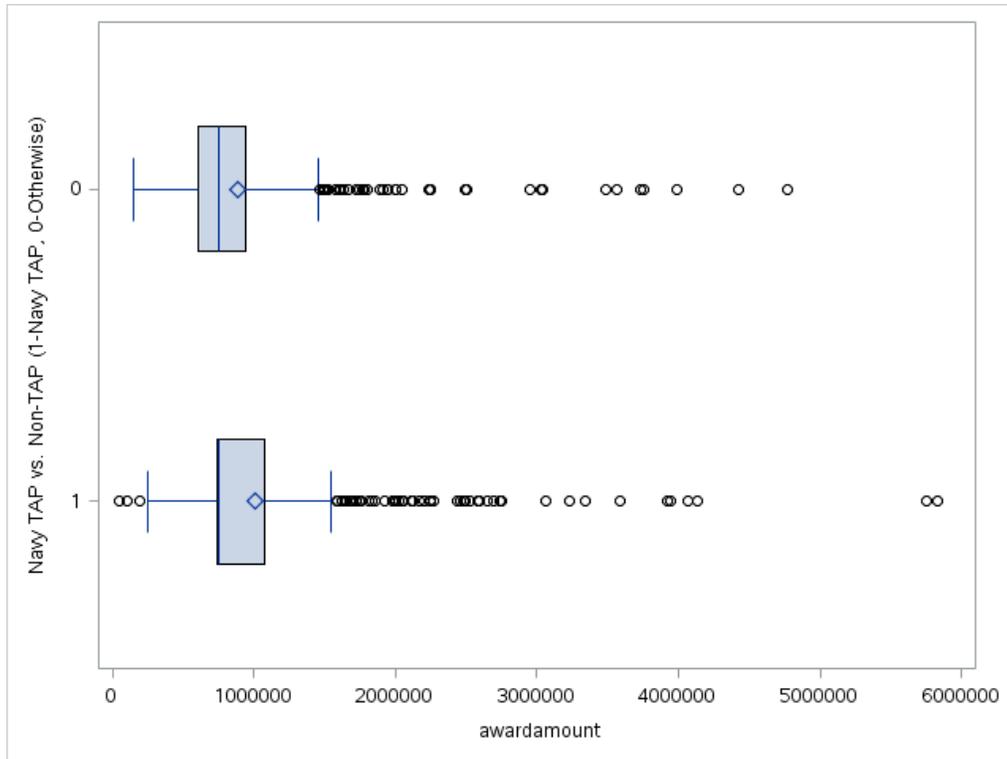
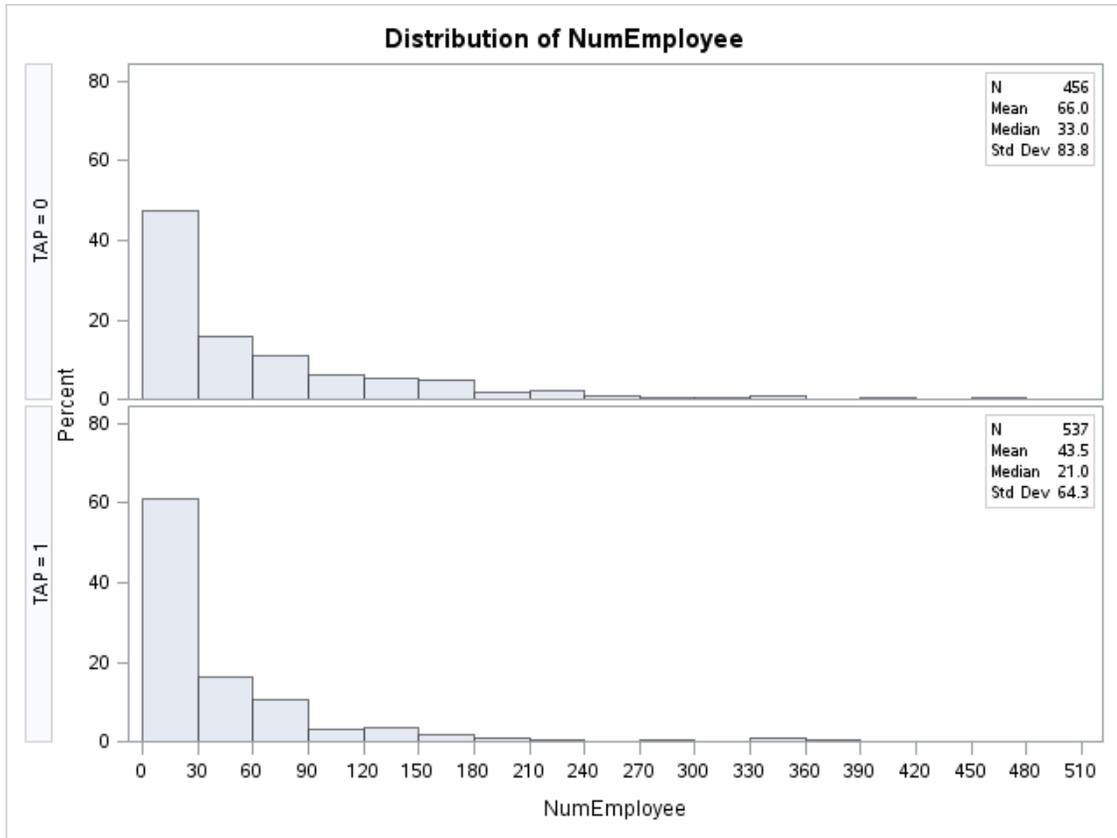


Figure 4 Boxplot of Phase II Award Amount: TAP versus Non-TAP

The net difference between the cohorts in average Phase II award funding is \$122,000, which is statistically significance at the 95 percent level. I will include Phase II award funding in the regression model.

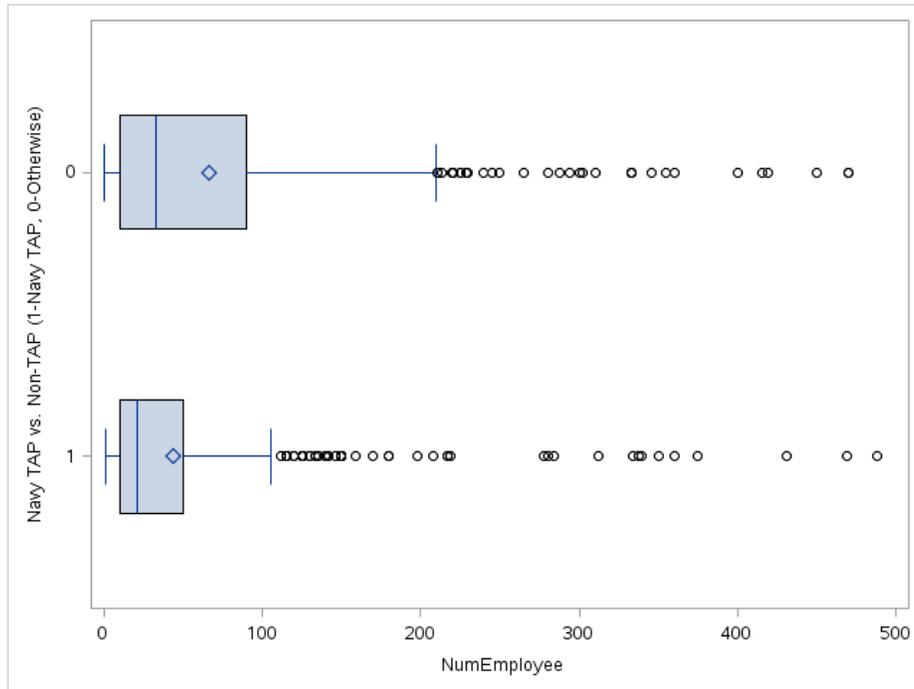
### 3.4.3. Number of Employees

It is unclear the impact, if any, the size of the SBIR firm has on project commercialization outcomes. I anticipate that the smaller firms, when measured by number of employees, may have a more difficult time commercializing their SBIR technology. They may not have sufficient staffing to address their market research or business development needs. To explore this impact, I included the number of employees at the time the firm submitted their SBIR Phase II proposal. The distribution of employees between the cohorts can be seen in Figure 5.



**Figure 5 Distribution of # of Employees: TAP versus Non-TAP**

Projects opting not to participate in the Transition Assistance Program (TAP) tend to be larger when measured by number of employees. The comparison group has a median number of employees of 33, and an average of 66. Both measures are higher than the treatment group, which has a median number of employees of 21, and a mean of 43.5. Close to 60 percent of the projects in the treatment group are from firms with less than 30 employees, compared to less than 50 percent for the comparison group. Figure 6 displays a boxplot of the number of employees for both the treatment and comparison groups.



**Figure 6 Boxplot of Number of Employees TAP vs. Non-TAP**

As seen in the boxplot, firms with more than 100 employees are considered an outlier within the treatment cohort, while, the comparison group’s outliers begin around 200 employees. The difference in mean number of employees between the subpopulations is statistically significant at the 95 percent level. I will include number of employees in the model to understand if the success probability changes with size (as measured by number of employees).

#### **3.4.4. Geographic Location**

The distribution of projects contained in this dataset originates from 48 of the 50 states, as seen in Figure 7. Lerner (1999) found that SBIR awardees based in zip codes with substantial venture capital activity experienced superior growth compared to their counterparts. Recognizing that geographic location may impact project commercialization, I compressed the states into the four U.S. Census based regions—West, South, Midwest, and Northeast—and include them as an exploratory dummy variable in the model.

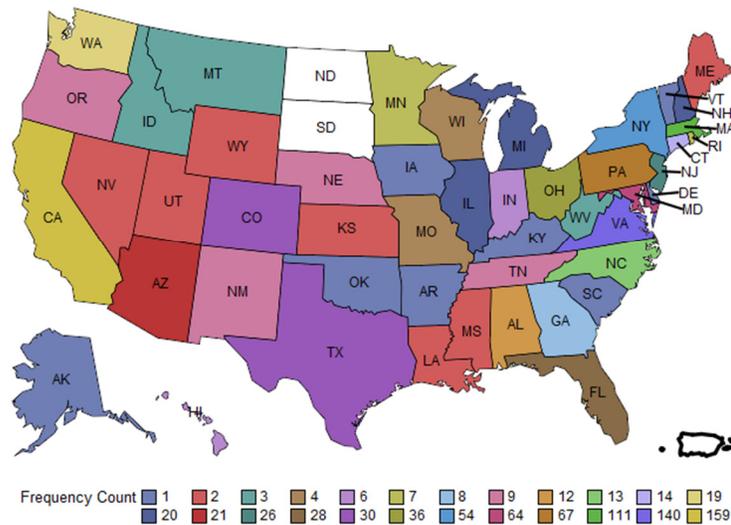


Figure 7 Distribution by State of Navy Phase II Awards w/in Dataset (2004-2008)

### 3.4.5. Funding Component

The systems commands within the Navy represent various functional responsibilities, technological interests, and resources. The implications of these variations and impact on SBIR project outcomes are unclear. I explore differences in success probabilities by adding sponsoring components as an exploratory dummy variable to the model.

### 3.5. Research Design Summary

I hypothesize that commercialization assistance programs increase the probability of commercial outcomes of SBIR Phase II projects. Utilizing secondary data sources, I have developed a treatment group comprised on the population of Navy Transition Assistance Program (TAP) participants who provided commercialization updates following program completion, and a comparison group from the population of projects who were eligible but chose not to participate in the Navy Transition Assistance Program. The resulting sample is 993 projects, 537 in the treatment group, and 456 in a comparison group, a sufficiently sized sample to test my hypothesis. This project will quantify the impact participation in commercialization assistance programs has on the on the odds of success and the estimated success probabilities, subject to the other control variables (i.e., Award amount, Number of employees, Geography, and Sponsoring component).

The results will help policy makers and program managers explore commercialization assistance as a policy option to enhance commercialization outcomes.

#### **4. Developing the Model**

**Probability (commercialization) = f(Technical Assistance; Controls)**

##### **4.1. Dependent Variable: Commercialization**

The dependent variable is project level commercialization, which is appropriate given the project level intervention of the Navy Transition Assistance Program (TAP). Commercialization has been consistently defined as sales or non-SBIR additional development funding related to the SBIR award (General Accounting Office, 1992; National Research Council, 2003; and National Research Council, 2008). The purpose of the Navy Transition Assistance Program is to increase the likelihood of participants receiving Phase III (non-SBIR) funding. Given this goal, I decided to use project level commercialization as a binary instead of a continuous variable. Descriptively, the cumulative commercialization outcomes of TAP participants are on average \$480 thousand higher than non-participants (see Table 4). While the cumulative commercialization outcomes are important to demonstrate a return on investment from federal expenditures on research and development; given the emphasis of the TAP—orienting firms to seek commercialization—I believe the percentage of projects successfully securing funding is a more appropriate measurement. This project will represent commercialization as a dichotomous variable taking the value of 1, if the project reported any non-SBIR funding, and 0 otherwise.

##### **4.2. Explanatory Variable: Transition Assistance Program**

I posit that participation in the Navy's Transition Assistance Program increases the probability of project commercialization success. To test this hypothesis I included a dichotomous explanatory variable taking the value of 1 if the project is in the treatment group (Navy TAP participant) and a 0 otherwise (comparison).

##### **4.3. Control Variables**

**Phase II Award Amount:** I hypothesize that the level of Phase II project funding has a positive impact on the probability of commercialization. I believe projects receiving higher levels of funding are better positioned to develop their technology, and in turn may be closer to a product or more attractive to outside investors.

**Number of Employees:** I will include the number of employees at the time of award as an exploratory variable. I do not posit a relationship; however, given the differences in size between the treatment and comparison groups, I will add the variable to explore if success probabilities vary based on firm size characteristics.

**Geographic location:** I do not posit a relationship to geographic location, but will add regional location as an exploratory dummy variable to ascertain if geographic differences impact project commercialization outcomes.

**Sponsoring Components:** variation in resources and authority vary across the Navy's sponsoring components. While I do not posit a direction or magnitude of impact, I do propose exploring potential differences in sponsoring components commercialization outcomes.

## **5. Treatment versus Comparison: Odds of Success**

The primary focus of this research is to assess the impact participation in the Navy's Transition Assistance Program (TAP), a commercialization assistance program, has on the probability of project commercialization success. To that end the principal explanatory variable is a dichotomous participation variable, taking the value of 1 if the project is in the treatment group (participated in the TAP), and a 0 otherwise. To measure this impact I am utilizing available data on projects who chose to participate in the program (treatment group) and those who were eligible but chose not to participate (comparison group), to identify if statistically significant differences exist in the groups odds of success.

### **5.1. Treatment as a Single Predictor of Success**

Although it would be a rather large assumption to assume the only relevant differences between the treatment and comparison groups was their participation in the Navy Transition

Assistance Program (TAP), I see value in developing a single predictor model to the measure the impact of the TAP prior to including the control variables. This cross classification process can indicate the presence and significance of any differences between the two groups solely as it relates to being in the treatment or comparison group.

The 2x2 contingency table I developed based on the population of observations can be seen in Table 6. The table classifies commercialization success across the treatment and comparison groups. The table was set up with the participation variable as the explanatory variable and commercialization as the response. As seen in Table 6, the proportion of the treatment group reporting commercialization success is 390/537, or .73. Meaning seven-out-of-ten of the projects participating in the Navy TAP reported some level of non-SBIR commercialization funding following program completion. Just under half of the projects in the comparison group reported commercialization success (212/456, or .46). The difference in success proportions between the treatment and comparison groups is .26, with an estimated standard of error of .0656.

**Table 6 Treatment versus Comparison 2x2 Contingency Table**

<b>Project Commercialization (1-Commercialized, 0-Otherwise)</b>			
<b>Group</b>	1	0	<b>Total</b>
<b>Navy TAP (Treatment- 1)</b>	390	147	537
<b>Non-TAP (Comparison - 0)</b>	212	244	456
<b>Total</b>	602	391	993

Based on the point estimate of .26 for the difference in sample proportions and a standard error of .0656, I am 95 percent confident that the difference in success proportion for the treatment compared to the comparison is at least 13 percent and at most 39 percent higher. Meaning a significant difference exists between the treatment and the comparison groups, with the treatment having a greater proportion of projects reporting commercialization.

While the percentage difference between the sample proportions may not appear highly impactful, a closer examination of the odds of success between the treatment and comparison groups makes clearer the impact of the Navy Transition Assistance Program. The estimated odds of commercialization success given that a project participated in the TAP is 3.05 times the estimated odds of those in the comparison group. I can be 95 percent confident that the estimated

probability of commercialization success for the treatment is at least 2.34 times, to at most 3.97 times, the comparison group. Assuming the sole explanation for commercialization outcome differences between Navy TAP participants and the comparison is the intervention, the Navy TAP participants estimated odds of success would be at least double the projects in the comparison group.

### 5.1.2. Model Results: Predicted Success Probabilities

Using the dichotomous treatment explanatory variable as a single predictor indicated that graduates of the Transition Assistance Program estimated odds of success were 3.05 times the estimated of odds of success for non-participating projects. This method of analysis does not account for potential differences in outcomes based on other variables. To explore this possibility, I ran a logistical regression model on the 993 observations in the dataset incorporating the control variables as explained in section 4. The Odds Ratio estimates resulting from this model can be seen in Table 7.

**Table 7 Logistical regression: Commercialization Success TAP versus Non-TAP (n=993)**

Parameter	Odds Ratio Estimate	Standard Error	95% Confidence Interval
<b>Treatment (TAP versus Non-TAP)</b>	2.768****	0.1394	(2.109, 3.643)
<b>Inawardamount</b>	2.130****	0.1591	(1.568, 2.929)
<b>NumEmployee</b>	0.997***	.000949	(0.995, 0.999)
<b>Region_Midwest vs. South</b>	1.346	0.2453	(0.836, 2.191)
<b>Region_Northeast vs. South</b>	1.244	0.1745	(0.884, 1.753)
<b>Region_West vs. South</b>	1.230	0.1813	(0.863, 1.757)
<b>Component_MARCOR vs. Other</b>	0.532	0.5386	(0.182, 1.519)
<b>Component_NAVAIR vs. Other</b>	0.466*	0.4406	(0.191, 1.089)
<b>Component_NAVSEA vs. Other</b>	0.606	0.4521	(0.243, 1.449)
<b>Component_ONR vs. Other</b>	0.593	0.4457	(0.240, 1.401)
<b>Component_SPAWAR vs. Other</b>	0.515	0.5405	(0.175, 1.477)
<b>Chi-Square Test Statistics (Alpha): *=.10; **=.05; ***=.01; **** = .0001.</b>			

As seen in Table 7, neither the regional or component dummy parameters are significant, except for the NAVAIR component (at an alpha of .10). Although the continuous variable for the

number of employees is significant at a 99 percent level of confidence, the confidence interval for the odds ratio provides a statistically insignificant result. In lieu of these findings, I removed the regional and component variables, and compressed the continuous number of employees into an ordinal variable. The updated model results are displayed in Table 8.

**Table 8 Reduced Logistical regression results for commercialization of TAP versus Non-TAP Participants (n=993)**

Parameter	Odds Ratio	Standard Error	95% Confidence Interval
<b>Treatment (TAP versus Non-TAP)</b>	2.753****	0.1390	(2.099, 3.621)
<b>lnawardamount</b>	1.992****	0.1531	(1.483, 2.706)
<b>Nemploy (1 vs. 5)</b>	3.74***	0.4099	(1.719, 8.699)
<b>Nemploy (2 vs. 5)</b>	4.162***	0.4323	(1.827, 10.079)
<b>Nemploy (3 vs. 5)</b>	3.284***	0.4228	(1.47, 7.821)
<b>Nemploy (4 vs. 5)</b>	2.69**	0.4809	(1.068, 7.116)
<b>Chi-Square Test Statistics (Alpha): *=.10; **=.05; ***=.01; **** = .0001.</b>			

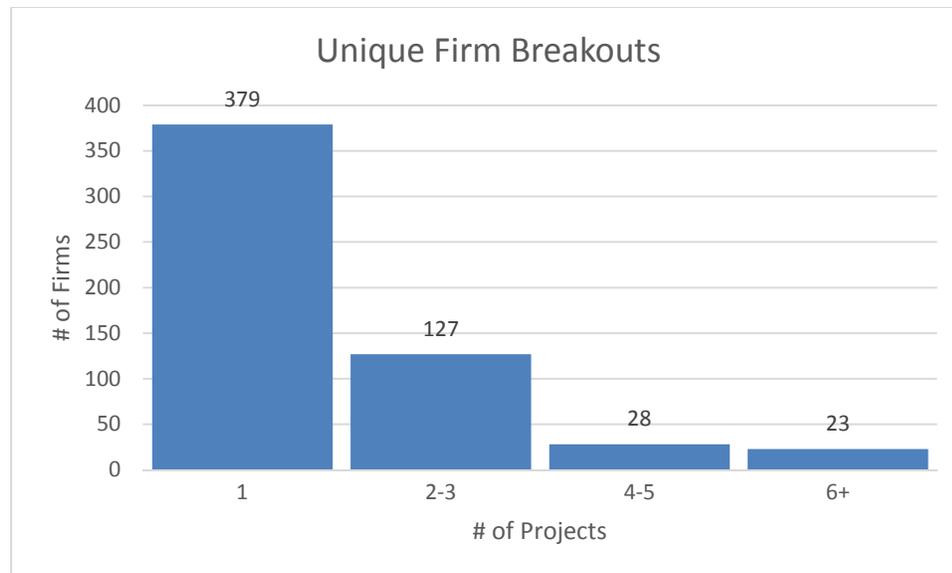
The updated model shows that while holding other variables constant, the odds of commercialization success for a Navy TAP project are 2.75 times the odds of success for a project in the comparison group. Adding additional variables (natural log of Phase II award size) and the bracketed number of employees impacted the odds ratio. Using the treatment as the sole predictor resulted in an odds ratio of 3.05, while the fuller model resulted in an odds ratio of 2.75. To understand the impact of the treatment across firm and project award sizes, I calculated the estimated probability of success for a project with a median Phase II award amount (\$749,949) across the firm size brackets. The Navy TAP graduates held a higher predicted probability of success across the size dimensions. The full results can be seen in Table 9.

**Table 9 Estimated Success Probabilities by Firm Size and Median Phase II Award (\$749,949): TAP versus Non-TAP**

Estimated Success Probability		
Firm Size	TAP	Non-TAP
Nemploy (<25)	72%	48%
Nemploy (25 to 49)	74%	51%
Nemploy (50 to 149)	69%	45%
Nemploy (150 to 249)	65%	40%
Nemploy (250+)	41%	20%

## 5.2. Unique Firms

Although my focus is to isolate project level commercialization outcomes as a function of participating in the Navy Transition Assistance Program (TAP), differences amongst firms’ success winning SBIR Phase II awards could potentially impact results. Reviewing the composition of firms in the dataset reveals that the 993 projects are represented by 557 unique firms. Figure 8 displays a histogram of the number of projects won by unique firms.



**Figure 8 Firm Demographics Overall Dataset**

As seen in the histogram, 379 out of the 557 unique firms (68 percent) won a single project during the years of interest. However, the cumulative number of projects from these firms represents 38 percent of the projects contained in the dataset. This shows a high concentration of

repeat winners within the Navy SBIR program. In contrast, firms winning two or more awards during the period of interest account for 62 percent of all projects. To understand the implications of this distribution, the proportion of successes and total commercialization funding was found for both the single project and the multiple project firms, and analyzed for statistical differences between the groups. This information can be seen in Table 10.

**Table 10 Proportion of Success amongst Firms: Single Project Winners vs. Multiple Project Winners**

Commercialization Success (1-Reported Funding, 0-Otherwise)				
Group	# of Firms	# of Projects	Commercialization Percentage	Total Commercialization
<b>Single Project Firms</b>	379	379	53%	\$362,148,069
<b>Multiple Project Firms</b>				
<b>2-3 Projects</b>	127	284	66%	\$398,496,878
<b>4-5 Projects</b>	28	124	71%	\$100,921,198
<b>6+ Projects</b>	23	206	60%	\$410,094,671
<b>Multiple Project Firms</b>	178	614	65%	\$909,512,747
<b>Totals</b>	<b>557</b>	<b>993</b>	<b>61%</b>	<b>\$1,271,660,816</b>

There is nearly a 12 percentage point difference in the proportion of success for multiple award winners compared to single project firms overall. It is also evident that less than 5 percent of the unique companies (23 companies winning 6+ projects) account for nearly a third (32 percent) of all reported commercialization funding. This finding is not unique. It was found that the 7 percent of firms winning the most Phase II awards accounted for 60 percent of SBIR commercialization (National Research Council, 2008, p. 156). The prevalence of concentrated success amongst a small subset of repeat winners is characteristic of the SBIR and STTR programs, and not specific to the Navy or the Navy Transition Assistance Program (TAP). Nonetheless, to understand if the probability of success changes given these firm characteristics, I developed separate contingency tables for the two subsets and analyzed their odds of success.

### 5.3. Single Project Firms

As stated previously, 557 unique firms won the 993 projects contained in this dataset. Although 68 percent of the firms represented in the dataset are unique, the distribution of projects

amongst unique firms is skewed. This section explores the proportion of success amongst the 379 single project firms based on their exposure, or lack thereof, to the treatment. As seen in Table 11, 52 percent of single-firm projects were exposed to the Navy TAP.

**Table 11 Firm w/ Single Project Contingency Table**

<b>Project Commercialization (1-Commercialized, 0-Otherwise)</b>			
<b>Singe Project Firms</b>	<b>1</b>	<b>0</b>	<b>Percentage of Projects</b>
<b>Navy TAP (Treatment)</b>	67%	33%	52%
<b>Non-TAP (Comparison)</b>	38%	62%	48%
<b>Total</b>	53%	47%	

Cross classifying these subsets based on commercialization outcomes across the treatment and comparison groups reveals that those exposed to the Navy TAP had a success proportion of .67. The proportion of projects in the comparison group reporting commercialization is .38. The difference in success proportions between the treatment and comparison groups is .29, with an estimated standard error of .0491. I am 95 percent confident that the difference in success proportion for the treatment compared to the comparison is at least 19 percent and at most 39 percent higher. Within the subset of single project firms, a significant difference exists between the treatment and the comparison group, with the treatment having a greater proportion of projects reporting commercialization. The estimated odds of commercialization success given that a project within this subset participated in the TAP is 3.3 times the estimated odds of those in the comparison group. I can be 95 percent confident that the estimated probability of commercialization success for the treatment are at least 2.2 times to at most 5 times those of the comparison group. Single project firms that participated in the Navy TAP estimated odds of success are at least double those in the comparison group.

### **5.3.1. Single Project Firms Model**

The dataset contains 993 project level observations represented by 557 unique firms. A subset of those firms had a single project during the period of interest, allowing comparisons without any concerns of spillover impacts from firms with multiple projects. I ran a separate logistical regression model based on this subset of one-time winners. Reducing the model in this

manner made the number of employees insignificant, and thus it was removed. The model results can be seen in Table 12.

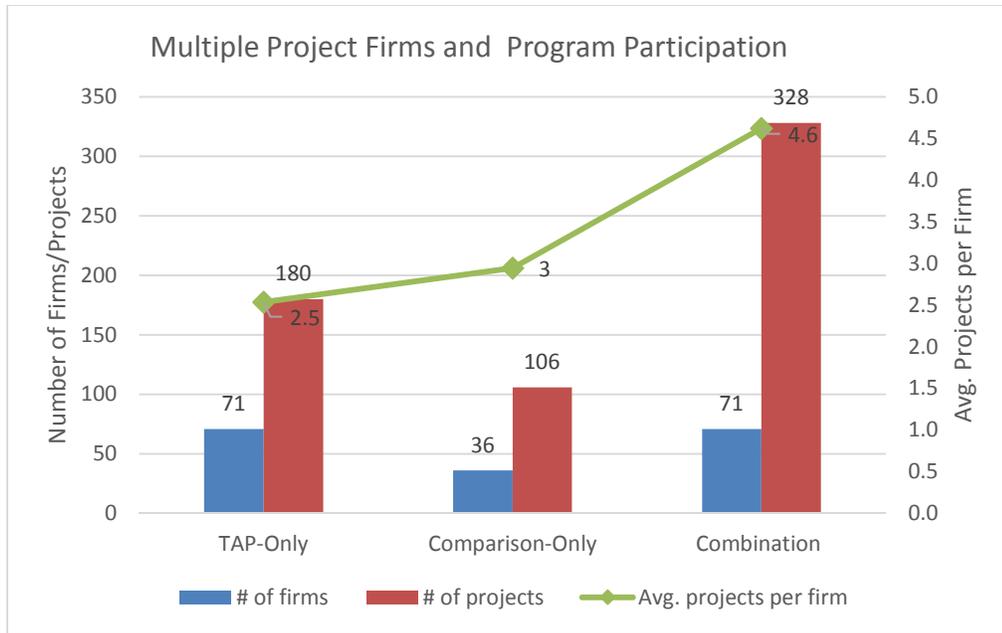
**Table 12 Logistical regression results for Single Project Firms for TAP versus Non-TAP Participants (n=379)**

Parameter	Odds Ratio	Standard Error	95% Confidence Interval
<b>Treatment (TAP versus Non-TAP)</b>	3.025****	0.2190	(1.976, 4.666)
<b>lnawardamount</b>	1.908**	0.2528	(1.178, 3.186)
<b>Chi-Square Test Statistics (Alpha): *=.10; **= .05; ***= .01; **** = .0001.</b>			

For the subset of single-winning firms, the model indicates that the estimated odds for success are 3.03 times the odds of success for a project in the comparison group, slightly lower than if the TAP was used as the sole predictor of success (3.3). The probability of success estimate for a median sized Phase II project (\$749,949) participating in the TAP is 65 percent compared to 38 percent for a comparison project. Amongst the subset of single-project firms, without concerns of spillover effects, the estimated odds of success are at least double the odds of success for projects in the comparison group.

#### **5.4. Multiple Project Firms**

A subset of firms (178) accounted for 62 percent of the sample projects. As discussed previously, the success proportion of this cohort relative to the single project firms was statistically significant, with the multiple project firms reporting a higher proportion of success. The presence of multiple-award winners can indicate endogenous firm factors as a possible explanation of success. The characteristics that have allowed these firms to win multiple Phase II awards, may also contribute to, or drive, their commercialization success. These firms further complicate the understanding of programmatic impact due to the possibility of spillover effects. Since the Navy TAP is a project level intervention, not all of a firm’s projects may be exposed to the treatment; however, to the extent that transferable learning occurs, the benefits of a single project could impact the outcomes of others. The potential for spillovers effects can be seen in Figure 9.



**Figure 9 Multiple Project Firms**

The graph looks at project participation by firms with multiple projects. The combination cluster shows that 71 multiple project firms split their projects by entering at least one of them in the Navy Transition Assistance Program (TAP). These 71 firms won 4.6 projects, on average, during the period covered. They cumulatively accounted for 328, or a third of all, projects. Their decision to enter a subset of projects into the treatment reinforces the possibility of spillovers; however, a full analytic accounting of such impact is beyond the scope of this thesis.

Of the multiple project firms, 107 made the decision to enter all or none of their projects into the Navy Transition Assistance Program. These subsets provide some insight into if commercialization outcomes amongst multi-project firms are impacted by participation in the program. The earlier analysis of multiple project firms, irrespective of program participation, demonstrated that they featured a higher proportion of success compared to single project firms. To measure the TAP impact amongst this group, I cross classified the subset of firms that entered all, or none, of their projects in the TAP. This eliminates concerns regarding spillovers based on a firm entering a subset of their projects. This classification can be seen in Table 13.

**Table 13 Firm w/ Multiple Projects Contingency Table**

Project Commercialization (1-Commercialized, 0-Otherwise)				
Multiple Project Firms	# of Firms	1	0	Total Projects
TAP Only (Treatment )	71	138	42	180
Non-TAP Only (Comparison)	36	50	56	106
<b>Total</b>	107	188	98	286

The multiple project TAP-Only firms (firm entered all of their eligible projects in the Navy TAP) have a success proportion of 138/180, or .77, compared to a success proportion of 50/106, or .47 for the comparison group (multiple project winners who did not enter any of their projects in the TAP). The difference in success proportions between the treatment and comparison groups is .30, with an estimated standard of error of .0577. Analysis of this subset of multiple project firms demonstrates a statistically significant difference between the treatment and comparison groups. The estimated odds of commercialization success given that a project within this subset participated in the TAP is 3.7 times the estimated odds of those in the comparison group. I can be 95 percent confident that the estimated probability of commercialization success for the treatment is at least 2.2 times to at most 6.2 times those of the comparison group.

**5.4.1. Multiple Project Firms Model: TAP-ONLY vs. Non-TAP ONLY**

Amongst the multiple project firms, 107 of them made the decision to solely enter their projects into the TAP, or to entirely bypass the program during the period of interest. There were 180 projects represented by 71 unique firms that entered all of their eligible projects into a Transition Assistance Program, compared to 106 projects represented by 36 unique firms who bypassed the program entirely. A logistical regression model, similar to the one for one-time participants, was run to understand if multiple winning firms muted the impact of the Transition Assistance Program (TAP). Based on the model results, the TAP cohort featured 3.6 times the odds of success when compared to the comparison group. The results of the model can be seen in Table 14.

**Table 14 Logistical regression results for Multiple Project Firms w/o program overlap (n=286)**

Parameter	Odds Ratio	Standard Error	95% Confidence Interval
<b>Treatment (TAP versus Non-TAP)</b>	3.581****	0.2651	(2.139, 6.060)
<b>lnawardamount</b>	1.871**	0.2714	(1.112, 3.256)
<b>Chi-Square Test Statistics (Alpha): *=.10; **=.05; ***=.01; **** = .0001.</b>			

#### 5.4.2. Multiple Project Firms: Potential Spillover Effects

Another subset of multiple project firms split their projects between the treatment and comparison groups. While the underlying rationale for the decision to enter certain projects in the program over others is unclear, the results of that decision could serve as an indicator of intervention spillover effects. Thus far the analysis has consistently shown a higher proportion of success for the treatment compared to the comparison. Examining this subset can reveal if the impact is muted or eliminated. The success outcomes of the 71 firms who decided to split projects between the treatment and comparison can be seen in Table 15.

**Table 15 Firm w/ Multiple Projects Split Between Treatment and Comparison**

<b>Project Commercialization (1-Commercialized, 0-Otherwise)</b>			
<b>Multiple Project Firms</b>	1	0	<b>Percentage of Projects</b>
<b>TAP Only (Treatment )</b>	75%	25%	49%
<b>Non-TAP Only (Comparison)</b>	55%	45%	51%
<b>Total</b>	65%	35%	

As seen in the table, the projects that were exposed to the treatment have a success proportion of .75, compared to a success proportion of .55 for the comparison group. The difference in success proportions between the treatment and comparison groups is .19, with an estimated standard of error of .0514. The difference is significant and a 95 percent confidence interval indicates that the proportion for the treatment is at least 9 percent and at most 29 percent higher than the comparison.

Although less pronounced than previous analysis, this subset still demonstrates a statistically significant difference between the projects in the treatment and comparison groups. The estimated odds of commercialization success given that a project within this subset participated in the TAP is 2.4 times the estimated odds of those in the comparison group. Constructing a 95 percent confidence interval around this point estimate means the estimated probability of commercialization success for the treatment is at least 1.5 times to at most 3.8 times those of the comparison group.

### 5.5. Multiple Project Firms Model: Potential Spillover Effects

Thus far the analysis has demonstrated a consistent pattern of increased odds of success for Navy TAP participants compared to their counterparts. The potential exists within the dataset for potential spillover effects since many firms have projects across both the treated and comparison groups. Given my hypothesis that the Navy TAP has a positive impact on the probability of commercialization, if spillover effects exist, I would anticipate that the odds of success will be lessened for the subset of multiple project firms that split their project participation. To test this effect, I subset the data based on 71 firms, representing 328 projects, distributed across both the treatment and the comparison groups. The model results can be seen in Table 16.

Table 16 Potential Spillover – Multiple Project Firms Split Participation in TAP and Comparison (n=328)

Parameter	Odds Ratio	Standard Error	95% Confidence Interval
<b>Treatment (TAP versus Non-TAP)</b>	2.159***	0.2490	(1.330, 3.535)
<b>lnawardamount</b>	2.088***	0.2761	(1.232, 3.654)
<b>Nemploy (1 vs 5)</b>	5.327**	0.6534	(1.480, 19.171)
<b>Nemploy (2 vs 5)</b>	6.592***	0.6765	(1.751, 24.822)
<b>Nemploy (3 vs 5)</b>	4.847**	0.6436	(1.373, 17.112)
<b>Nemploy (4 vs 5)</b>	3.231*	0.7035	(0.814, 12.828)
<b>Chi-Square Test Statistics (Alpha): *=.10; **=.05; ***=.01; **** = .0001.</b>			

Based on the model results, the potential for spillover effects exists. While the Navy TAP participants maintain higher odds of success (2.16) compared to the comparison group, the odds are closer than any of the previous models explored. While the findings as they relate to spillovers

cannot be deemed definitive, the muted impact amongst these crossover firms can serve as a stepping stone for more in-depth exploration of the potential spillover.

To understand the impact of the treatment across firm size and project award sizes, I calculated the estimated probability of success for a project with a median Phase II award amount (\$749,949) across the firm size brackets. The Navy TAP graduates held a higher predicted probability across the size brackets. The full results can be seen in Table 17.

**Table 17 Estimated Success Probabilities (Spillover) by Firm Size and Median Phase II Award (\$749,949): TAP versus Non-TAP**

Estimated Success Probability		
Firm Size	TAP	Non-TAP
<b>Nemploy (&lt;25)</b>	75%	58%
<b>Nemploy (25 to 49)</b>	79%	63%
<b>Nemploy (50 to 149)</b>	73%	56%
<b>Nemploy (150 to 249)</b>	64%	45%
<b>Nemploy (250+)</b>	36%	20%

## 6. Sensitivity Analysis

### 6.1. The Lower Bound

Cross classification is also useful in measuring the lower bound of TAP impact. While developing the dataset I observed 127 projects that participated in the Navy Transition Assistance Program, but did not provide an update to the DoD Commercialization database following program conclusion. These projects were excluded from the final dataset. If one assumes that these projects did not provide an update because they were unsuccessful, then the impact of the treatment versus the comparison group would be overestimated. To protect against this scenario I assume that these projects were unsuccessful, and reanalyze the data. If the TAP projects still demonstrate higher odds of success, the resulting odds ratio can serve as a conservative lower bound estimate of the programmatic impact.

**Table 18 Lower Bound 2x2 Contingency Table**

Project Commercialization (1-Commercialized, 0-Otherwise)			
Group	1	0	Percentage of Projects
Navy TAP (Treatment)	59%	41%	59%
Non-TAP (Comparison)	46%	54%	41%
<b>Total</b>	54%	46%	

Table 18 displays the updated cross classification which increased the number of unsuccessful treatment projects. The original dataset indicated a proportion of success of .73 for the treated firms, after updating the data to reflect this lower bound estimate, this proportion was reduced to .59. This updated figure still compares favorably to the comparison group which had a success proportion of .47. The updated difference in success proportions between the treatment and comparison groups is .12, with an estimated standard of error of .0302. Based on this information, I am 95 percent confident that the difference between the treatment and the comparison group is at least 6 percent and at most 18 percent higher. This means that at the lower bound, a significant difference still exists between the treatment and the comparison group, with the treatment maintaining a greater proportion of commercialization success.

It is clear that the magnitude of impact between the treatment and the comparison group is less pronounced. In the original dataset the treatment group had a 3 to 1 probability of success compared to the comparison group. Under the lower-bound scenario, the odds drop to a point estimate of 1.64 times the odds of the comparison group. Constructing a 95 percent confidence interval under this scenario shows the odds estimate ranges from 1.29 to 2.08. So under the more conservative evaluation of programmatic impact, I can be 95 percent confident that the probability of commercialization success is at least 29 percent higher, and at most double, the odds of success for the comparison group.

## **7. Summary of Results**

### **7.1. Probability of Commercialization Success**

Commercialization (private sector or Non-SBIR funding) of federally sponsored innovations is a key congressionally mandated goal of the Small Business Innovation Research

(SBIR) and Small Business Technology Transfer (STTR) programs. While much attention has focused on quantifying and assessing the commercial outputs of the SBIR program, limited research exists on the impact business advisory support initiatives have on project commercialization. These programs, such as the Navy's Transition Assistance Program (TAP), seek to augment the business capacity of SBIR/STTR award recipients by providing information and resources focused on facilitating the commercialization process. I employed a logistic regression model to examine commercialization outcomes from participants and non-participants in the Navy's Transition Assistance Program (TAP). A dataset comprised of 993 Navy Phase II projects awarded between 2005 and 2008 was used to populate the model. The self-reported commercialization outcomes contained in the dataset include 537 Navy TAP projects, and a comparison group of 456 Navy Phase II projects who opted not to participate in the program during the years covered. The resulting analysis found that the odds of success given that a project participated in the Navy TAP ranged from 1.5 to 6.2 times the odds of success for a non-participating project, depending upon firm characteristics (a summary of results can be seen in Table 19).

Based on the 95 percent confidence intervals from the respective models, the odds of success given that a project participated in the Navy TAP range from a high of 6.2 to a low of 1.5, depending upon firm characteristics. The full model which uses the entire 993 projects without any subsets indicates that the odds of success for TAP projects are 2.3 to 4 times the odds of success for non-participating firms. For the subset of single-winning firms, the model indicates that the estimated odds for success are 3.03 times the odds of success for a project in the comparison group. Stated differently, the model results indicate that for a Navy Phase II project with less than 25 employees, and a median sized Phase II (\$749,949) the estimated probability of success would be 65 percent, if they participated in the Navy TAP. If a project with the same characteristics chose not to participate in the Navy TAP, its success probability will fall to 38 percent. Amongst the subset of projects who were either entirely exposed to the treatment, or fully opted out of the program, the odds of success for those exposed to the Navy TAP are at least double the projects in the comparison group.

Table 19 Summary of Model Results: TAP versus Non-TAP

Model Results: TAP versus Non-TAP Commercialization Success Estimates			
Model Description	Odds Ratio (TAP as Single Predictor)	95 % Confidence Interval	Logistic Model Specification/ TAP Odds Ratio/Probability of Success
<b>Full Model (n=933)</b>	3.05	(2.3 to 4.0)	$logit[P(Y = 1)] = (-10.7095 + 1.0127(tap) + .6891(lnawardsize) + 1.3190(Employee < 25))$ Odds Ratio = 2.75 Probability of Success TAP is 72%; Non-TAP is 48% (at median award size (\$749,949), and less than 25 employees)
<b>Single Project Firms (n=379)</b>	3.3	(2.2 to 5.0)	$logit[P(Y = 1)] = (-9.2193 + 1.1070(tap) + .6463(lnawardsize))$ Odds Ratio = 3.03 Probability of Success TAP is 65%; Non-TAP is 38% (at median award size (\$749,949))
<b>Multiple Projects Firms: TAP-Only vs. NON-TAP Only (n=286)</b>	3.7	(2.1 to 6.2)	$logit[P(Y = 1)] = (-8.6350 + 1.2757(tap) + .6267(lnawardsize))$ Odds Ratio = 3.58 Probability of Success TAP is 75%; Non-TAP is 46% (at median award size (\$749,949))
<b>Multiple Project Firms: Projects Split across Treatment/Comparison (Potential Spillover, n=328)</b>	2.4	(1.5 to 3.8)	$logit[P(Y = 1)] = (-11.3173 + .7694(tap) + .7363(lnawardsize) + 1.6728(Employee < 25))$ Odds Ratio = 2.16 Probability of Success TAP is 75%; Non-TAP is 58% (at median award size (\$749,949), and less than 25 employees)
<b>Sensitivity Analysis: The Lower Bound (n=1120)</b>	1.64	(1.29 to 2.08)	

The 993 projects in the dataset was represented by 557 unique firms, meaning a subset of firms had multiple projects during the years covered. Specifically, 178 firms accounted for 62 percent of the projects within the dataset. These multiple award winners have close to a 12 percentage point difference in the proportion of successful firms compared to single project firms overall. It is also evident that less than 5 percent of the unique companies (23 companies winning 6+ projects) account for nearly a third (32 percent) of all reported commercialization funding. This finding is not unique, it is consistent with previous findings on multiple award winners and commercialization outcomes. The National Research Council found that 60 percent of SBIR

commercialization resulted from the 7 percent of firms winning the most awards (National Research Council, 2008, p. 156). The prevalence of concentrated success amongst a small subset of repeat winners is characteristic of the SBIR and STTR programs, and not specific to this dataset or the Navy Transition Assistance Program (TAP).

I ran two models focusing on these multiple project firms. The first model was populated by multiple project firms entering either all of their projects, or none of their projects, in the Navy TAP. This subset featured the highest model based odds ratio, indicating that projects exposed to the TAP are 3.6 times more likely to be successful than their counterparts. These models (single project firms, and TAP-Only versus Non-TAP multiple project firms) do not have to deal with potential spillover effects because there are no firm overlaps between the treatment and comparison groups. Without concerns of spillover, the odds of success given that a project participated in the TAP is estimated to be at least 3 times the odds of success of a project that did not participate in the program, and at least double based on the lower bound of the 95 percent confidence interval.

My analysis has demonstrated a consistent pattern of increased odds of success for Navy TAP participants compared to their counterparts. The potential exists within the dataset for spillover effects since multiple firms have projects across both the treated and comparison groups. Since I hypothesize that the TAP has a positive impact on the probability of commercialization, if spillover effects exist, I would anticipate that the odds of success will be lessened for firms with projects distributed across the treatment and comparison groups. To test this effect, I subset the data set based on 71 firms, representing 328 projects, distributed across both the treatment and the comparison groups. Based on the model results, the potential for spillover effects exists. While the Navy TAP participants maintain higher odds of success (2.16) compared to the comparison group, the odds of the success are closer than any of the previous models explored. While the findings as they relate to spillovers cannot be deemed definitive, the muted impact amongst these crossover firms can serve as a stepping stone for more in-depth exploration of the potential spillover.

## **7.2. Cost Benefit and Cost Effectiveness**

The Navy Transition Assistance Program (TAP) represents a cost effective way for both increasing the magnitude of commercialization success and probability of commercialization

success (the number of successes). As described earlier in Table 4, on average Navy TAP projects reported close to \$500,000 more in commercialization than their non-participating counterparts. A streamlined cost-benefit analysis, using the agency per project TAP expenditures as the primary cost, and the marginal difference between TAP and Non-TAP commercialization outcomes, I found a cost benefit ratio of 37.9. As seen in Table 20, the 537 projects that participated in the Navy TAP exceeded the non-TAP projects total commercialization by a present value of \$292.3 million, representing a net present value of \$284.5 million. The Navy investment in the Transition Assistance Program (TAP) has generated approximately \$38 in commercialization outcomes, per dollar invested, and has a net benefit of \$284.5 million.

**Table 20 Navy TAP Cost Benefit Analysis**

<b>Cost Benefit Analysis</b>	
<b>Costs (Present Value (PV) at r = 3%)</b>	
<b>Portfolio Participation Costs (PV)</b>	\$7,719,433
<b>Benefits (PV at r = 3%)</b>	
<b>Cumulative Difference in Commercialization<sup>10</sup></b>	\$292,250,682
<b>Net Present Value (NPV)</b>	\$284,531,249
<b>Benefit-Cost Ratio</b>	37.9

The Navy TAP also increases the probability of success, or stated differently, generates more successes than one would expect absent the program. As seen in the descriptive statistics of the dataset (described earlier in Table 4) using non-participant outcomes as the status quo, one would expect 46 successes per 100 SBIR Phase II awards in the absence of the Transition Assistance Program. Given the results of TAP participants, I would expect twenty-seven (27) additional successes (or 73 successes per 100 participating projects). This marginal increase represents a cost to the agency, simplified for these purposes, as the per project participation cost of approximately \$15,000 per project (National Research Council, 2007). As seen in Table 21,

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<sup>10</sup> I utilized a 3 percent social discount rate and assumed a delay between agency investment and commercialization outcomes. I anticipated commercialization occurring in year 4 (60% of expected commercialization) and year 5 (40% of commercialization).

based on these per project costs and anticipated outcomes, the cost to generate an additional successful project is \$55,556.

**Table 21 TAP Cost Effectiveness Analysis per Additional Success**

<b>Cost Effectiveness Analysis</b>	
<b>Successes per 100 Non-TAP projects</b>	46
<b>Successes per 100 TAP projects</b>	73
<b>Marginal increase in successful projects given TAP</b>	27
<b>Total cost per 100 TAP projects (\$15K x 100)</b>	\$1,500,000
<b>Total cost per additional success</b>	\$55,556
<b>Average TAP Commercialization (r = 3%)</b>	\$1,318,423
<b>Net Present Value (r = 3%)</b>	\$1,262,868
<b>Present Value Benefit-Cost Ratio</b>	23.73

This cost effectiveness ratio of \$55,600 per additional success is offset by the expected increase in commercialization. Simplifying the anticipated outcome as the known (present value) average commercialization of a Navy TAP project, I anticipate each additional success beyond the status quo, would generate \$1.32 million in commercialization. The net present value per additional success is \$1.26 million, and the present value benefit cost ratio is approximately 24. So utilizing the Navy TAP as a policy tool to increase the number of successful projects will cost federal agencies \$55,600 per additional success; however, they can expect a return of approximately \$24 per dollar invested.

Cost effectiveness analysis is a useful tool for federal policy makers when deciding how best to allocate the tax payer resources. The Navy investments in the TAP has had an overall cost-benefit ratio of 37.9, indicating an effective use of resources as measured by the increased generation of commercialization. It also appears, that the program is an effectiveness investment in not only maximizing the magnitude of commercialization dollars relative to the status-quo (non-TAP outcomes), but also in creating successes that otherwise would not have occurred. It costs the Navy, through the TAP, close to \$56,000 to generate a success that otherwise would not have occurred. This per success investment is easily offset, as it is anticipated that those additional successes will generate \$1.3 million in commercialization, for a cost-benefit return of \$24 per dollar invested.

## **8. Areas for Additional Research**

This project focused specifically on the odds of success given that a project participated in the Navy Transition Assistance Program (TAP). Award recipients from acquisition agencies have the dual opportunity of commercializing their federal research within markets internal to the government, as well as commercially. It is unclear if the effectiveness demonstrated by the TAP is also found in non-acquisition agencies. This unknown represents an area for additional exploration.

In addition, examination of the firm decision making process, including their pre-entry characteristics, could provide more insight into who and why certain firms request support while others do not. Lastly, a broader exploration based on commercialization assistance program investments and programmatic outcomes could shed light into the level of funding necessary to impact a project's commercialization outcomes.

## **9. Policy Implications**

### **9.1. Exogenous Business Support Can Enhance Success Probability**

This research demonstrates that exogenous support, like the Navy's TAP, can enhance projects probability of commercialization success. My analysis found that the odds of commercialization success are at least twice as likely for a project participating in the Transition Assistance Program, compared to non-participating projects. This finding has many policy implications, chief among them, is my belief that federal agency program managers should strongly consider establishing commercialization assistance programs.

In establishing the SBIR/STTR programs, Congress sought to harness the innovative capability of small businesses to both diversify the federal research and development service marketplace and generate societal benefits. Maximizing the economic outcomes from federal SBIR/STTR investments occurs as firms commercialize (either in commercial markets or through the federal acquisition process) products and services which generate jobs, support advanced weapon systems, or drive down federal research and development costs through increased competition. While the small firms attracted to the SBIR/STTR program may be technically

advanced, they may lack the necessary business capacity to create these down-stream societal benefits.

Storey (2003) found that small and medium firms tend to underinvest in the services which could augment their business capacity because they are unclear or underestimate the long-term benefits of those investments. The Navy, through the Transition Assistance Program (TAP), has sought to address this information failure, and to maximize the societal benefits from federal research and development funding in a cost effective manner.

The Navy investments in the TAP has had an overall cost-benefit ratio of 37.9, indicating an effective use of resources as measured by the increased generation of commercialization. It also appears, that the program is an effective investment in not only maximizing the magnitude of commercialization dollars relative to the status-quo (non-TAP outcomes), but also in creating successes that otherwise would not occur. Given the existence of the Navy TAP, we can anticipate 27 additional successes per hundred Phase II projects.

Establishing commercialization assistance programs will not only allow federal agencies to overcome this knowledge gap and generate increased commercialization both measured in magnitude and probability, but also provide an alternative to penalizing unsuccessful firms, and balance the sometimes competing goals of stimulating innovation and maximizing economic outcomes.

### **9.1.2. Alternative to Penalizing Firms**

Commercialization assistance programs can also be viewed as an alternative to penalties for failure to meet commercialization performance benchmarks. As discussed previously, these benchmarks were established to ensure firms make every effort to commercialize their SBIR/STTR projects. While this approach implies a failure of the firm, it is possible that the failure may be insufficient knowledge to transition from technologist to successful entrepreneurs. As a policy tool, commercialization assistance programs can be extended to these firms prior to any award penalties. This will ensure that their failure is firm, or technology, based, and not a reflection of a knowledge gap.

### **9.1.3. Commercialization Assistance Programs Balance Dual Programmatic Goals**

The SBIR program started as an initiative to leverage the innovative capacity of small businesses and use them in meeting federal research and development needs. Although increasing the private sector commercialization of federal research and development innovations was among the goals, it was not viewed as more important relative to other goals. However, with the increased emphasis on commercialization, I fear program managers of federal research and development programs may become more conservative in their award process, which could stymie technological innovation.

When the program was conceptualized by Roland Tibbetts, a key feature was the ability to test as many innovative ideas as possible. Implicit in this is an acceptance of technology failure which is inevitable when pursuing cutting edge innovations. While project commercialization potential is a component of the proposal evaluation process, I believe, through the implementation of commercialization assistance programs, agencies can balance their interest in funding the most technologically promising projects, while also pursuing economic outcomes from the federal research investments. Commercialization assistance programs are established and organized to augment the business capacity of participating firms, so award decisions can be tilted towards the most innovative technology pursuits while the firm specific business risks can be mitigated through exogenous assistance programs.

## **9.2. Broader Consideration of Programmatic Outcome Metrics**

Prior research has often sought to draw a direct line between a given SBIR/STTR award and commercialization outcomes. This approach fails to capture a demonstrated outcome form social capital networks--the development of new opportunities between partnering firms (Fountain, 1999). Social Capital (Fountain, 1999) is the process of establishing inter-organizational linkages based on trust, collaboration, and networks. Innovation is enabled through this collaborative effort. I believe the social capital enabling component of the Navy TAP contributes to commercialization success.

In many ways the Navy TAP serves as the hub for facilitating trust amongst the various acquisition actors. While the majority of activity is focused on the individual small firm, a key aspect of all interactions is enhancing their capacity to partner and leverage information and opportunities from others stakeholders. While some firms may go it alone, the majority will often

work with a large system integrator to ultimately transition their technology to the warfighter. The Navy TAP recognizes this pathway, and works to identify and facilitate connections with points of contact in the major defense primes and other arms of the acquisition community. While social capital as it relates to enabling innovation has typically focused on regional synergies and relationships, the Navy TAP, through its Navy Opportunity Forum, attempts to overcome these geographical boundaries by bringing together members of these communities for the opportunity to network and develop new, or more involved, relationships.

The role the Navy's Transition Assistance Program (TAP), and its contractor, Dawnbreaker, play in enabling these new networks and relationships has clear policy implications. A demonstrated outcome from social capital networks are the development of new opportunities between partnering firms (Fountain, 1999). Unfortunately, the growth of these new connections and possibly new lines of research and development may not be captured under current outcome metrics applied to the SBIR/STTR programs. Prior research has focused on commercialization outcomes related to the underlying SBIR/STTR projects. Enhancing the "social capital" of SBIR/STTR firms can result in new partnerships that lead to the development of novel lines of research. In lieu of this, broader outcome metrics should be used in evaluating the success of the SBIR/STTR programs, specifically as it relates to firms involved in initiatives, like the Navy TAP, which facilitate innovation based social capital.

### **9.3. Commercialization Assistance Funding Should be Increased**

Current legislation allows a firm to either expend, or receive on its behalf, external commercialization support amounting to approximately 1 percent of the typical Phase II award amount. This figure should be reexamined to ensure the resources provided are sufficient to enable the firm to overcome their knowledge gap, facilitate the development of social capital, and to navigate the challenging federal acquisition communities. Congress has demonstrated a continuous and growing emphasis on the commercialization outcomes of Federal SBIR/STTR research investments. While their emphasis is clear, per project commercialization investments are minor. Federal agencies and commercialization assistance providers should work to identify the minimum level of expenditures for commercialization support and make those amounts allowable expenditures from the SBIR and STTR set-asides.

Instituting the expansion of commercialization assistance programs will be a challenge because not all firms, or policy actors, believe the expenditures are warranted. Given the current federal budgetary landscape, any expansion will most likely be funded through the SBIR and STTR extramural set-asides. This inevitably places a challenge upon SBIR and STTR program managers, as it will either reduce the number of Phase I or Phase II awards, or decrease the award amounts. Either decision may be met with reluctance both in Congress, and from SBIR/STTR firm advocacy groups. While Congress has shown an interest in the economic outcomes, it has also sought to diversify the geographic dispersion of SBIR and STTR awards, and may view a reduction in awards as an affront to their outreach goals. Also, established winners of SBIR Phase I and Phase II awards, specifically repeat winners, may not feel commercialization support is sufficiently needed to reduce the number of awards, or decrease individual project awards.

Despite these challenges, based on the anecdotal reports, and as this research has demonstrated, the Navy TAP is a cost-effective mechanism to both increase the magnitude of commercialization dollars and the probability of commercialization success. I believe the Navy TAP has demonstrated investments in commercialization assistance programs represent a cost effective way to maximize programmatic outcomes and increase the probability of programmatic success.

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