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Survive, But Not Thrive? The Constraining Influence of Government Funding on Technology Start-Ups

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Abstract

This paper examines the potential constraining effects of funding from mission-oriented (e.g., NASA, DoD, DHS) public-funding agencies on the future growth of technology-based startups. Prior research on innovative, small-business government funding programs illuminates the beneficial nature of such public resources in overcoming resource limitations in launching new technology ventures. However, this research is based mainly on empirical analysis of non-constraining, grant-based relationships with science-oriented public-funding agencies and does not explicitly take the perspective of the entrepreneurial firm. I fill this gap by analyzing the potential limitations of government funding on technology start-up survival and growth. I argue that those government funding programs that constrain a start-up's strategic agility (i.e., limit opportunity discovery and exploitation) can have adverse long-term effects. By quantitatively examining over 27,000 technology start-ups, I find that such agility-constraining resources increase the likelihood of start-up survival, but limit growth. This paper, therefore, contributes to strategic management, entrepreneurship, and public policy literature.

Introduction

"In any given new technology, entrepreneurs could fail to identify any opportunities, or could identify the wrong opportunities, making an explanation for the discovery of opportunities an important part of the domain of entrepreneurship research" (Shane, 2000).

It is widely acknowledged that firms seeking to commercialize new technology ventures face significant resource constraints. Empirical evidence has shown that innovative companies suffer financing constraints for new technology ventures as conventional sources of for-profit capital (e.g., internal investment, VC, CVC) tend to under-invest in high-risk R&D (Howell, 2017; Lerner, 2012). In high-growth markets, where firms may experience fewer financing constraints, other resources become scarce. Acquiring technical talent, for example, can become a powerful constraint as ventures seek to scale in competitive labor markets (Kazanjian, 1988; Stern, Porter, & Furman, 2000). In combination, many firms fail in their attempts to bring new technologies to market.

To overcome resource constraints, it has long been the policy of nation-states with growth-focused economies to subsidize new technology ventures. While all firms face resource constraints in launching technology ventures, small firms feel the effects of these constraints the strongest (Gans & Stern, 2000). Small firms tend to suffer from an ability to appropriate social returns from their innovations and are therefore more likely to under-invest in new technology ventures (Anton & Yao, 1994). To counteract under-investment by small firms, governments have developed funding programs to subsidize innovation in small firms. These include such well-researched programs as the U.S. SBIR program (Howell,

2017; Link & Scott, 2010), the Chinese Innofund program (Guo, Guo, & Jiang, 2016; Wang, Li, & Furman, 2017), or the Swedish VINN NU program (Söderblom et al., 2015).

These subsidies tend to be particularly salient to resource-strapped technology start-ups (Kropp & Zolin, 2005). While small firms certainly face resource constraints, there are a large number of fixed costs for new firms that require additional resources. Thus, government funding programs that subsidize innovation in small firms tend to be overly prescribed by new firms. For example, in the U.S. SBIR program, 60% of all funding goes to firms under five years of age. Thus, technology start-ups are heavily represented in these early-stage R&D funding programs.

Research regarding the impact of small-business innovation funding policies has mainly found positive results. Primarily taking the view of the government, scholars have shown that such programs increased knowledge-spillovers leading to broader economic growth, overcame financial constraints in resource-strapped geographies, and increased the number of new technology ventures started from scientific endeavors as well as the number of commercial products introduced to market (Audretsch, 2003; Audretsch, Link, & Scott, 2002; Feldman & Kelley, 2006; Gans & Stern, 2000; Link & Scott, 2010). Of those scholars that have explicitly evaluated the impact of small-business innovation programs from the view of the firm, the majority have studied the effects of government funding on private R&D intensity (i.e., how much the firm spends internally on R&D), uncovering both complementary and substitutionary effects (Guerzoni & Raiteri, 2015; Wallsten, 2000). In general, these findings have found that small-business funding programs have had a positive impact on economic growth.

Interestingly, however, little research has explicitly investigated the impact of these programs on technology start-up performance. Recent research has indicated that scholars who study the effects of such government policies should expressly examine the nature of technology funding programs on entrepreneurial activity as opposed to grouping small businesses and start-ups under the same category (Hellmann & Thiele, 2017). Besides the large fixed costs of forming a new technology start-up, there exist significant differences in growth objectives and business models. What makes a small business successful, therefore, may not make a new firm successful. Given that prior research takes a macro-approach at evaluating the effect of these policies on economic and firm performance, there remains a gap in understanding how small-business innovation funding programs impact technology start-up performance.

This paper attempts to address this question by evaluating the potential negative influences of small-business funding programs on technology start-up growth. Specifically, I argue that while providing resources to technology start-ups increases the likelihood that they will survive, government-backed resources can impede growth by limiting a firm's strategic agility. While resources remain critical for technology start-ups, that's not all that necessary for a performant high-growth technology-start-up. Organizational research on entrepreneurial firms has illuminated how an entrepreneur's cognitive and behavioral traits influence a new firm's ability to discover and exploit optimal opportunities (Baron, 2007; Helfat & Peteraf, 2015). For example, scholars have shown that start-ups identify capabilities via cognitive frames that are generated through prior experiences (Baron, 2007; Baron & Ensley, 2006), engage in opportunities through rapid decision making governed by the firm's standard operating procedures (Bakker & Shepherd, 2017; Eisenhardt, 1989; Ott, Eisenhardt, & Bingham, 2017) and are able to exploit opportunities via institutional bricolage (Baker & Nelson, 2005; Phillips & Tracey, 2007). In combination, new ventures with high strategic agility—the ability to recognize new opportunities, make important decisions about those opportunities quickly, and re-deploy institutional resources to exploit those

opportunities—are more likely to be successful. Thus, engaging with resources which constrain strategic agility may weaken firm performance.

To test these theories, I analyze a matched sample of 27,730 dual-use technology start-ups. Dual-use technology ventures are a particularly appropriate research setting as they have the option to receive funding from both private sources of capital and mission-funding agencies. Many technology ventures are considered dual-use (cybersecurity, artificial intelligence, etc.), thus making it a particularly important part of the high-technology economy (Lin, 2016). Funding from a mission-funding agency (e.g., militaries, space agencies, homeland security agencies) provides a particularly salient example of an agility constraining opportunities, as mission funding agencies often have unique, monopsony needs, restrictive contractually-based mechanisms, and pre-set resource allocation rules that limit a firm's ability to discover and exploit opportunities. In combination, dual-use technology start-ups have multiple initial resource opportunities and therefore can select into potentially constraining ones.

To test the impact of these programs, I employ a quasi-experimental design through a robust matching, cox-proportional hazard, and differences-in-differences approaches. Specifically, I assess the impact of the DoD's SBIR program on technology start-up survival and growth (number of employees and revenue, logged). By collecting quantitative and qualitative evidence, I find that the DoD SBIR program provides much-needed sources of revenue for firms and that firms receiving SBIR contracts experience more extended survival rates. Interestingly, however, I find that firms who receive SBIR contracts from the DoD establish patterns of behavior that limit strategic agility. Quantitatively, I show that for SBIR-start-ups, post-award growth is slower, as revenue is net-negative compared to a comparable set of industry peers.

I make two contributions. First, I contribute to strategic management by introducing the concept of an agility-constraining opportunity. While prior research has focused on how firms become more agile by discovering and exploiting opportunities, this paper argues that discovering and exploiting an agility-constraining opportunity can have long-lasting adverse effects where competitors have multiple resource paths to pursue. Second, I contribute to policy research by detailing the conditions under which firms might be more or less successful when partnering with the government. Specifically, I show that the impacts of government funding for new ventures are distinct from more traditional small businesses. By showing how small-business funding programs can be determinantal for growth in new firms, I argue for new policy which takes entrepreneurial growth goals and business models into consideration.

Research Setting

I explore this question by investigating the impact of the U.S. Department of Defense (DoD) Small Business Innovative Research (SBIR) program on new venture survival and growth. The SBIR program was instantiated to specifically counter-act underinvestment from small businesses in new technology ventures (Audretsch, 2003; Audretsch, Weigand, & Weigand, 2002). Funding for the SBIR program is significant, with the total spending breaching $2.5 billion in 2017. Subsequently, the SBIR program remains one of the most well-researched small business programs and is a model for both OECD and non-OECD countries seeking to develop their innovation funding programs (Wang et al., 2017).

Although prior research often investigates the U.S. SBIR program in its entirety, there is significant heterogeneity within the program itself. The SBIR program is funded directly by individual government funding agencies, such as the Department of Energy (DoE), National Science Foundation (NSF), or the National Air and Space Administration

(NASA). Specifically, each funding agencies allocates 3.2% of their annual extra-mural R&D budget (i.e., the part of the yearly budget dedicated toward funding R&D external to the organization) towards the SBIR program. Accordingly, each funding agency is allowed to decide how to allocate those funds, leading to significant heterogeneity in policy implementation. Variation in funding strategy includes differences in which technology sectors to fund (i.e., energy vs. space), the maturity of technology required prior to funding (i.e., basic through applied research), and the nature of the interaction between government agency and funded firm (i.e., grant-based or contractually-based relationships).

To best research how government funding might constrain technology start-up strategic agility, the U.S. DoD SBIR program presents a particularly salient example. Prior research has focused primarily on science-oriented funding agencies funding new technology ventures through grant-based relationships (Bruce, de Figueiredo, & Silverman, 2018; Pahnke, Katila, & Eisenhardt, 2015). The DoD is a mission-oriented funding agency which caters to public-sector demands through contract-based relationships, which creates two significant differences from this prior work. First, while previous research generally studies the impacts of public funding programs administered by science-oriented funding agencies who fund firms to introduce new technology ventures to the private-sector market, mission-oriented funding agencies fund firms to introduce new technologies to public and private-sector markets. The DoD, for example, controls the market for military technologies and therefore invests in technology ventures which have the potential for commercial application internal to the military (Dasgupta & David, 1994; Mowery, 2009). As a result, DoD SBIR funding heavily incentivizes firms to develop products or services to meet military demands.

Second, while prior research has generally studied the impact of funding programs which allocate funds through unrestrictive grant-based relationships, the DoD funds technology ventures through more restrictive, contractually-based relationships (Congress, 1977; Flammer, 2018). In grant-based relationships, firms may adapt or alter their R&D activity as more knowledge is gleaned in the course of the R&D activity. In contrast, any change in R&D activity in a contract-based relationship requires a re-negotiation of the contract itself. As a result, DoD SBIR funding incentivizes firms not to adjust R&D activity. In combination, the public-sector demands of the DoD and the generally restrictive nature of contractually-based relationships make the U.S. DoD SBIR program a particularly useful context from which to measure the impact of small-business innovative funding programs on technology start-up performance.

Theory Building and Hypotheses

Research at the intersection of entrepreneurial strategy and technology start-up performance highlights three important firm-based performance outcomes: firm survival, firm growth, and innovations produced (normally assessed by patents or product introductions). Research intersecting technology start-ups and government funding has primarily evaluated the later and has generally found that government R&D funding dedicated to innovation results in both more technologies invented and products introduced (Audretsch, 2003). For example, the only two studies that specifically address the impact of mission organizations—one on NASA and the other on the DoD—use survey and case-based evidence to show that SBIR-contract receiving companies report both an increase in the number of new technology ventures embarked and number of commercial products successfully introduced to market (Archibald & Finifter, 2003; Audretsch, Link, et al., 2002). Therefore, this paper focuses solely on the impact of the U.S. SBIR funding program on technology start-up survival and growth.

Government Funding and Firm Survival

Entrepreneurial cannon on growth-focused technology start-ups has long emphasized the importance of acquiring critical resources quickly. These include access to capital, access to capable technical talent, and both technical and social legitimacy (Armanios et al., 2017a; Eberhart, 2017; Hsu, Roberts, & Eesley, 2007; Lerner, 1999). Finding and employing capital is vital given that technology start-ups incur significant costs before generating revenue. Finding and hiring technical talent is important given limited technical labor supply and the need to scale effectively and quickly. Gaining both technical legitimacy and social legitimacy is important to generate ties with resource providers (e.g., suppliers, customers, strategic alliances). In sum, for technology start-ups to survive, they must quickly acquire critical resources.

Government funding can be particularly useful in providing such resources. First, government subsidy programs provide direct, non-dilutive capital to firms. The SBIR program offers, on average, up to $225,000 for an early stage contract. While this amount of funding might not be significant for larger, more established firms, it is precious for early-stage companies. In comparison, the median angel investment round, which would be the comparable private capital funding mechanism, is ~$285,000. Furthermore, while the median angel investor charges ~8% equity for that initial investment, the SBIR program takes no equity stake (Knauss, Edwards, & Williams, 2017). Government funding is therefore particularly attractive to technology start-ups.

Second, government funding provides access to technical experts. Access to government researchers is a critical part of government funding programs that invest in new technology ventures (Sauermann & Stephan, 2012). Across all U.S. funding agencies, for example, SBIR projects are administered by advanced-degree holding researchers who work directly with the funded companies (SBA, 2014). These government researchers spend significant time with the funded company to help the firm meet its funded R&D goals (Pahnke et al., 2015). The government also indirectly incentivizes interaction with non-government backed technical experts as displayed in program selection biases. For example, Feldman and Kelley (2006) find that firms who partner with research institutions experience higher likelihoods of receiving government funding. Thus, technical talent is a crucial resource provided by government funding partnerships.

Lastly, government funding supports technical and social legitimacy via certification and access to a stabilizing set of government ties. Given their resident technical expertise, partnering with a government organization is interpreted as a certifying stamp of technical legitimacy (Armanios et al., 2017b; Eesley, Li, & Yang, 2016). Studying 151 Chinese entrepreneurs who entered a funding partnership with the Chinese government, Armanios et al. (2017) showed that while the entrepreneurs benefited from the resident technical expertise (skill adequacy), those entrepreneurs who were relative unknowns in the social context benefited significantly more from the certification received by participating in the program. Explicitly, the technical quality of the entrepreneur is signaled by the government's certification of the firm. Similar research has been done investigating firms who partnered with the government in Finland (Autio & Rannikko, 2016) and Spain (Busom, 2000).

Government partnerships also provide social legitimacy by enforcing a stabilizing series of political ties between government funding agency and firms. Research has illuminated that political ties generate important social legitimacy for firms dealing with uncertain environments (Hiatt, Carlos, & Sine, 2017; Hillman, Zardkoohi, & Bierman, 1990; Wang & Qian, 2011). For example, researching 282 airline ventures in 10 South American countries, Hiatt et al. (2017) found that those airlines which had political ties with the military

were more likely to survive in times of social unrest. Thus, the very nature of receiving a government contract can increase a technology start-up's technical and social legitimacy.

Given access to unique, technical, and high-capital resources, along with sources of legitimacy from technical certification and political ties, government funding provides a unique set of resources for technology start-ups. I argue that, in combination, these positive externalities of government funding make it much more likely for firms who receive government funding to survive relative to those firms who do not engage in such partnerships. This leads me to my first hypothesis:

H1: Technology start-ups who receive government funding are more likely to survive than similar firms who do not.

Government Funding and Firm Growth

Entrepreneurial cannon has also established that firms grow by rapidly discovering and exploiting novel opportunities (Eckhardt & Shane, 2003; Hitt et al., 2001; Ireland, 2007; Shane & Venkataraman, 2000). Prior work in strategic management has introduced the concept of strategic agility—that is, the ability rapidly identify and engage in profitable opportunities—as a core trait of successful entrepreneurial firms (Doz & Kosonen, 2010; Ryu, Kwon, & Park, 2018). This can best be broken down into three distinct parts: identifying capabilities by employing multiple and heterogeneous cognitive frames, rapidly experimenting, evaluating, and selecting opportunities by applying reliable and repeatable standard operating procedures, and exploiting opportunities via bricolage (reconfiguring and deploying resources in novel ways). Technology start-ups that can effectively engage all three activities exhibit high strategic agility, allowing them to discover and exploit valuable opportunities which result in firm growth.

When government funding constrains strategic agility, therefore, it may have a limiting effect on future growth. Given that the U.S. DoD SBIR program has unique, public-sector demands and employs more restrictive, contractually-based relationships, firms who receive DoD SBIR contracts may experience impediments to growth. Specifically, I argue such funding programs impose two unique impediments on technology start-ups: *institutional impediments*, which limit opportunity identification, and *structural impediments*, which limit opportunity evaluation speed and resource bricolage, respectively. For example, by encouraging technical performance (a unique, public-sector demand) over-commercialization, mission-funding agencies incentivize firms to seek professional opportunities for new technology ventures instead of growth opportunities for which to introduce new commercial products (Eesley, 2016; Sauermann & Stephan, 2012). In turn, the potential impediments caused by agility-constraining government funding may limit growth.

Institutional Impediments

Institutional impediments are initiated via differences in institutionalized norms and behaviors between mission-oriented government funding sources and that of technology start-ups. Norms of mission-oriented funding agencies, derived from the institution of the state, have been characterized by a focus on new technology ventures to support unique, mission-focused demands (Branscomb, 1993; Prendergast, 2002; Thornton, Ocasio, & Lounsbury, 2012). For example, the primary objective of the U.S. SBIR program is to "fund innovative new technology ventures." Conversely, norms of technology start-ups, derived from the institution of the corporation, have been characterized by a focus on resource acquisition, market-driven research, and controlling access to intellectual property (Liebeskind, 1996). I argue that by incentivizing technology start-ups to follow mission-

oriented funding agency norms instead of technology start-up norms, government funding sources limit the ability for start-ups to identify growth opportunities.

Scholars have shown that new firms often adopt the norms and behaviors of their critical resource providers. For example, Grégoire et al. (2010) showed that how start-ups recognize opportunities is driven by prior experiences and present network structure. Gulati & Higgins (2003) find a firm's future experiences are limited to those made available by early-influencing partners, re-enforcing initial opportunity recognition behavior. Thus, for start-ups whose only experiences are constrained to interactions with mission-oriented funding agencies, opportunity recognition will be driven by a set of norms and behaviors that prioritizes new-venture formation over existing-venture growth.

Indeed, interviews with entrepreneurs highlight some such effects. For example, the founder of one company who received multiple U.S. DoD SBIR awards pined over his failure to recognize commercial-funding opportunities. He stated,

> One of my regrets of course having wizened up after this [company failure due to slow growth] and maybe this is the lesson that is we should have gotten commercial funding earlier. … It wasn't a question of not wanting to give away a part of the company or equity. I think we were just a little risk averse and weren't sure, and I don't know why. Why we were risk averse to the idea of getting any commercial funding and things of that nature. So, in retrospect I think, had we 10 years ago gone and gotten some commercial funding, things would've been very different.

He attributed his firm's ultimate demise to not recognizing commercial opportunities, prioritizing winning multiple SBIR awards instead of pursuing alternative sources of revenue or investment.

It, therefore, stands to reason that opportunities driven by the government, as opposed to commercial markets, become more salient as the ties with the government become stronger. While capitalizing on such opportunities may be beneficial for capturing the future government market, they may limit the opportunity to identify growth-focused opportunities.

Structural Impediments

Structural impediments are driven by the contractual nature of relationships between mission-oriented government funding agencies and their partnered firms. *Contracts* are a "binding agreement between a buyer (government) and seller (firm) to provide goods in return for compensation" (Congress, 1977). Unlike grants, when the public-funding sponsor has limited insight into R&D activity in the private firm, in contracts the public partner has a significant say, and imparts strategic direction, on the firm's R&D activity. They are often executed on behalf of public, mission-oriented funding agencies as these agencies cater to specific public-markets with unique public-sector demands (David & Hall, 2000). For example, while both mission and non-mission funding agencies execute SBIR programs, SBIR-based public-private R&D relationships with the NIH (non-mission) collaborate use grants, while relationships with the DoD (mission) use contracts. Thus, those start-ups who engage with the U.S. DoD SBIR program do with through more intensive, contract-based relationships.

Contracts impose two structural impediments which constrain strategic agility. First, government program managers enforce mission-oriented demands on firms. On one hand, mission-oriented demands result in highly organized and formalized approaches to R&D activity. On the other, it enforces a large time cost on behalf of the developing firm, which

limits the firm's ability to rapidly experiment with emerging opportunities. For example, contracts require statements of work, which describe—to specific technical detail—the proposed R&D path as well as the ultimate contract deliverables. This requires significant work on behalf of the entrepreneur. For example, a private investor who invested in 10 SBIR-receiving companies stated,

> There was a fairly involved process of actually negotiating the deliverables and the timelines and whatever went into an agreement that was crafted. I'm not sure if every single one of the applications needed it, but I've heard back from some of them that this took a bit of doing, that this was a fairly long process, because some of the funds were dispersed in transfers and they had to accomplish certain things, and so they had to put in place various goals and deliverables and things like that, so that took a bit of doing.

Thus, engaging in contracts can impart significant time costs to the partnered firm.

Second, if the technology start-up wishes to alter its development path, it requires contractual revisions. The Federal Acquisition Regulation, the U.S. federal law which governs contract usage, clarifies that contract change agreements are required when the firm or government funding agency wishes to change a Statement of Work. An investor discussed how that could be damaging to start-ups who are continually adapting as new information becomes available in the R&D process. He stated, "If, down the road, they [the start-up] suddenly had to change their funding allocation or something changed that they didn't anticipate, and this renegotiation of the spending and the budgetary items took a little bit of time." In turn, contracts make it difficult to pivot R&D as new information emerges.

In combination, structural impediments constrain the ability to evaluate rapidly and deploy resources against, new opportunities. Lengthy contract negotiations limit rapid decision making, while contractual revisions restrict the ability to quickly re-deploy resources. In sum, although government-funding may increase firm survival, I argue that funding from mission-oriented funding agencies can impede growth. Specifically, institutional and structural impediments limit the ability of firms to recognize and rapidly exploit novel opportunities. Therefore, my second hypothesis is as follows:

H2: Technology start-ups which receive government funding from mission-oriented funding agencies are associated with slower growth than firms who do not.

Methods

Data

I analyze the associations between the U.S. DoD SBIR program and technology start-up performance over 15 years from 1997–2012. My sample comprises specifically of *dual-use technology firms* (referred to as "dual-use firms" from here on out). Dual-use firms are defined as technology firms who can sell products to the public or private sector. These firms comprise significantly large industries, such as aerospace, cybersecurity, and IT. I choose to analyze dual-use as they have multiple types of investors and a large variety of potential go-to-market strategies. They therefore represent a set of firms that face the question of if, and with whom, to receive funding from.

I begin my sample by collecting the full population of new ventures who received funding from the U.S. Department of Defense (DoD) Small Business Innovative Research (SBIR) program from 1997–2012. Out of the total DoD SBIR awarded firms in between these years, more than 60% of the companies who received SBIR contracts were new

ventures. A new venture qualifies any firm less than five years of age at the time of winning their first SBIR contract.

Next, I collect data on all firms in the sample dating back to 1994, the year the government mandated SBIR contract-receiving companies register in Dun and Bradstreet, thus providing the best starting point for data collection. Although the oldest firm in the sample is founded in 1997, beginning data collection in 1994 allows controlling for financial capabilities up-to three years before receiving an SBIR award. Although my sample ended in 2012, I continue data collection through 2015 or until the firm declares bankruptcy, or is acquired. This allows for additional outcome analysis. One resulting strength of my data set is that it contains the entire population of new, DoD SBIR-funding receiving firms during this time. There are 1,965 total firms in my data set, all founded between 1997 and 2012.

To develop a sample of dual-use firms, I next sample Dun and Bradstreet for firms with a similar founding year and SIC. Since firms register in Dun and Bradstreet when they seek a credit rating, the resulting data set is particularly complete (Eesley & Roberts, 2012). Specifically, I query every U.S. firm in Dun and Bradstreet founded between 1997 and 2012 which shares at least one 4-digit Standard Industrial Code (SIC) in common with the SBIR receiving firms. Comparable firms are limited to the United States as all SBIR companies must be at least 51% owned in the United States. Four-digit SIC is a useful measure of a firm's industry at the level of product offerings. For example, the 2-digit code 36 classifies "Electronic and Other Equipment" companies, while adding two more digits to get to the 4-digit code of "3672" classifies the firm as producing "Printed Circuit Boards." Combining these data sets, I compiled a total sample of 358,535 firms.

My primary data set is was collected from the SBIR database (SBIR.gov) and Dun and Bradstreet. To measure venture-backed funding partnerships and pertinent, annual firm performance data, I utilized Thompson One and PitchBook. Where there were discrepancies, I turned to other data sources for clarification, include CapitalIQ, Crunch Base, and Data Fox.

Measures

Dependent Measures

The first hypothesis measures the likelihood of firm survival. Given the lack of commonly-available standard performance information for newly formed private-ventures, firm survival is an important and commonly used metric of new-venture performance (Chatterji, 2009; Klepper, 2002; Paik, 2014). This is captured in two variables, *exited* and *exit-date*. Exited is measured by a binary variable of whether a firm goes out of business, 1 if it goes out of existence and 0 if it still exists. This does not include acquisition or IPO, as those exit strategies may qualify as still "surviving," although in a different format. *Exit-date* is qualified as the year in which the firm goes out of business. In combination, both variables are used to analyze the first hypothesis.

For robustness, I also evaluate *Acquired,* as acquisition represents a potentially positive outcome for young firms and therefore a distinctly alternative exit strategy. Given the SBIR program's data rights clauses, and that those rights are transferable through acquisition, SBIR companies who developed unique and innovative technologies are likely to become acquisition targets for larger firms. *Acquired* is measured by a binary variable of whether a firm was acquired, 1 if acquired and 0 if not.

The primary aim of hypothesis two is to measure the influence of funding on entrepreneurial growth. I define growth in two dimensions, *Log Revenue* and *Log Employees*. *Log Revenue* is used as it is strategy invariant, as the majority of start-ups seek

revenue regardless of growth, IPO, or acquisition strategy (Eesley & Roberts, 2012). Specifically, I calculate log revenue as the log of revenue in each firm-year of operation. As employees indicate growth goals, I also include *log employees.* Log employees are calculated as the log of employees in each firm-year of operation.

Independent Measures

I operationalized my main explanatory variable of interest with *SBIR-awardee.* I measured whether a firm received government funding with an *SBIR-awardee* binary variable coded as 1 if the firm received an SBIR contract and 0 otherwise. Multiple awardee recipients were recorded in the *Number of SBIR awards* variable.

Controls

Given the different measures of performance, the following controls are either recorded at the founding, before award, or per firm-year, depending on the needs of the model. For assessing survival rates, our variables do not change in time. For evaluating growth, some variables—where required—are measured as lagged by one year.

I measured whether the firm received *venture-funding* with a binary variable coded as 1 if the firm received VC investment and 0 otherwise. As prominent VCs may be more likely to influence innovation, I also measured relationship to high-status VCs for sensitivity analysis. VC's eigenvector centrality in venture capital syndication networks was included to control for ranking, and the top 30 VCs were coded with a 1 in the binary variable *Top-tier VC.*

Since older firms are correlated with higher revenues and more employees, I control for *firm age.* Firm age is the difference between the founding year as reported in the Dun and Bradstreet database and current year. As *the industry* is an essential discriminant in performance, I also control for the 4-digit *SIC*. I build on prior literature that uses this level of detail to describe industry effects (Zajac, 1988). I also control for the location with *state.* SBIR program restricts funding companies to which U.S. citizens own 51% of the firm. Therefore, all of the firms in our data set are U.S. based. State is a dummy variable across all 50 states.

I control for firm technical resources with firm *patents.* I.P. owned and appropriated before SBIR or Venture award may affect both the likelihood of firms receiving an award and entering into a contractual arrangement. Patents are recorded as the total number of patents awarded in a given firm-year.

I also include a standard control for *founding team size*. Larger founding teams are known to be correlated with higher performance outcomes. It is well acknowledged that the range of an entrepreneur's ex-ante functional expertise and experience will influence organizational decisions, and therefore the greater the team size, the higher the functional collective knowledge (Beckman & Burton, 2008; Gompers, 2005). I measure team size by the number of founders (Pahnke et al., 2015). Founding team size is recorded as the total number of employees listed on Dun and Bradstreet at the time of founding (Eisenhardt & Schoonhoven, 1990).

I also control for *Woman* and *Minority*-owned businesses. The U.S. Small Business Association, which oversees the SBIR program, gives special attention to, and incentivizes participation from, woman and minority-owned businesses (Bramble, 2015; SBA, 2014). As a woman and minority businesses may be therefore more likely to apply to SBIR, they

represent a necessary control. Woman and minority are binary variables recorded as 1 if at least 51% owned by one or more women or minorities, respectively.[1]

Finally, I control for *temporal effects* that might be correlated with performance outcomes given macroeconomic conditions beyond our control. Temporal effects are measured with yearly dummy variables from 1994 to 2015, strictly for growth models.

Methods

I take a quasi-experimental approach towards assessing our hypotheses. This involves a process that controls for *selection* through matching methods, by applying both strict sub-sampling and coarsened-exact-matching, and *treatment*, by applying cox-proportional hazard model and differences-in-differences methods

Matching

The goal of the matching method is to generate matched sets of control-treatment firms that are as close as possible so they can be used to estimate the counterfactual in ways that are relevant for the outcome (Shadish, Cook, & Campbell, 2002). Given the large sample size available, I employ strict sub-sampling (Stuart, 2010). Strict sub-sampling matches firms exactly on matching covariates, resulting in K-1 matches (control to treatment). Given previous research that has applied similar methods, I matched firms on geographical location, founding year, and SIC (Goldstein & Narayanamurti, 2018; Pahnke et al., 2015). Altogether, I create matched sets of firms that receive SBIR. For the primary sample, this reduced total firms in the analysis to 27,730 firms, 1,414 received at least one SBIR contract.

Cox Proportional Hazard

To test the survival rate of firms, I build on previous literature examining firm longevity by employing the proportional hazards modeling as described by Cox (Audretsch & Mahmood, 1995; Mata & Portual, 1994; Suarez & Ulterback, 1995). This method uses a logarithmic transformation of a hazard of failure as the outcome variable. As firms experience a higher likelihood of failures, their hazard rate shifts upwards. The hazard model is

$$\ln\ h(t) = \ln h_0(t) + X\beta,$$

where $h_0(t)$ is the baseline hazard function, X is a vector of covariates, and β is a vector of the coefficients. The resultant prediction of the hazard function shows a value greater than 0.5 if a firm is likely to exit relative to its control group. A negative value implies that a firm is more likely to survive.

Difference-in-Differences

I use a differences-in-differences approach to asses longitudinal performance. Estimating treatment effects by constructing a matched control group and analyzing panel

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[1] The definition of minority is supplied by the U.S. Small Business Association and is publicly available. These include minority groups which are presumed to be socially and economically disadvantaged, such as African Americans, Hispanic Americans, Native Americans, Alaska Native Corporations, Indian Tribes, Native Hawaiian Organizations, Community Development Corporations, Asian Pacific Americans, and Subcontinent Asian Americans.

data using a difference-in-differences approach has shown to be a robust approach to evaluating policy treatments, such as government funding (Short & Toffel, 2010). This method yields separate estimates for selection and treatment effects and allows a comparison of treatments over time, which is essential when measuring changes in the rate of growth post-treatment. H1 is measured with Cox-proportional hazard model, while H2 is measured with the differences in differences approach.

Results

The central results of the paper are shown in Tables 2 and 3. Model 2, Table 2 represents the impact of SBIR funding on start-up survival. Models 2 and 4, Table 3, represent the associations between government funding and start-up growth. Figures 1 and 2 summarize these results by showing differences in firm performance pre and post-award. Table 1 presents covariate descriptive statistics, post-match.

Table 1. Means, Standard Deviations, and Correlations

Table 1. Means, Standard Deviations, and Correlations

	Mean	S.D.	Exit	Woman	Minority	Founding Team Size	Venture	Patent	SBIR Awardee	Firm Age	Revenue (log)	Employees (log)
Exit	0.032	0.177	-									
Woman	0.054	0.225	-0.0093	-								
Minority	0.092	0.289	-0.016	0.3	-							
Founding Team Size	3.091	27.76	0.00065	0.0041	-0.0045	-						
Venture	0.054	0.226	0.0038	0.0086	-0.012	0.058	-					
Patent	3.091	27.76	-0.0036	0.044	0.0095	0.055	0.41	-				
SBIR Awardee	0.052	0.222	-0.015	0.065	0.071	0.016	0.069	0.27	-			
Firm Age	8.302	4.022	0.035	0.073	0.11	0.066	0.07	0.11	0.14	-		
Revenue (log)	11.099	3.72	-0.016	0.083	0.071	0.094	0.079	0.11	0.12	0.21	-	
Employees (log)	1.27	0.905	-0.0093	0.13	0.059	0.24	0.2	0.23	0.19	0.28	0.61	-

Table 2 represents the cox-proportional hazard model for firm survival. I find evidence to support H1. Model 2 shows that SBIR awards have a significant and negative impact on firm death, thus leading to higher survival rates. Specifically, these results indicate that firms which receive a contract early in their existence have a 60% greater chance of survival as compared to those similar firms which do not win a government contract.

Table 2. Exit: Cox Proportional Hazard Model

Table 2. *Exit*: Cox proportional hazard model		
Variables	Full Data Set	
	(1)	(2)
Independent Variables:		
SBIR-awardee		-0.816****
		(-1.250, -0.381)
Controls:		
Venture Raised	0.181	0.155
	(-0.119, 0.480)	(-0.146, 0.456)
Firm Age	-0.053****	-0.051****
	(-0.074, -0.032)	(-0.071, -0.030)
Patents	-0.345***	-0.260**
	(-0.596, -0.093)	(-0.514, -0.006)
Founding Team Size	-0.0001	-0.0005
	(-0.002, 0.002)	(-0.003, 0.002)
Woman	-0.114	-0.1
	(-0.459, 0.231)	(-0.445, 0.245)
Minority	-0.450***	-0.431***
	(-0.738, -0.162)	(-0.719, -0.143)
Dummies Included:		
SIC (4-digit)	Yes	Yes
State	Yes	Yes
N	27,730	27,730

Note: *p<0.1; **p<0.05; ***p<0.01; ****p<0.001

Table 3 represents the differences in differences models for firm growth. I find partial evidence for H2. First, Models 2 and 4 (SBIR-awardee variable) indicate that SBIR contracts are awarded to higher performing firms. This indicates a significant and positive selection effect for SBIR awards, consistent with earlier research. Second, Model 2 (SBIR-awardee x After treatment variable) indicates weaker revenue growth post-award, while Model 4 indicates stronger employee growth. Specifically, Model 4 suggests that contract-receiving firms experience ~10% greater employee growth post-SBIR award, while Model 2 shows that those same firms experience a 70% decrease in revenue. I return to these intriguing findings in the conclusion.

Table 3. Diff-in-Diff

Table 3. Diff-in-Diff				
Variables	Revenue (Logged)		Employee (Logged)	
	(1)	(2)	(3)	(4)
Independent Variables:				
SBIR-awardee		1.529****		0.244****
		(1.398, 1.661)		(0.214, 0.274)
After treatment		1.090****		0.139****
		(1.042, 1.137)		(0.128, 0.150)
SBIR-awardee x After treatment		-0.742****		0.100****
		(-0.886, -0.598)		(0.067, 0.133)
Controls:				
Intercept	9.100****	8.859****	1.364****	1.224****
	(6.435, 11.765)	(6.211, 11.508)	(0.759, 1.969)	(0.623, 1.826)
Venture Raised	0.696****	0.672****	0.522****	0.515****
	(0.628, 0.765)	(0.604, 0.740)	(0.506, 0.537)	(0.500, 0.531)
Firm Age	0.259****	0.226****	0.059****	0.054****
	(0.255, 0.264)	(0.221, 0.230)	(0.058, 0.060)	(0.053, 0.055)
Patents	0.038****	0.036****	0.014****	0.013****
	(0.030, 0.046)	(0.028, 0.044)	(0.012, 0.016)	(0.012, 0.015)
Founding Team Size	0.009****	0.009****	0.006****	0.006****
	(0.009, 0.009)	(0.009, 0.010)	(0.006, 0.006)	(0.006, 0.006)
Woman	0.601****	0.578****	0.290****	0.280****
	(0.538, 0.664)	(0.515, 0.640)	(0.276, 0.304)	(0.266, 0.295)
Minority	0.302****	0.280****	-0.021****	-0.030****
	(0.254, 0.350)	(0.233, 0.328)	(-0.032, -0.010)	(-0.040, -0.019)
Dummies Included:				
SIC (4-digit)	Yes	Yes	Yes	Yes
State	Yes	Yes	Yes	Yes
Year	Yes	Yes	Yes	Yes
N	236,387	236,387	236,387	236,387
Adjusted R-squared	0.174	0.184	0.254	0.264

Note: *p<0.1; **p<0.05; ***p<0.01; ****p<0.001

Figure 1 represents the differences-in-differences graphs. The graph on the left indicates that firms who receive SBIR awards have greater revenue before award, but firms who do not win SBIR awards experience stronger growth post award. As successful firms experience their initial sources of revenue during this period (between 2 and 4 years of age), this result is consistent with existing empirical research. The graph on the right indicates that firms who receive SBIR awards do experience stronger employee growth post award.

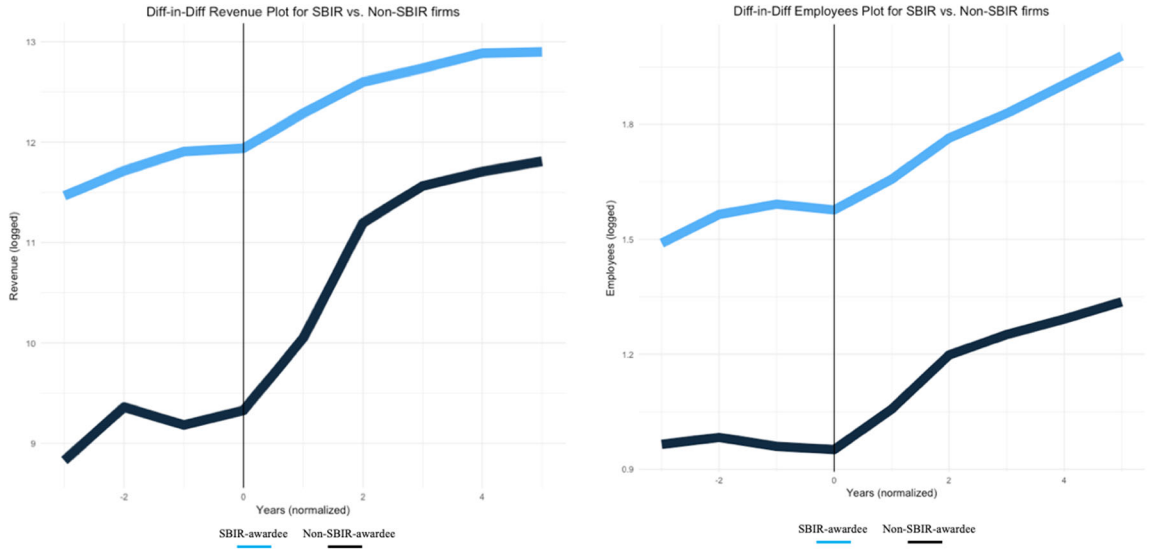

Figure 1. -Diff-in-Diff Plots for Revenue (Left) and Employees (Right)

Note. Plots are interpreted by differences in growth post award. Non-SBIR receiving firms experience rapid revenue growth post award, while SBIR receiving firms experience greater employee growth post award.

Also of interest are a few covariates. Notably, the countervailing effects of venture financing indicate some intriguing results. Table 2 shows that venture raised has a positive, if not a significant impact, on firm death. While potentially counter-intuitive, this is mostly consistent with recent empirical research which indicates that venture capital accelerates both firm growth and firm death. Given that government funding protects against some of the volatility inherent in VC-backed growth strategies, we would expect to find differentiated results between government funding and venture funding. Table 3 shows, however, that venture-backed firms experience significant and positive impacts on future growth. Thus, raising venture may overcome some of the impediments inherent in government funding relationships.

To further explore this variation, I separate and evaluate firms who receive venture before SBIR funding (ex-ante) against those who receive venture after SBIR funding (ex-post). Table 4 shows the results for logged revenue. Interestingly, firms who receive venture ex-ante experience similar impacts on future performance. However, firms who receive venture ex-post have no significant lasting adverse effect on revenue growth post-award. This directional analysis provides further support for H2. Specifically, that raising venture capital post-SBIR-award may counter-act some of the government-funding impediments. For example, venture might open new pathways for opportunity recognition, overcoming institutional impediments. However, receiving venture before award would still leave firms open to constraining institutional and structural impediments.

Table 4. Growth, Log Revenue: Diff-in-Diff

Table 4. *Growth, Log Revenue*: Diff-in-Diff

Variables	Ex-Ante		Ex-Post	
	(1)	(2)	(3)	(4)
Independent Variables:				
SBIR-awardee		1.708****		1.244****
		(1.309, 2.107)		(0.590, 1.897)
After treatment		1.678****		0.937****
		(1.423, 1.932)		(0.575, 1.299)
SBIR-awardee x After treatment		-0.551**		-0.445
		(-0.987, -0.116)		(-1.151, 0.262)
Controls:				
Intercept	12.491****	12.087****	6.811****	7.039****
	(9.383, 15.600)	(9.012, 15.162)	(3.169, 10.453)	(3.399, 10.679)
Firm Age	0.276****	0.231****	0.221****	0.184****
	(0.236, 0.317)	(0.191, 0.271)	(0.182, 0.260)	(0.144, 0.224)
Patents	0.058****	0.045****	0.034****	0.032***
	(0.043, 0.073)	(0.030, 0.060)	(0.014, 0.054)	(0.012, 0.052)
Founding Team Size	0.007****	0.007****	0.046****	0.045****
	(0.005, 0.008)	(0.005, 0.008)	(0.041, 0.051)	(0.040, 0.051)
Woman	0.566****	0.660****	0.26	0.144
	(0.279, 0.853)	(0.377, 0.943)	(-0.093, 0.613)	(-0.209, 0.497)
Minority	0.084	-0.058	0.134	0.109
	(-0.128, 0.296)	(-0.268, 0.153)	(-0.159, 0.428)	(-0.184, 0.401)
Dummies Included:				
SIC (4-digit)	Yes	Yes	Yes	Yes
State	Yes	Yes	Yes	Yes
Year	Yes	Yes	Yes	Yes
N	11271	11271	5605	5605
Adjusted R-squared	0.223	0.245	0.279	0.287

Note: *p<0.1; **p<0.05; ***p<0.01; ****p<0.001

Conclusion

In Shane's (2000) seminal work on opportunity discovery, he suggested that there exist "wrong" opportunities for new firms. That is to say, he hypothesized that there existed an opportunity that could offer immediate support to the entrepreneurial firm, but ultimately result in unforeseen adverse consequences. Yet, since Shane, little if any work has illuminated what a "wrong" opportunity might be. For the first time, this paper illustrates one

possible example, arguing that agility-constraining opportunities may provide critical resources for firm survival, but have damaging long-term consequences to firm growth.

The results of this paper illustrate a particularly exciting outcome: that while mission-oriented agency funding seems to have a constraining effect on revenue-growth, it has a positive and complementary impact on employment. Post-result interviews with entrepreneurs provided some additional context. For example, when asked, “What is the first thing you spend your SBIR funding on?” all interviewees claimed to allocate the funds towards hiring personnel. This is mostly consistent with the nature of DoD SBIR awards. By statute, all SBIR funding has to be allocated toward technically-oriented tasks. This means that SBIR funding cannot be spent on other, business growth tasks—such as sales or marketing. Given this additional information, it is easy to reconcile these differences between SBIR net revenue and net employment growth effects.

Also of interest is the impact of venture funding. The DoD instituted a SBIR “fast-track” program in 1995 to incentivize firms to pursue private capital along with SBIR funding by prioritizing the applications of firms who received third-party financing (Wessner, 2000). Reviews on the fast-track program have found that companies who receive both public and private capital experience commercialization rates five times greater than SBIR-receiving firms who do not participate in the fast-track program. This result is supported by Table 4. Therefore, while the fast-track program was initially established to keep relevant firms solvent through long contracting timelines, I argue that it has a more critical function with technology start-ups. Specifically, by incentivizing private capital, the SBIR program reduces potential institutional impediments by expanding a firm’s opportunity recognition space.

There are limitations to this research. First and foremost, although matching via strict sub-sampling provides the most accurate quasi-experimental design results, the quantitative methodology concludes only strongly-supported associations, not causal inference. Second, one should not interpret these results as being a slight towards the U.S. DoD SBIR program. There exist significant and well-supported reasons why the DoD might fund companies via agility-constraining opportunities. Although mission-oriented funding agencies support technical innovation, their application for that technology may be significantly different from commercial applications. Furthermore, military applications have a comprehensive set of rigorous safety and robustness standards that the retail market does not. Thus, although these opportunities might be constraining to entrepreneurial growth, that does not mean that they are not necessarily so.

However, important findings can be extrapolated for new policy. First, if funding agencies must employ a resource constraining opportunity, they should recognize the potentially damaging effects on technology start-ups. Instead, for those opportunities, perhaps the government should prioritize existing small business over start-up applications. Alternatively, the results indicate that if the military wishes to partner with entrepreneurial firms, it should take a less restrictive approach. Perhaps employing grants instead of contracts or allocating additional funds for firms to expand their institutional resources outside of the military market would significantly decrease negative associations between contract award and growth. Ultimately, the critical insight is that technology start-ups are different from small businesses, and should be approached as such.

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