Small Business Innovation Applied to National Needs

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Small businesses have long supplied a disproportionate share of major innovations in the United States. We review a centerpiece policy on this topic: the US Small Business Innovation Research (SBIR) program. We trace its legislative history and summarize program evaluations over the past four decades. Using newly matched data on SBIR awards and venture capital investments into small businesses, we show that, despite often being compared to venture-backed businesses, SBIR-backed businesses pursue very different strategies. We use simple economic theories to motivate the SBIR program as a vehicle for the government to invest in small-scale, well-defined, but risky technologies that have large externalities, and we highlight a number of case studies consistent with this framework. Because the motivating friction lies at the level ideas, our perspective encourages future evaluations to determine how the SBIR program influences not just *who* does the inventing, but *what* gets invented. Looking forward we discuss how rising industrial concentration and the diffusion of artificial intelligence may reshape the program's comparative advantage in the innovation policy toolkit.

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1. Introduction

Virtually all empirical evidence to date indicates that businesses under-invest in innovation relative to the social optimum.[1] The key friction leading to this underinvestment is that there are many ideas (i.e., potential new products or technologies) for which the social value of pursuing the idea is larger than the private value of the pursuit. In turn, those ideas are less likely to be discovered.[2] As such, there is an essential role for the government to increase welfare by subsidizing the pursuit of new ideas.

But how exactly do we define the new ideas that should be the target of innovation subsidies? One answer lies in the US Internal Revenue Service's definition of business expenses that qualify for the research and development (R&D) tax credit. Those subsidies target any pursuit "*which is undertaken for the purpose of discovering information which is technological in nature, and the application of which is intended to be useful in the development of a new or improved business component*" (IRS Code Section 41). An alternative approach is to abandon attempts at classifying ideas and instead identify organizations that are inherently more likely to pursue ideas with large social value. This includes policies related to entrepreneurship (e.g., bankruptcy laws, investor protections) and non-profit organizations (e.g., tax exemptions, basic research grants).

An attractive feature of these broad policies is that they do not require the government to have much information about the specific ideas that should be pursued. But the vague definitions that govern these policies can introduce the possibility of moral hazard — public funds may be redirected to unintended uses. Still, they are designed to leverage the information and incentives of markets.

However, it is often the case that the government has unique information about certain ideas; ideas that have high social value and are not on the margin of businesses' investment decisions (even in the presence of the aforementioned subsidies) because they involve high risks or low private returns. For example, the Department of Health and Human Services may be aware of a need for wearable sensors to better monitor patients in clinical trials; the National Aeronautics and Space Administration may be aware of a need for a lighter-weight robotic arm for space-bound vehicles; or the Department of Defense may be aware of a need for more accurate measurements of aircraft components. The identification of these *national needs* — specific technological ideas with a large social value relative to their private value — raises a key question: what organizations are best positioned to deliver the innovation needed? Quite often, the answer is *small businesses*.

[1] For a review, see Bryan and Williams (2021).

[2] Formally, if a business cannot use first-degree price discrimination to fully appropriate the total surplus they would generate if they discovered a new product, then the businesses' investment in discovery will be below the socially optimal level.

One of the most important US policies at the nexus of national innovation needs and small businesses is the US Small Business Innovation Research (SBIR) program. In this chapter, we focus on the SBIR program, highlighting the critical role of small businesses in meeting national innovation needs. To do so, first, we review the history and governing legislation of the program. Second, we present new insights on SBIR-backed businesses by comparing them to small businesses backed by venture capital. Third, we review economic theory that motivates the SBIR program and highlight the types of national innovation needs that small businesses are particularly well-suited to engage with. Lastly, we conclude with two forward-looking discussions about the on-going role of the SBIR program, and small business innovation more generally, amid increasingly concentrated private markets and the age of artificial general intelligence.

2. The Small Business Innovation Research (SBIR) Program

2.1. History and Legislative Structures

The central US policy at the intersection of small business innovation and national needs is the Small Business Innovation Research (SBIR) program. The SBIR program traces its roots to the late 1970s, when Roland Tibbetts of the National Science Foundation (NSF) championed an experimental effort to fund R&D for small businesses. Tibbetts believed that innovative small businesses should be given access to R&D funding that was, at the time, either explicitly or implicitly only accessible to larger federal contractors. Tibbetts' NSF pilot, titled "*Small Business Innovation Applied to National Needs*", demonstrated the potential of small business innovation and helped build political support for a government-wide initiative.

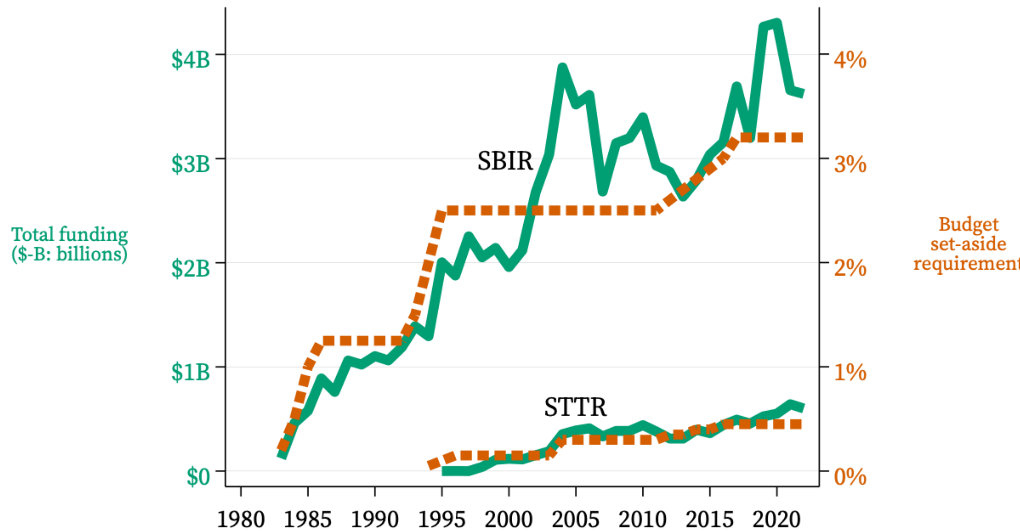
In the ensuing years, lawmakers from both parties embraced the concept. This culminated in the passage of the Small Business Innovation Development Act of 1982 (Public Law 97-219), which was approved by Congress with bipartisan support and signed into law by President Ronald Reagan. Businesses eligible for SBIR funding must have fewer than 500 affiliated employees and with majority-ownership by US citizens or permanent residents.

The SBIR program is not permanent. It requires ongoing congressional reauthorization, which has occurred in 1992, 2000, 2011, 2016, and 2022, with another reauthorization due for debate in 2025.[3] Broadly speaking, Congress has been supportive of the program as evidence by its persistence and the steady increases in the percentage of a federal agency's extramural research budget that must be allocated to SBIR awards (see Figure 1). In most recent years, statutory requirements dictate that any federal agency with an extramural

[3]The timing of a subsequent reauthorization is determined in the prior reauthorization.

research budget larger than $100 million must allocate 3.2% to the SBIR program, which has annual SBIR funding approaching $3.5 billion.

FIGURE 1. Growth of the SBIR and STTR Programs



Note: The solid lines (corresponding to the left *y*-axis) plot the total spending, in USD-2025 (adjusted using the Consumer Price Index), for the SBIR and STTR programs since their inception. The dashed lines (corresponding to the right *y*-axis) plot the statutory requirements for the percent of a federal agencies extramural research budget that must be allocated to the SBIR and STTR programs since their inception.

In the mid-1990s, the Small Business Technology Transfer (STTR) program was developed within the umbrella of the SBIR program. In an effort to foster collaborations between businesses and academic institutions, the STTR program included an additional requirement that all applicants partner with an academic institution when competing for funding and that a minimum share of work be performed by both parties.[4] Only federal agencies with extramural budgets in excess of $1 billion are required to participate in the STTR program and, most recently, those participants are only required to allocate 0.45% of that budget to STTR awards. In most recent years, annual STTR funding is on the scale of $0.5 billion (see Figure 1).

The explicit structure of the SBIR program has been relatively consistent since its inception. There are three phases of awards. As of 2024, participating agencies may issue a Phase I award of up to roughly $300,000. Then, agencies may award any Phase I winners a Phase II award, which may be up to roughly $2 million.[5] Phase III awards are unique from

[4]Typically, STTR regulations have required that both the small business and the academic institution perform at least 1/3 of the work funded through any award.

[5]Agencies may submit waivers to the US Small Business Administration to exceed these limits. Also, certain agencies at certain times have been able to award "Direct to Phase II" awards that circumvented the requirement of a Phase I award. Although, this path is less common.

the first two in that they have no statutory funding requirements — there is money set aside for Phase III awards. These awards must be funded by the agencies' non-SBIR budgets, but they afford the SBIR business some unique benefits that they would otherwise not receive if they obtained a similar contract outside of the SBIR program.[6] Broadly speaking, these Phase III benefits are designed to insulate the SBIR business from competition in the procurement stage (i.e., after inventing some new technology), so that they stand to gain from the value they generate and their technology is not, for example, duplicated at lower cost from a competitor (which would lead to a dynamic disincentive for the SBIR business).

2.2. SBIR Processes in Practice

The founding legislation outlined four major goals, which have remained relatively intact since the program's inception, and now are written as goals to: (*i*) to stimulate technological innovation; (*ii*) use small businesses to meet federal research and development needs; (*iii*) foster and encourage participation by emerging and undercapitalized small business concerns in technological innovation; and (*iv*) increase private-sector commercialization of innovations derived from federal R&D. To better understand the implicit objectives of the SBIR program, it is helpful to consider some of the key processes and regulations governing the program and discuss how these processes align with these explicit goals.

Focusing on the goal of commercializing innovations due to federal R&D (Goal *iv*), one clear motivation here is the so-called "Valley of Death." In short, federally funded basic research supported in universities may not be commercialized because neither academia nor private investors have the right mix of incentives to engage with certain developmental tasks (i.e., tasks that are not novel enough for academics to be interested, but still too risky for private investors to consider funding). The STTR program is clearly the explicit directive focused on this friction. However, the STTR program accounts for roughly one eighth of total SBIR/STTR spending (see Figure 1), which suggests this particular goal is not a leading priority. Furthermore, the data suggests that businesses may not see the STTR program as being so differentiated from the traditional SBIR program. While approximately 5% of SBIR-awardees also receive an STTR award, more than 50% of STTR-awardees also receive an SBIR awards — if the STTR program was highly differentiated, we would have expected a higher degree of separation from participants in either track of the program.

The specific language of the third goal has evolved over time, but has historically

[6] Phase III also allows for the right to sole-source the contract, provides the awardee with "Data Rights" which prevent the government from disclosing the SBIR business's data to other businesses, provides an exemption from SBA size standards for a procurement, and has no limits on the dollar size.

focused on small businesses owned by women, minorities, and other under-represented groups. There is clear, longstanding motivation for concern that the static and dynamic consequences of discrimination prevent inventors with great potential from accessing resources necessary for their pursuits (Bell et al. 2019; Agarwal and Gaule 2020). In principle, a program could engage with these frictions with access to these explicit subsidies.[7] The SBIR legislation does include certain reporting requirements for documenting the composition of the businesses that receive awards; however, the program has never included any processes that explicitly lower the cost (or increase the benefit) of participation for businesses owned or operated by certain groups.[8]

It is helpful to conceptualize goals (*i*) and (*ii*) as being on opposite poles of the same spectrum of objectives. At one end, the goal (*i*) of stimulating small businesses "technological innovation" writ large can be motivated by traditional financial market frictions (Lerner 2000), which inspires analogies such as "The Government as Venture Capitalist."[9] What would a policy look like that truly embraced this goal? The Israeli government's "Yozma" program provides one illustrative example: ten approved venture funds received matching investments from the government at a rate of 40% (up to $8 million in total for each fund) and the funds faced a small number of limitations on which small businesses they could invest those funds in (Baygan 2003). This design leverages the information and capabilities of the private sector. The SBIR program does not have any processes as dramatic as the Yozma matching approach. Although, the original pilot of the SBIR program led by Tibbetts at the National Science Foundation did include an explicit scoring bonus for proposals that included credible commitments from private investors — a matching policy of sorts — but no such bonus has ever been included in the official program.[10]

In practice, the SBIR program processes reflect the goal (*ii*) of meeting federal R&D needs. Many participating federal agencies (e.g., DOD, DHS, DOT, EPA, NASA) award funds predominantly (or only) via *contracts*, which tend to include more pre-specification of a technology that the funder is interested in developing. Even in the case of the agencies that more often (or always) rely on *grant* mechanisms to make SBIR awards (e.g., NIH, NSF), applications are subject to many of the same criteria and evaluation processes that allow the agencies to influence which pursuits receive funding. Furthermore, the formal distinction between grants and contracts masks a common structure: Phase I awards

[7]For example, the US National Institutes of Health have a number of explicit policies aimed at assisting young researchers per their "Early-Stage Investigator" rules and processes; see: https://grants.nih.gov/policy-and-compliance/policy-topics/early-stage-investigators.

[8]There are, of course, rules governing participating in the SBIR program per the ownership structure of the business (e.g., nationality of owners).

[9]This is the title of Lerner's (2000) influential analysis of the SBIR program, which sparked a long line of analyses that we review in the next Section below.

[10]We are also unaware of any explicit mandates that require the composition of the review panels that evaluate SBIR programs to include any minimum number of participants from the private sector in general, or the venture capital sector specifically.

offer a small investment with few explicit strings attached, but the “carrot” incentive of the Phase II award encourages awardees not to veer too far from the initially stated objectives.

Altogether, SBIR program design not only emphasizes more innovation writ large, but also steering towards technologies with out-sized public benefits. Critically, this is in stark contrast to the more technology-agnostic, unfiltered, profit-maximization behavior of venture capitalists. To dig more into the differences between the SBIR program and venture capital, and to see how much the SBIR program’s implicit objectives show up in observable outcomes, the next section leverages a new dataset that tracks SBIR- and VC-backed businesses, their growth, and their innovations.

3. A New Look at the SBIR Program Compared to Venture Capital

The SBIR program is often referred to as “*America’s Seed Fund*”. In line with this moniker, the program is frequently evaluated through the same lens of success applied to the US venture capital (VC) sector. Despite an abundance of anecdotal comparisons, systematic data on small firms’ engagement with the SBIR program and/or the VC sector has been challenging to obtain. The problem is that data on businesses’ features (i.e., their age, employment count, revenues, etc.) are typically not jointly collected with data on the businesses’ investors (i.e., VC, SBIR awards), innovative output, or engagements with the federal government more generally. So, while the empirical record consistently shows that small businesses are responsible for a disproportionate share of innovations in the US (Cohen 2010), there are still many open questions as to how best to continue to support that innovation.

Here, we highlight some statistics based on a newly assembled dataset of small US businesses that have received either (*i*) SBIR awards, or (*ii*) seed or series investments from VC. Our goal is to highlight the similarities and differences in how these two sets of businesses generate value in both private- and public-sector markets. The following results should be interpreted as reflecting some (unknown) combination of both *treatment effects* due to the different bundles of resources provided by the SBIR program compared to the VC industry, as well as *selection effects* due to different types of businesses (i.e., pursuing different technologies) making different choices about engaging with the SBIR program versus the VC industry.

3.1. Dataset Construction

The key inputs into this new dataset are: (*i*) the National Establishment Time Series dataset, which includes the name, location, age, employment, and unique identifiers for business establishments and their corporate hierarchies for 2000–2021 (Walls 2021); (*ii*) the Small

Business Administration's public record of SBIR awards (SBA 2024); (*iii*) the Crunchbase record of VC investments, which includes businesses' names, locations, and investment amounts for 2000–2021; (*iv*) the USPTO's PatentsView dataset, which includes businesses' names, locations, and patent assignment information for 1976–2021 (USPTO 2024); and (*v*) the Federal Procurement Data System (FPDS) dataset, which includes business names, locations, and federal contracting information for 2000–2021 (BFS 2024).

There are some notable challenges to assembling this data. First, systematic comparisons of NETS data with US Census data on business establishments has shown some systematic biases due to the sampling and missing-data-imputation processes used in NETS (Barnatchez, Crane, and Decker 2017). That is, NETS appears to mischaracterize the full population of US businesses, especially for smaller organizations (Barnatchez, Crane, and Decker 2017). In light of this, we only report results that condition on a business appearing in both the NETS and either SBIR or VC datasets.[11]

The second challenge is linking businesses across the datasets in the absence of a standardized, unique identifier common to all datasets. To overcome this challenge, we use the `linktransform` software (Arora and Dell 2023) to compute the semantic similarity between business names across all datasets. We then merge businesses across datasets under the requirements that the semantic similarity is above a reasonable threshold and that the location of the activity (i.e., the patent assignee's location; the government contractor's location) is in the same state. This still leaves a problem of potential duplication, whereby two businesses could be located in the same state and have semantically similar names. To avoid this, we restrict our sample to businesses that are uniquely matched in the NETS data from the other datasets. This reduces our sample size, but increases our confidence in the accuracy of the data construction.

To maintain a reasonable degree of comparability between SBIR- and VC-backed businesses, we restrict our attention to businesses that receive no more than $2.5 million per year from either source. This is roughly the 99th percentile of funding observed among SBIR-backed businesses. However, while this excludes only the top 1% of SBIR award winners, it excludes the top 45% of VC-backed businesses. This clearly illustrates the dramatic unconditional differences in these two populations that can generate misleading conclusions if not properly accounted for.

A third challenge is related to interpreting the data. In the simpler case of the procurement data, we have a clear understanding of the parties involved (i.e., the US federal government and a particular contractor) and the value of that relationship (i.e., the dollar value of the contract). However, in the case of the patent data, these values are less clear. To

[11] The NETS data also contains a number of imputed values based on private methodologies (Barnatchez, Crane, and Decker 2017). We have no reason to assume that the imputation methodology depends on whether a business was SBIR- or VC-backed, so we are less concerned with how this may bias our relative comparisons.

identify relationships, we follow Fadeev (2024) and interpret citation flows from one patent to another as being indicative of a business relationship.[12] To proxy for the value of a patent, we rely on Kelly et al.'s (2021) measure of technological innovation, which has been computed for the universe of USPTO patents issued up until 2016. In short, the measure is based on a patent describing a technology that few patents had described previously (i.e., novelty) and that many patents engage with subsequently (i.e., impact). Specifically, we use their binary indicator of a breakthrough based on a patent's 5-year performance. Within our sample, roughly 14% of patents are classified as breakthroughs.[13]

3.2. Initial Business Conditions

Figure 2 plots the distribution of businesses' features at the time of investment from either the SBIR program or a venture capitalist. Figure 2A highlights the significant difference in investment strategies of the two groups. For SBIR-backed firms, the structured nature of the Phase I and Phase II awards is clearly visible. The distribution of VC investments is much smoother. Furthermore, compared to the SBIR program, which awards many businesses small investments (Phase I awards), the VC distribution indicates a strategy of issuing (relatively) much fewer investments on the scale of the SBIR Phase I and much more investments on the scale of the SBIR Phase II.

The optimal distribution of investments is far from clear and depends on many factors. The SBIR distribution is consistent with traditional risk-diversification and real-options theories (Markowitz 1952; Dixit and Pindyck 1994). In contrast, the VC distribution is consistent with there being significant economies of scale and/or non-diversifiable risks (Sahlman 1990; Denes et al. 2023). An important political economy point of note here is the conjecture that the rigidity and smaller stakes of the SBIR program may be one reason the program appears relatively robust to regulatory capture (Lerner 2009).

Figures 2B–2C illustrate relatively similar age and size distributions for the two sets of businesses. The median SBIR-backed business is four years old and has five employees at the time of award,[14] and the median VC-backed business is three years old with three employees at the time of investment.

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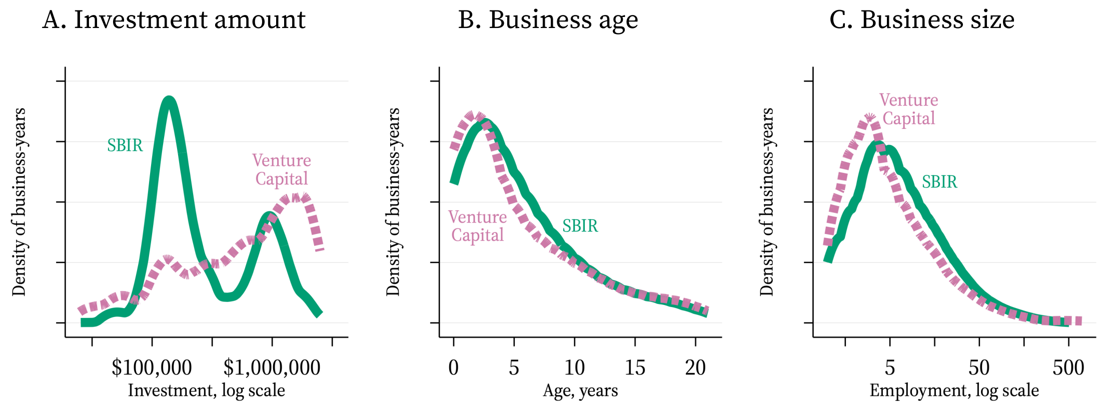
[12] Fadeev (2024) finds that roughly 3/4 of citation pairs are between supplier-buyer pairs or businesses with cooperative research agreements.

[13] In the full Kelly et al. (2021) data, over our sample period, the breakthrough rate is roughly 12%.

[14] As a benchmark, the SBA award data reports an SBIR awardees' number of employees for roughly 60% of business-year observations. The median of the non-zero values reported is 7, which is consistent with our estimate of 5 per the NETS data.

FIGURE 2. SBIR- vs. VC-backed: Features at the Time of Investment



Note: Plots the distribution of business-year observations, where the business receives more than zero and less than $2,500,000 from either the SBIR program or a series/seed round of investment from venture capitalists, per the total amount received by the business that year (Panel A.), the age of the business in that year (Panel B.), and the number of employees at the business that year (Panel C.).

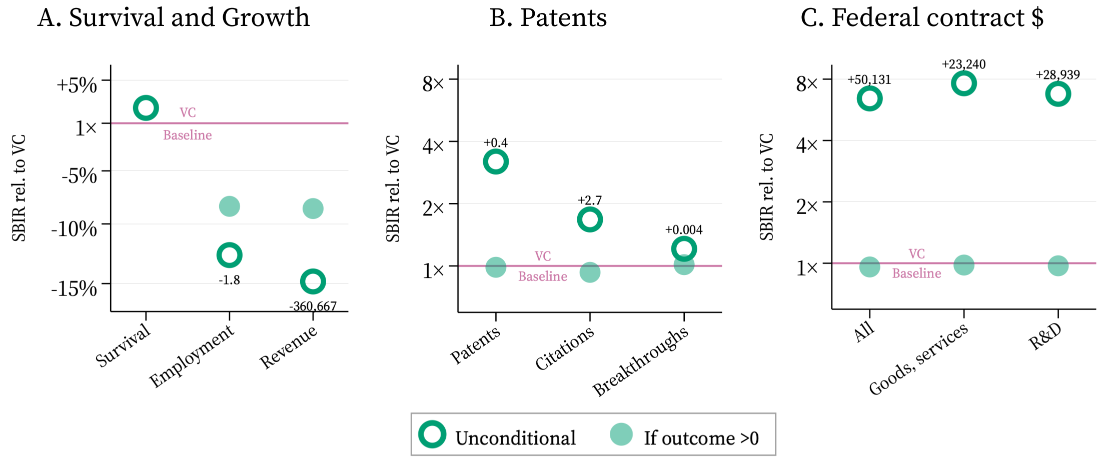
3.3. Market Outcomes

Here, we report a series of estimates from regressions of business-year-level outcomes (i.e., survival, employment, revenues, patents, federal contracts) on a binary variable indicating that a business previously received an SBIR award. We include a vector of year-specific indicators to control for any secular trends correlated with the growth of VC over this period. While we can estimate regressions that include only business-year observations where the outcome is non-zero, given the structure of the data we also observe business-years whether or not the business has produced any of the outcomes of interest. This allows us to run what we term *unconditional* regressions, which include zeroes for any business-year observation that has not survived or did not produce any of the focal outcome. Given the inclusion of these zeroes and the non-negative nature for the outcomes, we estimate Poisson regressions in all cases, which yields an estimate of the percentage difference between SBIR- and VC-backed businesses with respect to each outcome (Chen and Roth 2024).

The unconditional regressions are useful in that they incorporate all treatment and selection effects (including survival differences) that might give rise to any difference in outcomes. The regressions where we condition on a non-zero outcome remove some, but certainly not all selection effects — they remove the survival selection effect, and they also remove the extensive margin selection effect (i.e., some businesses simply choosing not to pursue any patents, or not to pursue any federal contracts).[15]

[15] However, since we cannot directly observe businesses' choices per se, we are also conditioning on some amount of the differential treatment effect since, for example, one funding source may improve a businesses'

FIGURE 3. SBIR- vs. VC-backed: Private and Public Market Outcomes



Note: Reports the relative differences in outcomes for SBIR-backed businesses compared to VC-backed businesses along multiple dimensions based on unconditional and conditional (outcome>0) regressions. Numbers reported next to the unconditional estimates convert the relative difference into absolute levels per the sample averages.

Figure 3A reports the results from the unconditional and conditional regressions, focusing on several traditional private market outcomes of business growth. First, we consider survival, for which the unconditional and conditional regressions are the same: we find that, on a year-to-year basis, SBIR-backed businesses are 1.4% more likely to survive (on a base survival rate of 80%). We also find that SBIR-backed businesses have annual employment and revenues that are roughly 15% lower than VC-backed businesses. This amounts to roughly 2 fewer employees and $360,000 less revenue each year.

Looking at patent-based metrics (Figure 3B), the unconditional results show large relative differences in patent outcomes. SBIR-backed firms produce roughly 200% more patents, 70% more citations, and 20% more breakthrough patents; but it should be noted that these large relative differences are based on small level differences (i.e., +0.4 more patents, +2.7 citations, and +0.004 breakthrough patents). The rarity of these events in the unconditional sample yields large relative differences. The unconditional regressions show that SBIR-backed businesses are less likely to grow per employees or sales, but more likely to develop and receive a patent for an invention. However, once we condition on the business surviving and having non-zero values for these outcomes, we no longer estimate any major differences between the SBIR- and VC-backed groups. All differences that remain are less than 10%.

Figure 3C reports the results from the unconditional and conditional regressions, focusing on outcomes based on the federal procurement data. The unconditional regres-

odds of getting any patents conditional on filing a patent application.

sions illustrate a dramatic relative difference in the dollar value of contracts that these two sets of businesses obtain. Whether looking at contracts related to the procurement of goods and services, or those based on some research and development activity, SBIR-backed businesses have nearly 8 times as much engagement with the federal procurement system per the unconditional regressions. Still, just as we saw in Figure 3B, these differences are explained by the extensive margin difference. Conditional on having any federal contracts, the dollar value of these contracts are virtually identical regardless if they involve an SBIR- or VC-backed business in our sample.

The results illustrated in Figure 3 indicate that SBIR- and VC-backed businesses engage in very different strategies. VC-backed businesses often focus on growing their business in ways that do not involve the patent record or federal contracts. The opposite appears true for SBIR-backed businesses. Overall, this is consistent with the SBIR program not simply trying to mimic venture capitalists, but rather, the program is distinct, generating some combination of selection and treatment effects that pull or push participants towards the development of technologies that are patentable and needed by federal agencies. In theory, the program should be pulling and pushing these businesses towards technologies that have high social value but a low private value (and, therefore, would go unpursued in the absence of the SBIR program). In the next section, we use economic theory to highlight the features of such national needs that the SBIR program is well-suited to target.

4. What National Needs can Small Business Innovations Solve?

The results in the previous section indicate that SBIR businesses are different from VC-backed businesses. Namely, they are much more likely to be pursuing patents and federal contracts. Unfortunately, we lack a more systematic way of analyzing the degree to which the specific technologies involved in these pursuits are truly national needs — technologies with high social value.[16] However, economic theory can provide some guidance as to the sorts of national needs that SBIR-backed businesses should be well-equipped to pursue.

4.1. Theoretical Framework

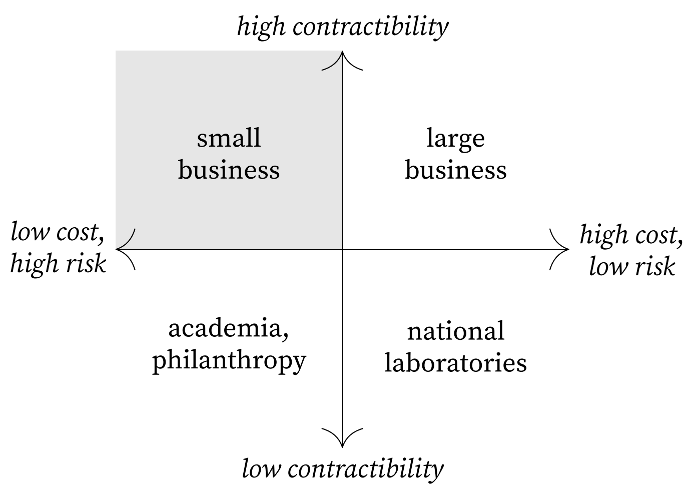
Economists have long been interested in the comparative advantages of different organizational forms vis-à-vis innovation, with the unique capabilities of small businesses often highlighted. Here, we are less concerned with the ability of different organizations to innovate writ large. Rather, we are concerned with the ability of different organizations

[16] On this point, Narain (2025) provides compelling evidence that VC-backed businesses pursue technologies that are more likely to pay off sooner, compared to SBIR businesses, who tend to pursue technologies with a longer time horizon of development.

to pursue different types of national innovation needs. Thus, for the purposes of this discussion, it is helpful to assume that the wedge between social and private returns to pursuing the innovations in question (which determines the optimal subsidy rate) is the same.

First, it is helpful to classify innovations along three dimensions: (*i*) contractibility, (*ii*) scale, and (*iii*) risk. *Contractibility* refers to the degree to which the innovation can be legally specified ex-ante. For example, if a new technology must be able to achieve very well-defined performance metrics, then it is highly contractible. *Cost* refers to the expected financial cost of resources necessary to pursue the innovation. *Risk* refers to the uncertainty in the expected value of pursuing the innovation. Figure 4 uses these three dimensions (converted into two axes) to illustrate the organizational types best suited for different types of innovations as suggested by prevailing economic theories.

FIGURE 4. Organizational and Innovation Type Alignment



Note: Plots the organizational types best suited for innovations with certain features as suggested by prevailing economic theories.

Broadly speaking, the contractibility of a potential innovation — the degree to which the government can legally specify the requirements of the technology needed — is the chief determinant as to whether the technology should be sourced from the private market. In general, there is a tradeoff between the high-powered incentives of the for-profit market and the costs of writing and negotiating contracts with businesses. Most economic theories yield a prediction that, as the transaction costs of interacting with businesses decrease (e.g., the government can more easily and clearly specify the technological need), the more efficient it is to source the innovation from businesses (Hart, Shleifer, and Vishny 1997; Levin and Tadelis 2010).[17]

[17]The sourcing distinction can also be conceptualized as a continuum of control with outsourcing on one

The cost and risk of the project at hand are important determinants of the scale of the organization best suited to pursue the project. Cost is relatively straightforward. Assuming that there are some economies of scale in the organizations' operations, larger organizations should be matched with more costly projects. For highly contractible projects, this would be large businesses. For less contractible projects, this would be the large national laboratories or other intramural research programs.

Risk is complicated. There is some intuitive appeal to the notion that larger organizations may be able to diversify the risk from any particular innovation project they undertake; however, we are less concerned with different organizations' abilities to handle risks that are forced upon them. We are more concerned with the organizations' appetite for choosing to take risks.

Overall, there are many theoretical arguments with empirical support that smaller organizations will have inherently larger appetites for risks. There are two broad motivations for this result. First, smaller organizations will have fewer potential tasks to be undertaken, which will generate less tension between more measurable, routine tasks and unmeasurable, risky tasks. This allows for more resources in the organization to be allocated to novel, innovative activities (Sah and Stiglitz 1986; Holmstrom 1989). Second, smaller organizations will have fewer opportunities in their choice set. The ownership over the potential gains from pursuing those opportunities will be divided between fewer people. This creates less pressure from external and internal capital markets to choose safe, short-term opportunities and motivates more innovative effort (Holmstrom 1989; Aghion and Tirole 1994; Anton and Yao 1995; Stein 1997).

To summarize, small businesses tend to be best suited for developing innovations that solve small-scale, uncertain, well-defined problems. As we argue below, there are an increasing number of national needs that fit these criteria.

4.2. Small Parts of Big Networks

While small businesses tend to be best suited for solving small-scale problems (i.e., scale of costs), it is certainly not the case that they can only generate solutions with large scale benefits. As the world increasingly revolves around networks of technologies with interdependencies (Katz and Shapiro 1994), an ever-growing body of theoretical arguments and empirical evidence continues to emphasize that there can be points in those networks that are small when viewed in isolation, but are very important to the functioning of the network as a whole. The "network" in question may revolve around a single platform product that is a network of technological components (Baldwin and Clark 2000; Baldwin,

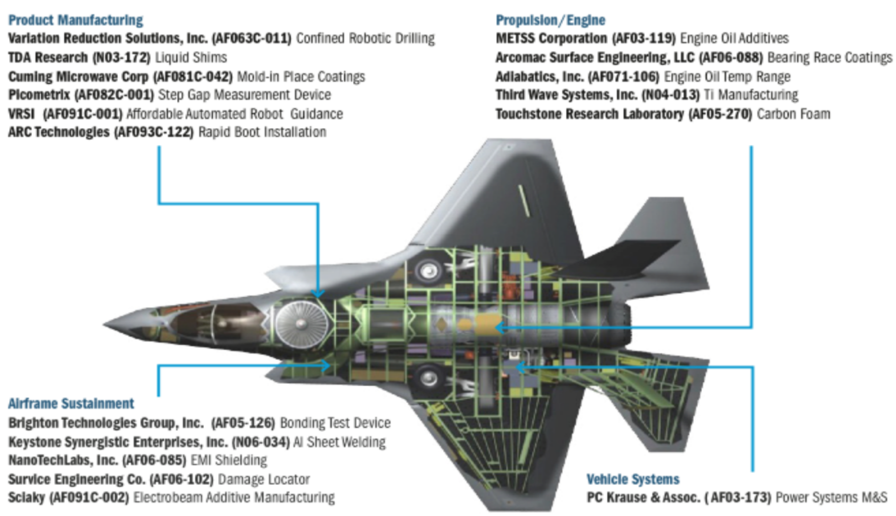
end and full in-house provision on the other end. Through this lens Lerner and Malmendier (2010) and Bruce, de Figueiredo, and Silverman (2019) highlight the role of termination options and cooperative agreements (i.e., more control to the funder) in less contractible settings.

Woodard et al. 2009; Kretschmer et al. 2022), industries connected together via a network of businesses (Milgrom and Roberts 1990; Kremer 1993; Jones 2011; Acemoglu et al. 2012; Elliott, Golub, and Jackson 2014; Bigio and La'o 2020), or even a network of countries connected through trade and migration (Kremer 1993; Jones 2011).

Here, we provide some illustrative examples of how SBIR awardees have made significant technological contributions within networks at the product-, industry-, and country-level. These examples highlight the presence of small technologies addressing large externalities (both positive and negative) within each type of network.

Network of Components. The federal government is increasingly involved in the procurement of extremely complex products that involve a large network of individual components. In these networks of components, there are often technologies that are, by themselves, of relatively little value, challenging to develop, but relatively easy to specify. These narrow technological challenges are a prime example of a national need well-suited for a small, innovative business. In line with this rationale, it is easy to find many examples of SBIR-backed businesses contributing small, but crucial components to some of the most complicated products that the federal government procures (see Figures 5–6).

FIGURE 5. SBIR Technology in the F-35

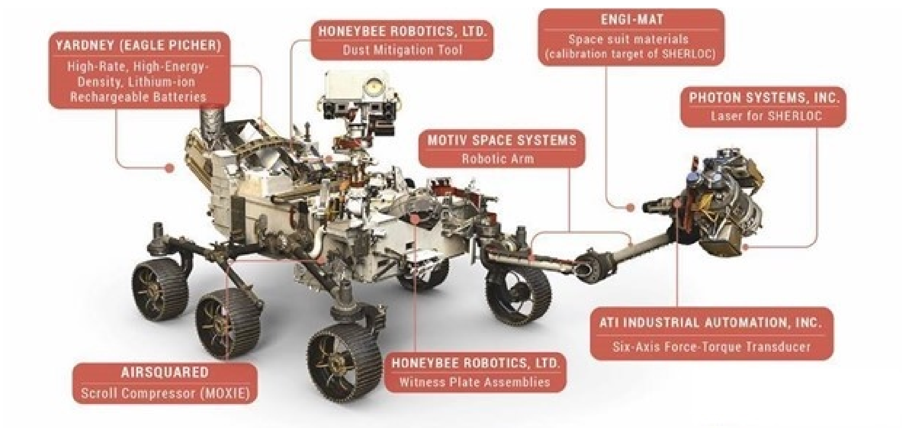


Credit: SBIR at the Department of Defense (2014) National Academies of Sciences, Engineering, and Medicine. Washington, DC: The National Academies Press. *Note:* Shows the SBIR-funded companies, and their respective technologies, that were integrated into the F-35 Lightning II.

A good example is given by Picometrix, Inc., who developed a measurement tool to inspect the seams of the panels on the F-35 and ensure proper tolerance. This SBIR awardee produced an essential scanner to ensure the proper fit of the coated exterior surfaces on the aircraft. The firm's nondestructive testing system minimizes manufacturing costs for F-

35s and offers valuable contributions to additional markets demanding applications such as measuring coating thickness, subsurface inspection, surface topography measurements, and coating cure states.

FIGURE 6. SBIR Technology in the Mars Perseverance Rover



Credit: Jet Propulsion Laboratory; NASA. *Note:* Shows the SBIR-funded companies, and their respective technologies, that were integrated into the 2020 Perseverance Rover.

Separately, Motiv Space Systems, Inc. engineered the mechanical arm on Perseverance Rover with the integral function of rock sampling and collection on Mars. This technology is not only central to the essential aims of the US mission, but the business has also applied this technology in additional (terrestrial) markets, offering ground robotics for critical needs among disaster relief, oil and gas extraction, bomb disposal tasks, chemical manufacturing, power generation, and even subterranean. Likewise, Honeybee Robotics, Ltd., has a longer history working on space projects developing and manufacturing vacuum seal containers, drive tubes, and drill components. The latter of which enhanced the operation and production of the mechanical arm on Perseverance for rock extraction.

Network of Businesses. When industrial sectors and supply chains are viewed as networks, it is easy to find instances where small innovations yield large benefits for the network as a whole. Often these innovations take the form of measurement devices or tools. These innovations tend to be under-delivered by the private sector because they generate information. Though, information is generally challenging to monetize (Arrow 1962). So, it is not surprising that there are many success stories of SBIR-backed businesses developing new measurement technologies that help generate value for multiple businesses within a sector. In the healthcare sector, these technologies often revolve around monitoring patients' health or improving our diagnostic capabilities.[18] In the energy and

[18] Exemplar SBIR awardees include: BioSensics, LLC, which has made substantial contributions in the arena of wearable sensors with enhanced digital technologies; QT Medical, Inc., which developed an at-home

transportation sector, these technologies often focus on monitoring the quality of air or infrastructure.[19]

Network of Countries. Networks now, more often than not, span the entire globe, which leads to the possibility of there being national needs based in other nations. A classic example of this sort of (negative) international externalities is pollution. For a developing country, the value of using dirty energy technologies (e.g., to grow capital-intensive sectors of their economy) is well beyond the direct cost of the pollution within the boundaries of their country. Of course, other countries bear additional costs due to this pollution. Would an innovative small business based in the US expect large gains from improving the environmental impact of the energy technologies used by such a developing country? Perhaps not, because that business does not have much to gain privately (because the willingness of businesses in that developing country to pay for that technology is low). This is despite the fact that the US may have much to gain from the reduction in pollution. However, with support from the SBIR program companies may be incentivized to engage with these sorts of national needs.[20]

5. SBIR Program Evaluations

5.1. Literature Review

While the prior section highlights illustrative examples of how SBIR recipients respond to national and public needs, we review the academic literature for a more comprehensive understanding of programmatic returns. In one of the first evaluations, Lerner (2000) documented an overall positive return of the program on business sales and employment. Though he identified systematic variation across returns — geographies proximate to regions of private financing and new firm creation amplified the return while businesses recipients with multiple awards attenuated it.

Several subsequent academic studies document myriad benefits of the program in terms of bolstering positive knowledge spillovers (Myers and Lanahan 2022); enhancing access to private financing (Lanahan and Armanios 2018); and accelerating strategic alliances (Toole and Czarnitzki 2007). Whereas, other studies document limitations. These include differential returns among program recipients whereby Phase I versus Phase

electrocardiogram (ECG) for children.

[19] Exemplar SBIR awardees include: 2B Technologies, which developed a novel air pollution monitoring system that can more easily attached to drones, kites, balloons, and aircraft, for expansive monitoring of air quality; and Fuchs Consulting, Inc., which developed a non-destructive method to inspect bridge maintenance without the need of traffic control or disruption.

[20] Exemplar SBIR awardees include: ASAT, which developed an integrated stove that significantly reduces biomass emissions; and Porifera, which has developed technologies to efficiently extract water from a wide range of (possibly contaminated) solutions.

II recipients pursue different growth trajectories (Lanahan, Armanios, and Joshi 2022). Moreover, while there is a political interest in tracing the returns of employment (Lanahan, Joshi, and Johnson 2021), the program does not fulfill this direct outcome and rather is more successful in producing innovative returns (Howell 2017; Myers and Lanahan 2022).

Additionally, some studies conclude that multiple award winners are inefficient in achieving programmatic goals (Howell 2017), while others detail a more nuanced trend documenting how these repeat winners uniquely fit into the innovative landscape in an economically significant manner (Feldman et al. 2022). [21] Illustrative case studies reveal that the leading set of multiple award winners pursue distinct strategies that can demonstrate value to the government, market, and society. Though, a high concentration of any government subsidy among a small set of recipients will raise questions of regulatory capture. Altogether, this scholarship, along with our correlative results reported herein, indicates that SBIR recipients fill a distinct and valuable niche.

In addition to academic scholarship, the NASEM has conducted several reviews of the program across the leading participating agencies (i.e., DOD, HHS, NSF, DOE, and NASA). Recognizing commonality across the program, these reviews share similar tasks in tracing the extent to which recipients stimulate technological innovation and meet federal R&D needs. Moreover, these reviews place emphasis on examining the review of application and award procedures (complementing academic work in this domain; Bhattacharya 2021), along with understanding the challenges and effectiveness of outreach to potential applications.

Since 2020, NASEM has published three reports for DOE (National Academies of Sciences, Engineering, and Medicine 2001, 2020), NSF (National Academies of Sciences, Engineering, and Medicine 2023), and HHS (National Academies of Sciences, Engineering, and Medicine 2022), respectively (with reviews of DOD and NASA actively underway as of 2025). Among the published reports, a common theme has emerged. There is broad evidence documenting the innovative returns of the program; however, features of programmatic administration produces significant hurdles for rigorous and valid assessment.

First, the SBA manages a central repository for all Phase I and Phase II awards, yet they do not report a unique identifier to connect the sequence of project progression. While scholars and reviewers can roughly infer these connections using computational semantic techniques, this is a cumbersome and imperfect task. Moreover, the contract-awarding agencies (i.e., DOE, DOD, and NASA) emphasize transition to Phase III. Yet, administrative

[21] Feldman et al. (2022) offer a unique assessment of multiple award winners tracing the extreme right skew in the distribution of SBIR awards. Physical Optics lies at the far right of the skew with 1,119 SBIR awards. This small business is heavily engaged with national defense needs as illustrated not only by the scale of their SBIR portfolio, but also the significant level of long-term DOD procurement contracts.

detail on this activity or an ability to infer this outcome is incomplete.

Second, with few exceptions (i.e., Howell 2017; Belz et al. 2019; Howell et al. 2025), applicant detail is restricted and often limited to a single agency or even a set of offices within an agency. This places notable constraints to examine causality and discern broader generalizations. As a workaround, research has leveraged other techniques that include case studies (Feldman et al. 2022), firm matching techniques (Lerner 2000; Wallsten 2000), and non-competitive funding from complementary state match programs (Lanahan and Feldman 2015) to reveal valid insight on the program. While these alternative design options provide some access to examine the program, applicant data would greatly enhance the design, evaluation, and our understanding of this critical and distinct program.

5.2. New View on Average Returns

A challenge that all of the aforementioned analyses of the SBIR program grapple with is what metric to use as the outcome of interest. The ideal theoretical concept is clear: we want to know the net impact of the SBIR program on social welfare, which could be quantified, for instance, in terms of the marginal value of public funds committed to the program (Hendren and Sprung-Keyser 2020). But while the costs of the program are relatively clear (i.e., the total dollar value of awards disbursed plus administrative costs), quantifying the benefits is a more challenging exercise.

With a few exceptions (i.e., Howell et al. 2025), evaluations of the SBIR program have not been able to connect SBIR investments in a given business with the flow of federal contracts (from non-SBIR-related work) to that same business. This has been unfortunate given the explicit goal of the program to meet federal "needs" and the results we have shown in Figure 3C, which indicate that, at least compared to VC-backed businesses, SBIR awardees are much more likely to win procurement contracts. Thankfully our dataset allows us to dig deeper into the flows of SBIR funding and non-SBIR contracts to SBIR-awardees.[22]

Since our data has linked SBIR awardees to the FPDS data, we can observe the dollar amounts of the SBIR awardees' contracts with the government, importantly, including all non-SBIR contracts. Furthermore, if we make three, admittedly large assumptions, we can provide a new view of the *average* returns to the SBIR program. Those three assumptions are as follows: (*i*) the government's willingness to pay an SBIR business for a contract is a proxy for the public value of the contract; (*ii*) the SBIR business would not have obtained any contracts with the government if not for their participation in the SBIR program; (*iii*) the government would not have awarded the contract with an SBIR business to a non-SBIR

[22]See Belenzon and Cioaca (2022) for an important, broader effort to match businesses in the Federal Procurement Data System to details in other databases.

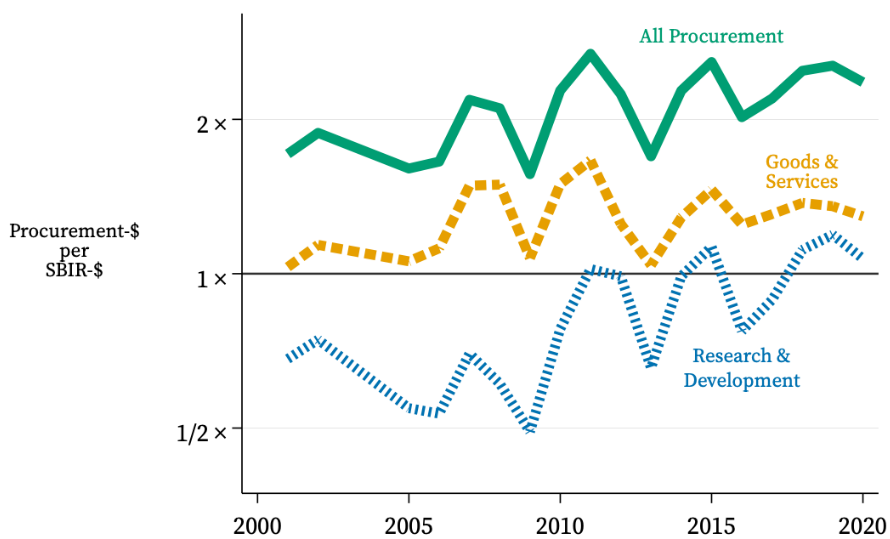
business in the absence of the SBIR business.

Given these assumptions, then we can construct an extremely simple measure of the average flow of returns to the SBIR program by dividing total non-SBIR spending by total SBIR awards. Intuitively, this provides a simplistic rate of return metric that is above 1 (i.e., indicating a positive return) if SBIR awardees are obtaining more non-SBIR-contract-dollars than SBIR-award-dollars. For the years where we have data on federal contracts, 2000–2021, this ratio is equal to:

$$\frac{\text{\$ value of all non-SBIR-contracts awarded to SBIR-businesses}}{\text{\$ value of all SBIR awards}} = 2.7\,,$$

which indicates that for every $1 awarded to SBIR businesses between 2000–2021, those same businesses received $2.7 in non-SBIR contracts with the federal government.

FIGURE 7. Relative Government Spending on SBIR Firms



Note: Plots the 4-year rolling average of the ratio of (*numerator*) the total amount of non-SBIR contract dollars awarded to prior SBIR award-winning businesses per (*denominator*) the total amount of SBIR dollars awarded. The ratio is reported annually for three different *numerator* values: (*i*) all procurement contract dollars, (*ii*) R&D contract dollars only, and (*iii*) all non-R&D contract dollars for "Goods & Services". Note the log scale. For example, if the government awarded $1 billion in total SBIR funding in a given year, then a ratio of 1 indicates that, in that same year, the government awarded prior SBIR award-winners $1 billion in procurement contracts.

Figure 7 plots this average public return metric for SBIR awardees from 2000–2020. It also splits total non-SBIR contract dollars into spending due to R&D contracts (e.g., to continue developing SBIR-originated technologies) versus spending due to non-R&D contracts for goods and services (e.g., to procure fully-developed SBIR-originated technologies). Overall, we obtain an average return ratio of roughly 4 — for every $1 the government spends on SBIR awards in a given year, that same year the government is procuring $4 worth of goods, services, and continued R&D from businesses that have previously obtained an SBIR award. This ratio has been trending upwards since the late 2000s, leveling off in most recent years.

In one sense, this ratio is a lower bound on the average returns of the program since there is a host of socially valuable outcomes from the SBIR program that do not directly result in federal contracts. On the other hand, interpreting the ratio as a metric of average returns does require strong assumptions about the causal effect of the SBIR program. And while the evidence referenced thus far does generally support the view that the marginal dollar invested into the program does spur innovation, the aggregate impact of the program being applied to a national need are still unclear.

5.3. Evaluations of the future

The common view of the SBIR program as a quasi-venture-capital fund has led evaluators to ask questions centered around individual businesses: did an SBIR awardee hire more people, raise more private money, or survive longer than an observationally similar business that did not receive an SBIR award? Amazing data collection efforts and clever research designs (i.e., regression discontinuities around agency score cut-offs) generally conclude that the marginal award boosts business-level performance.[23] But the theoretical motivation and practical implementation of the SBIR program suggests a "*SBIR as venture capitalist*" lens misses a very important part of the picture. A venture capitalist is focused on generating private returns based on the development of a specific business, regardless of which ideas they pursue. But the SBIR program is focused on generating social returns based on the development of a specific idea, regardless of which business is responsible.

Looking forward, the empirical challenge will be to understand idea-level counterfactuals: how much more likely is it that some technology is invented, refined, and deployed because of SBIR-backed businesses? Regression-discontinuity designs will remain useful for many important dimensions of this questions. For example, Howell et al. (2025) shows that open-topic solicitations pull new entrants into the defense base, which surely is relevant for a healthy churn of innovative ideas. But many traditional business-level analyses will not tell us whether society ends up with different innovations, or just a different set of winners. Myers and Lanahan (2022) provides a hint of a way forward, in that they are able to estimate technology-level regressions to compare progress surrounding ideas that receive more or less SBIR investment. However, Myers and Lanahan (2022) rely entirely on the patent record for measures of value, which is still far from the more ideal notion of the marginal value of public funds that policymakers could use compare

[23] With the notable exception of the null result for traditional SBIR awards identified by the regression discontinuity design in Howell et al. (2025).

across programs. Credible future evaluations will need richer outcome measures that convert complex benefits of technologies (e.g., downstream emissions reductions, defense readiness gains, health improvements) into dollar values, and research designs that can identify plausibly-exogenous investments at the idea level, not merely at the firm level (although, aggregations of business-level variation may prove useful in identifying idea-level variation in investments). These efforts will be essential for improving the nation's portfolio of innovation policies.

6. The Future of Small Business Innovation and National Needs

Here, we focus on two major trends that are relevant to small businesses' role in the US innovation ecosystem: market concentration, and the emergence of artificial intelligence (AI). Clearly, the innovation policies of the future will need to grapple with both of these issues.

6.1. Case Study of Consolidation: Defense Innovation Base

The rise of "*superstar*" or "*mega*" firms has been one of the most important evolutions of the US economy in recent years (Autor et al. 2020). One sector full of national technological needs where market concentration has become quite pronounced is the national defense industry — see Figure 8A for an illustration. The consolidation of the Department of Defense's (DoD) major prime contractors continues to receive a significant amount of attention, especially in terms of how it has changed the role of small businesses in the defense innovation base. As highlighted by a recent DoD report: "*Insufficient competition may leave gaps in filling [the DoD's] needs, remove pressures to innovate ... result in higher costs to taxpayers ... and raise barriers for new entrants*." (pg. 1, US Department of Defense 2022). Anecdotes of unintended consequences and misaligned incentives are abundant (Shah and Kirchhoff 2024). However, quantitatively diagnosing how this consolidation has played out, especially with respect to small businesses' role, is quite challenging.

For example, Carril and Duggan (2020) find these consolidations to have led to a significant increase in the rate of "cost-plus" contracts. On one hand, that is concerning because, compared to the alternative "fixed-price" contracts, the cost-plus contracts increase the potential scope for inefficiencies (i.e., moral hazard). However, Carril and Duggan (2020) find no significant changes to acquisition costs. This may be due to a combination of two forces: (*i*) the government is still able to exercise significant monopsony power as the only buyer of many goods and services the primes produce (Carril and Duggan 2020); or (*ii*) economic theory suggests that the use of cost-plus contracts is more efficient when procuring more complicated goods and services (Bajari and Tadelis 2001), and, by most accounts, the complexity of defense technologies continues to increase over time.[24]

In theory, how might this consolidation have affected the rate of defense innovation and the role of small businesses in the defense innovation base? Unfortunately, economic theories yield a wide range of possibilities. Consolidation at this point of a supply chain could plausibly increase or decrease prime contractors' incentives and capabilities to innovate, which in turn has an ambiguous effect on the small businesses that supply primes with innovation (Hart et al. 1990).[25]

While the trend illustrated in Figure 8A has been widely circulated, it has proven difficult to observe how the rest of the defense innovation base has evolved.[26] To provide a new view of the defense innovation base during this period of consolidation among the "mega" prime contractors, we again look to the patent record.

We identify businesses that are plausibly active suppliers of innovation to the mega defense prime contractors by identifying corporate assignees that meet two criteria: (*i*) one of the businesses' patents is cited by a patent of one of the mega primes in a given year, and (*ii*) the business obtains a patent within five years that the citation was received. The first criterion is based on the result due to Fadeev (2024), that most patent citations reflect business arrangements, and the second criterion helps ensure that the business cited by the mega prime is still in operation (as evidence by them recently obtaining a patent). In this case study, since we want to observe the industry trends prior to the shift in consolidation, we also infer business size directly from the patent record based on the number of unique inventors assigned to a businesses' patents in a given year.[27]

Figure 8B illustrates the change in the number of businesses (small and large) that are connected to mega defense primes in the patent record over the same period of consolidation. Two interesting patterns emerge. First, the onset of consolidation in the early 1990s, which is apparent in Figure 8A, is not obviously noticeable in Figure 8B. From 1980 to 2000, there was roughly a 4–5 fold increase in the number of these defense innovation suppliers, and this increase was roughly equal to the relative decrease in the number of mega primes over the same period. However, from 2000 onward, there has been only very modest growth in the number of small and large businesses that are innovation

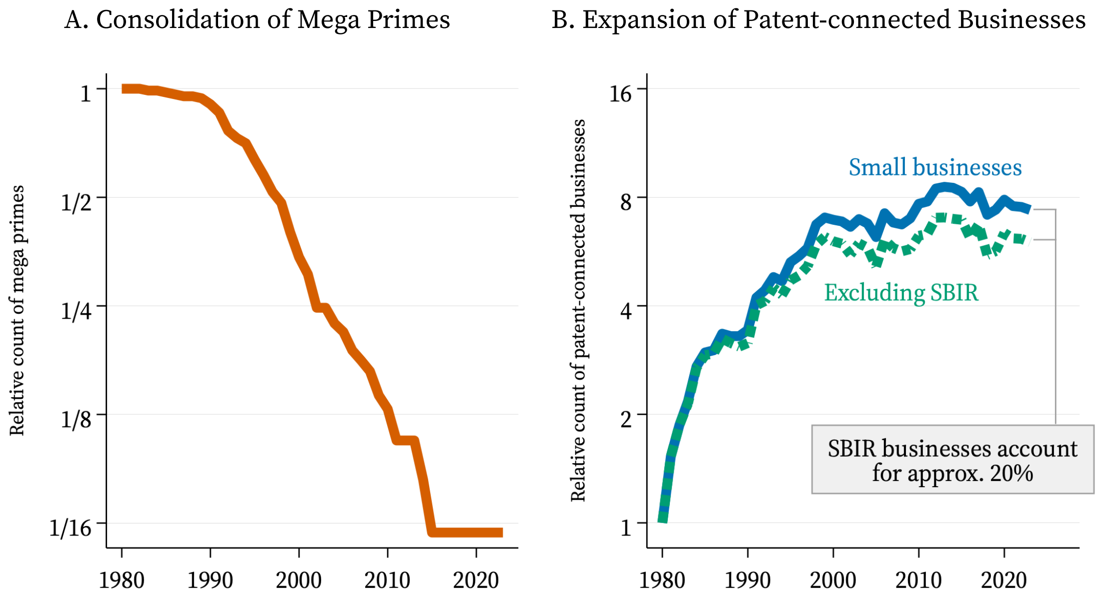
[24]For example, the number of "source lines of code" (a measure of software complexity) in the DoD's leading fighter jets have increased by roughly an order of magnitude with each new generation (West and Blackburn 2017).

[25]Prime contractors may use their increased monopoly power to squeeze rents out of their suppliers, which could shrink the defense base; or, the primes may use that power to foster increased competition and innovation among their suppliers.

[26]One commonly reported estimate is that the number of small businesses in the defense *industrial* base shrunk by 40% during the 2010s (Cronk 2021); however, it is unclear how this estimate was constructed.

[27]Our NETS data does not cover businesses prior to 1990. We label businesses with fewer than 50 unique inventors listed on their patents in a given year, since, for the years we can jointly observe patents and actual business size, very few small businesses (per total employee counts) have more than 50 unique inventors appear in the patent record in any given year.

FIGURE 8. The Evolving Defense Innovation Landscape



Note: Panel (A.) plots the relative count of mega prime defense contractors per Figure 2 of US Department of Defense (2022). Panel (B.) plots the relative count of patent assignee businesses that, in a given year, (*i*) are cited by a mega prime and (*ii*) obtain a new patent within the following five years. Small businesses are proxied by having fewer than 50 unique inventors listed in the patent record.

suppliers to the mega primes. Now, while there is 1/16 as many mega primes compared to 1980, there is only about 5–8 more innovation suppliers compared to 1980.

Figure 8B also illustrates the extent to which SBIR-backed firms comprised this set of innovation suppliers. In most recent years, we estimate that roughly 20% of these patent-connected small businesses were SBIR program participants.

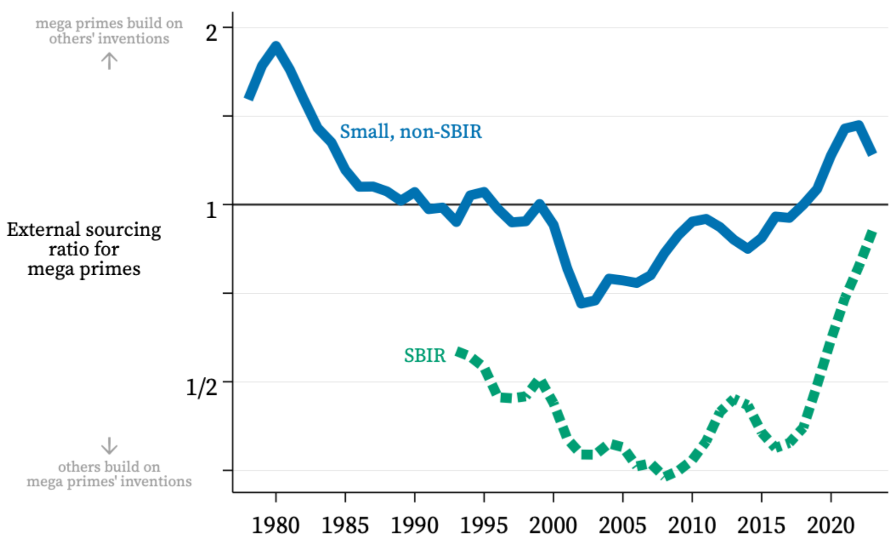
Another way the patent record can provide some insight here is by using it to identify whether innovations have become more *internally sourced*, with mega primes dictating the direction of innovation, or more *externally sourced*, with other businesses developing innovations that mega primes integrate into their own technological systems. Again, patent citation flows can prove useful here, since we can proxy for the sourcing of innovation based on whether (*i*) a patent citation flows from a non-mega prime to a mega prime, which we label as internally sourced, or (*ii*) a patent citation flows from a mega prime to a non-mega prime, which we'll label as externally sourced. This allows us to construct a metric of external innovation sourcing that is the ratio of those two citation flows:

$$\text{external sourcing ratio} = \frac{\text{cites to other businesses from mega defense primes}}{\text{cites to mega defense primes from other businesses}}.$$

We don't take a sense on what the optimal sourcing ratio is here, but instead use the ratio to understand shifts over time in where the new ideas for defense innovations are sourced from. Figure 9 plots the external sourcing ratio over the past 40 years for small businesses, large businesses, and SBIR businesses.[28]

Four patterns are of note in Figure 9. First, unlike Figure 8B, the onset of consolidation among the mega primes in the 1990s is more apparent. Focusing on the non-SBIR businesses, we see that there was a marked shift towards internal sourcing around 2000 — it was more common for outsiders to build on the mega primes' inventions than vice versa. A second interesting pattern is related to the shift towards internal innovation sourcing; small (non-SBIR) businesses were much less likely to be pulled towards the internal innovations of the mega primes. The shift towards internal sourcing was roughly half the relative magnitude for small businesses compared to larger.

FIGURE 9. External Sourcing of Innovation and Mega Defense Primes



Note: Plots the external sourcing ratio, as defined in the main text. Values above 1 indicate that mega primes cite other businesses' patents more than those businesses cite mega primes, and vice versa. Small businesses are proxied by having fewer than 50 unique inventors listed in the patent record.

Another pattern illustrated by Figure 9 is the difference between SBIR and non-SBIR small businesses. Clearly, SBIR businesses are much more likely to be building inventions on top of mega primes' own inventions. This is very consistent with the DoD's historic use of the SBIR program. Awards are given to pre-specified needs of the military branches, which will very often revolve around improving the components of the systems developed

[28]We exclude SBIR businesses from the "Small" category. We exclude the initial decade of SBIR data since the number of awards is so small that there is likely a significant amount of noise in the ratio.

and integrated by the mega primes. This also indicates that the SBIR program has not historically been a vector for new technologies (i.e., inventions outside the scope of the mega primes' systems) to enter the defense base.

A final pattern that emerges from Figure 9 is the dramatic increase in external sourcing of innovation that has occurred in the most recent years. Part of the jump is plausibly pandemic-related: Covid-19 likely exposed vulnerabilities in certain areas (e.g., medical logistics, secure telework) where the mega primes lacked in-house capabilities and therefore turned to outside inventors. At the same time, the technological frontier has expanded toward software, autonomy, and cyber-physical systems—domains in which specialized small firms can move faster than sprawling integrators. The result is a recent surge in citations from primes to external patents, reversing two decades of increasingly inward-looking R&D.

Institutional reforms within the Department of Defense also may have begun to pry open the innovation pipeline. The Defense Innovation Unit (DIU) has shown great success at incorporating new ideas into the defense base with efforts to reduce frictions by developing novel contract designs (i.e., Other Transaction Authorities) and ensuring geographic proximity to leading technology hubs (i.e., offices in Silicon Valley, Boston, and Austin).[29] AFWERX, within the Air Force, pioneered a more expansive use of "open topic" SBIR funding announcements that invite businesses to propose dual-use technologies of their choosing (Howell et al. (2025)). Similarly, the Army's xTechSearch prize competitions now offer cash awards for promising prototypes and channel winners into follow-on SBIR or procurement contracts.

Taken together, the evidence from the patent record is consistent with anecdotal concerns that incumbent consolidation can make the industrial base stale. Still, even these metrics we present here are limited in their ability to convey the social value of the technologies at hand. As we noted in the prior section, continued work to develop datasets that quantify and track the social value of technologies will be crucial for being able to monitor the defense industry as it continues to evolve.

6.2. Small Business Innovation and National Needs in the Age of AI

The rapid emergence of generative artificial intelligence (AI) offers some unique challenges and opportunities for the role of small businesses in the innovation economy. An increasingly likely possibility is that AI tools will allow for businesses to simultaneously be both *small*, as defined by the number of humans employed, and *enormous*, as defined by the scale of their business operations. Small businesses with this extreme "digital leverage" (e.g., 10 humans managing 10,000 agentic AIs) could be able to perform orders-

[29] See Shah and Kirchhoff (2024) for an excellent review of the DIU.

of-magnitude more operations than current businesses, so long as those operations can be digitized.

How might the emergence of small businesses with high digital leverage shape the innovation landscape? First, it is helpful to note that many of the comparative advantages of small businesses vis-à-vis innovation could remain. Although the digital workforce of these firms could be much larger than their human workforce, the division of equity is likely to still be small — there will still only be a few humans in the firm who have much to gain from their innovations. Thus, the incentive misalignment concerns highlighted in Section 4 could still favor small businesses as the ideal setting for small, high-risk, contractible R&D. However, many other important factors could change.

Opportunity costs. With access to such a large digital labor force, small businesses' opportunity costs may change dramatically. Traditionally, a small business with specialized capabilities would face a narrow set of feasible market opportunities — they would face small opportunity costs if they choose to engage with government contracts and national needs (instead of pursuing commercial projects). But as AI capabilities improve, so too will small businesses' ability to pivot to more lucrative commercial markets, and so too will the opportunity cost of engaging with the government. Such a shift would decrease the government's ability to direct small businesses towards the most pressing national needs, and it could also increase the government's uncertainty about the supply of small businesses that might be able to address any given need. As emphasized by Acemoglu (2011), if the costs of switching between technological pursuits are too low, there may be a suboptimal amount of diversity in the innovation base. Monitoring the diversity of small business innovators amid the rise of AI will certainly be important.

Digital versus physical. Another interesting dimension to monitor will be how national innovation needs evolve in the age of AI. As the AI workforce rapidly overcomes many digital bottlenecks, it will expose a new set of technological challenges that cannot be solved by software alone — challenges that will rely on physical skills, analog capabilities, and tacit knowledge. Thus, the increasingly canonical image of small business innovation involving software intensive operations may not persist when it comes to national needs. Furthermore, program maintenance and evaluation for new and existing initiatives will become increasingly challenging. If the bottlenecks to progress become less amenable to digitization, then national needs will be less visible in the data, which implies that data-based management and evaluation may become less possible.

Pacing and sourcing. There is much optimism that the rate of innovation will achieve new speeds not seen before. While exciting for consumers, dramatic increases in the speed of innovation could prove challenging for traditional institutions that have supported small business innovation in the public sector. Historically, international pressures have created national needs that often emerge at the technological frontier. Studies of innovation in the wake of World War II and the Space Race suggest that governments have been responsible for major technological developments (Gross and Sampat 2023; Kantor and Whalley 2025). However, the pace of progress in consumer-oriented technologies now often has the private sector arriving at the frontier first. This will require new institutions that ensure that government managers are kept up-to-date on the capabilities of the private sector. Efforts such as the Defense Innovation Unit and the Air Force's AFWERX (discussed in Section 6.1) are promising steps in that direction. Ultimately, success will depend on continued innovations in the process of innovation itself — testing new ways to find and support small businesses, connecting public and private efforts, and shortening the path from prototype to practical use.

6.3. Conclusion

All of the groups in this innovation ecosystem have distinct comparative advantages: small businesses excel at tackling small-scale, well-defined, highly uncertain technical problems; venture capitalists excel at spotting businesses with large private upside and then supplying the capital and managerial capabilities to scale them rapidly; and government agencies excel at obtaining unique information about externalities—the gap between the social and private returns—associated with emerging ideas and technologies that are in national need.

The SBIR program is a unique innovation policy at the intersection of these three groups, and there still may be ways to leverage the comparative advantages of each group even more in the future. Efforts by groups such as the Defense Innovation Unit have demonstrated the value of providing small businesses not just with raw capital, but with connections and channels towards commercialization. Perhaps the SBIR program of the future could include more explicit resources or guarantees along the commercialization journey so that the small businesses can focus on what they do best: inventing new, amazing technologies. The perspective of venture capitalists is partially incorporated into the program via participation on review panels, but Tibbet's original NSF pilot, which awarded a bonus in the review stage for businesses with pre-commitments from private investors, provides an example of what a more explicit incorporation of the VC perspective would look like. And while there is no doubt that government officials work hard to surface national needs (i.e., problems in need of solutions), the success of the Air Force's AFWERX program suggests there are still large gains to be had from making sure that these officials have the most up-to-date information about small businesses' capabilities at the technology frontier (i.e., solutions in need of problems). Stitching these groups together, while keeping an eye on not just the success of any specific business, but the value created by the entire SBIR program, can help this ecosystem continue to deliver outsized benefits to the nation.

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