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Article

The Impact of I-Corps on Accelerating Venture Discontinuation in a Southeastern US University

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Abstract

This study contributes to the literature on accelerators which focuses on private sector accelerators by providing an analysis of an accelerator in the public sphere that works with early-stage, science-driven applications, the National Science Foundation's Innovation-Corps (I-Corps) program. The methodology is based on a comparison of the ability of the services delivered through the I-Corps program to teams at the Georgia Institute of Technology (Georgia Tech) to speed their venture project discontinuation decisions over and above those of researchers receiving baseline commercialization services only. We find modest evidence that the I-Corps program helped Georgia Tech I-Corps teams make faster decisions to discontinue venture projects. The total savings of quicker I-Corps project discontinuation are estimated at more than $3.6 million over the 8-year observation period.

Key words: I-Corps; accelerator; academic entrepreneurship

1. Introduction

The Endless Frontier Act of 2020 aims to position the US National Science Foundation (NSF) toward more of an innovation orientation by establishing a new directorate for technology, renaming the Foundation, and adding new funding and programs. Whether this is an appropriate science policy direction is the subject of debate between those concerned about global competitiveness versus those concerned about the impact of public funding crowding out commercial innovation and venture activity (Mervis 2020).

NSF already administers several programs in this technology and innovation area (Bhushan 2015). One of these is the Innovation-Corps (I-Corps) program. Although not always overtly referred to as an accelerator, I-Corps shares defining accelerator characteristics of hastening commercialization decision-making, competitive admission, financial support, education and mentoring, and working with teams (Clarysse et al. 2011, 2015; Pauwels et al. 2016). I-Corps is designed to address the long time horizons and risks traditionally associated with efforts to transfer basic science to the market (Nelson 2004; Pisano 2006). The program originated in the NSF in 2011 to provide training in entrepreneurship methodologies to accelerate commercialization research of its principal investigators (PIs) (Youtie and Shapira 2017). I-Corps is primarily an NSF program, although the Department of Energy, Agriculture, and Homeland Security have sent teams to training and the National Institutes of Health set up its own version of I-Corps focused in biomedical technologies in 2014 (VentureWell 2019). The budget for I-Corps has been roughly $30 million from fiscal year 2016 until the budget request for fiscal year 2019. The program ramped up from an initial $1.06 million in fiscal year 2011 to roughly $30 million starting from fiscal year 2016.

The program through 2020 had three facets: (1) I-Corps Nodes, particular locations in different US regions where the training is held; (2) I-Corps Sites to support entrepreneurial activities, including training, administered by universities; and (3) I-Corps Teams which are organized around an application of research of an NSF PI. In addition to the PI, teams are comprised of a member who leads exploratory interviews with potential customers and partners (usually a student or post-doc), and a mentor. I-Corps Nodes grants have been several millions of dollars for multiple years. I-Corps Site grants have been in the range of one or more hundreds of thousands of dollars. I-Corps Teams awards have been for $50,000 to support travel to the training and for customer discovery. NSF put forth a solicitation for the I-Corps program in early 2020 that reconfigured the system around Hubs, rather than Nodes, eliminating Sites and retaining Team awards (National Science Foundation 2020).

Studies of I-Corps have been performed at the University of Michigan (Huang-Saad et al. 2017) and by VentureWell (2019), which collects data from I-Corps participants nationally. Our paper gives a perspective of I-Corps outcomes at Georgia Institute of Technology (Georgia Tech), the location of one of the first nodes established by NSF in 2012. Rather than addressing the range of outcomes, our analysis focuses on what is the most defining contribution of this accelerator program—the discontinuation decision. We propose that I-Corps projects will be more likely to reach the discontinuation decision and will reach it faster than a baseline group. Our paper also makes contributions to understanding the types of outcomes from public as opposed to private accelerators and to the use of projects working in basic research and early stage innovations.

We begin the next section with background literature on private accelerators. We specifically draw on a model developed for analyzing entrepreneurial activities of private accelerators by Yu (2019). Yu's model emphasizes the importance of knowledge gained for sensing entrepreneurial opportunities and the outcomes of improved sensing leading to more efficient decisions about staying or going out of business. Section 3 extends this model to science-driven activities in a local commercialization ecosystem around Georgia Tech. Although this is a single-site study of Georgia Tech, much can be learned from the Georgia Tech experience because it was one of the first I-Corps Nodes selected by NSF. Georgia Tech has had teams qualify and go through the I-Corps program since the program began in 2011 and was awarded an I-Corps Site grant in 2017. Georgia Tech's VentureLab program, which has administered the node at Georgia Tech, has offered fundamental services to entrepreneurs since 2001. Some of these services have transformed into I-Corps offerings, which affords a unique opportunity for assessing the effects of I-Corps over and above VentureLab's baseline services on the decision to discontinue or pursue a venture. Section 4 describes our model, how it is operationalized, and the data we use to test the model. Section 5 presents our findings and the paper ends with a discussion of the results and conclusion about implications, limitations of the study, and opportunities for future research from this work.

2. Background

University commercialization support initiatives have evolved since the Bayh-Dole Act of 1980 (Grimaldi et al. 2011; Siegel and Wright 2015). Approaches after the Bayh-Dole Act emphasized technology transfer offices and tended to be more centralized, intellectual property-oriented, and revenue seeking. However, recent university support commercialization programs, in part due to the rise of accelerators, are more decentralized and closer to the needs of the research investigator (Breznitz 2011).

Accelerators are widely used as a technology transfer instrument, but not easily delineated from other commercialization approaches. The Global Accelerator Report 2016 identified 579 accelerators worldwide working with more than 11,000 startups (Gust 2016). Definitions of an accelerator are unclear due to variations in programs, organizations, and funding models, but taking together overlaps in definitions in Pauwels et al. (2016), Clarysse et al. (2011), and Clarysse et al. (2015), accelerators share several defining characteristics: (1) objective to advance commercialization decision-making, (2) competitive entry, (3) some type of funding support, (4) time limited education and mentoring service packages, and (5) working through cohorts of participant teams rather than with one company or inventor at a time.

The definition of an accelerator does not always do well in differentiating this instrument from other technology transfer mechanisms despite the body of scholarly research on them. The co-citation analysis of Hausberg and Korreck (2020) applied to 347 journal articles of incubators and accelerators situates accelerators as a subset of incubators. Isabelle (2013) likewise suggests that a lack of agreement exists about the distinctions between incubators and accelerators, calling accelerators 'an incubation model ... with a more explicit focus on accelerating the growth of firms' (p. 18). One of the contributions of this paper is to efforts to develop an accelerator definition, by focusing on an impact of accelerator programs (which we call discontinuation) that is embedded in the design of an accelerator as distinct from that of an incubator.

There have been several reviews of the body of literature amassing on accelerators (Crisan et al. 2019; Drori and Wright 2018; Hausberg and Korreck 2020). For the purpose of this study, we focus on the literature on accelerator outcomes. The particular interest of this paper is on the outcomes of accelerator interventions in general and I-Corps in particular. We precede a discussion of accelerator and I-Corps outcomes with a look at the rationale for accelerators to enhance the efficiency of decisions as to whether to continue entrepreneurial pursuits.

2.1 Accelerator outcomes

Crisan et al.'s (2019) extensive review of literature on accelerators reported on 98 accelerator studies. Most of these were qualitative; only 15 of the 98 accelerator studies reviewed used quantitative methods. Of the 81 papers with information about outcomes, there was little agreement as to which were the best outcomes to use to assess accelerator performance. Two of the three most common accelerator measures were output activities: number of participants and number of applicants; the authors acknowledged that these were activity measures of the accelerator process rather than accelerators' results. Number of jobs created was among the performance measures of accelerators that were reported in the literature review, but this kind of metric requires additional downstream activities beyond the accelerator to be produced. The measure used in our study, project discontinuation, was not explicitly mentioned although 14 studies used startup survival rate to assess accelerator performance; Crisan and his coauthors appeared more favorably inclined toward this measure because it most closely reflected the accelerator purpose. Just one of the studies mentioned a comparative approach such as we are using in this study to assess projects going through I-Corps relative to those receiving baseline services only.

Most of the studies in the literature review found positive firm results. Many of these studies did not use a comparison group approach. Such an approach can be difficult because of the challenge of finding a counterfactual for startup firms. For incubator studies, examples of comparison groups include rejected incubator applicants (Sherman and Chapple 1998) or propensity score matching of firms that applied but were not accepted (Stokan et al. 2015). Hallen et al. (2014) matched startups in several different accelerators with a comparable set of ventures not in accelerators. The accelerator startups reached their funding milestones more quickly, but the difference varied across the accelerators and overall was not significant. On the other hand, Smith and Hannigan (2015) compared startups that advanced out of accelerators versus those supported by

angel investors, finding that accelerator graduates were more likely to achieve their next financing milestone.

In sum, this review suggests that the potential for confusion exists as to which metrics are most useful for examining the results of accelerators. Many different metrics are being used. Some are more intertwined with the accelerator process—such as numbers of participants—while others are too indirectly related to the accelerator services—such as number of new jobs. This confusion is exacerbated by the lack of quantitative studies of accelerators, particularly studies with a comparative element.

2.2 Reducing uncertainty about likelihood of commercialization success

A major need of research investigators seeking commercialization of their scholarly work is improved capabilities to obtain relevant information to reduce uncertainty about the likelihood of commercialization success. This need has been highlighted in Yu's study of accelerators (Yu 2019). Yu proposes that accelerators provide training to enable entrepreneurial participants to learn how to identify relevant information signals about the likelihood of success of their ventures. These signals will lead to greater efficiency in decision-making about continuing the entrepreneurial venture or going out of business. Yu tested this proposition by developing a dataset of 900 companies from 13 accelerators matched with similar ventures not part of accelerators. Going out of business, also known as discontinuation, has been explored in other studies of entrepreneurship (see e.g. Liao et al. 2008). Yu's analysis found that the odds for ventures in accelerators of going out of business were 150% higher than for non-accelerator ventures. Yu concluded that feedback from improved information signal assimilation obtained through accelerator participation leads to greater efficiencies in deciding to exit.

A similar qualitative study was conducted by Cohen et al. (2018). The authors begin from a bounded rationality framework (Simon 1955), drawing on the Carnegie School's theories of bounded rationality, decision-making structures, routine-based behavior and learning, and conflicts and cooperation (Gavetti et al. 2007). The authors created a dataset of 37 ventures in 8 accelerator programs and conducted qualitative interviews with founders and accelerator directors to understand how founders use accelerators to deal with limited information that typically plagues startup companies. The authors found that accelerators helped founders wade through available information more quickly. The authors concluded that accelerator services enabled founders to avoid making decisions without having sufficient information. In a parallel study, Cohen et al. (2019) showed that the way accelerators are designed can affect who becomes an entrepreneur and thus regional capacities and economic outcomes.

These studies suggest that one of the core functions of the accelerator is to complement the information processing capability of the venture teams, so they make efficient decisions for their future business. As an important decision in the venture business, the accelerators may help the venture team speed up the discontinuation decision by enabling better evaluation of the feasibility and profitability of their business plan. To private accelerators, this function seems to help to achieve their primary goal—maximizing the return to private investors by saving investments into unprofitable business models.

A similar benefit with some difference can also be expected with public accelerators. Public accelerators such as I-Corps are designed using some principles from private accelerators. However, in contrast to private accelerators that place greater emphasis on returns to private investors, public accelerators may be concerned about value to taxpayers and regional or national economies (see Leleux and Surlemont 2003, for analogous research on public versus private venture capital). Therefore, a public accelerator's enhancement of the information processing capability of venture teams may help to screen a less feasible business idea early, which saves the public money that would have otherwise been invested into an unsuccessful business model. This benefit could be particularly important when venture teams pursue science-driven commercialization efforts, which often are more distant from the market and more difficult to measurably associate with a commercial application (Jaffe and Jones 2015). Although research investigators are likely to have the absorptive capacity to understand science-driven opportunities (Cohen and Levinthal 1990), investigators may not have the capacity to take action on new entrepreneurial information and completely take advantage of new options (Henderson and Clark 1990). Investigators' existing academic careers may lead to well-established ways of shaping, arranging, and grouping phenomena, resulting in overly narrow and shallow perceptions (Thagard 2005). Highly significant information for starting a firm, such as about the market, may be systemically overlooked, producing fewer options for pursuing (March 1994; Simon 1997).

3. I-Corps and Georgia Tech's commercialization programs

3.1 I-Corps and the discontinuation decision

The I-Corps training, based on the Stanford Lean Launchpad course, provides instruction on how to structure an initial business model, test it with potential customers and partners, and make changes as a result (Blank 2003; Osterwalder and Pigneur 2010; Ries 2011). I-Corps includes six weeks of follow-up to check on the teams' progress. At the end of the period, the team reaches a conclusion about the 'go/no go' decision, i.e. whether to continue discontinue the venture (VentureWell 2019). Although the NSF 2020 solicitation shifts away from a binary 'go/no go' declaration at the end of the I-Corps training, allowing for additional intermediate options that encompass varying amounts of time and resources, the discontinuation decision was an integral design element of the I-Corps program during the time we examined it at Georgia Tech and remains one of several entrepreneurial possibilities.

3.2 I-Corps outcomes

Studies of the outcomes of I-Corps have been conducted nationally and at the university level. Huang-Saad et al. (2017) provides an in-depth description of the operation of the I-Corps program at the node at the University of Michigan. The lesson most relevant to this paper is about the usefulness of the go/no go decision which the authors contend has helped academic participants to learn business model terminology and market opportunity pathways. The paper also reports a range of node, individual, and institutional outcomes experienced at the Michigan node. Node level impacts reported include numbers of participants and instructors, and follow-on grants. Individual level impacts reported include additional commercialization training, business formation, licensing, and patent filing. Institutional level impacts include invention disclosures, patenting, license agreements, and new business formation.

This range of impacts parallels national I-Corps impact reporting from VentureWell, a private nonprofit organization under contract

to NSF to collect activity and outcome data about I-Corps. Nationally, more than 1,300 teams were educated in 63 cohort trainings held from fiscal years 2012–2018. These teams created more than 640 startups and more than $300 million of investment funding (National Science Foundation 2019). VentureWell also collects data from its participant survey on the ability to determine the viability of products and services—discontinuing or pursuing the venture activity—short-term outcomes such as knowledge gains from the training received, and longer-range impacts such as incorporation status, licensing, patenting, and other intellectual property (VentureWell 2019).

3.3 I-Corps at Georgia Tech and VentureLab

Georgia Tech's I-Corps involvement began (in addition to I-Corps teams awards to Georgia Tech investigators in 2011) through the I-Corps South Node, which was established in 2012 through the university's VentureLab unit. VentureLab is a Georgia Tech program established in 2001 to assist faculty members through the commercialization process (Youtie and Shapira 2008; Georgia Tech News Center 2012). This paper is not about the I-Corps South Node, which delivers training to teams in the southeastern USA. Rather it concentrates on projects at Georgia Tech that have received assistance through VentureLab, including I-Corps-assisted projects. This university-focus distinguishes the paper from the Huang-Saad et al. (2017) work which covers the node as well as University of Michigan services and impacts.

VentureLab principals act as advisors to Georgia Tech faculty wishing to apply for funding from the Georgia Research Alliance (GRA), a private non-profit organization with the mission to foster economic development by leveraging the research capabilities of the state's universities. GRA modeled its seed grant program on the three-phase award structure of US Small Business Innovation Research (SBIR) and Small Business Technology Transfer (STTR) grants. VentureLab principals help faculty apply for these GRA seed grants as well as for I-Corps grants (Table 1). VentureLab principals also have provided I-Corps training and have used some of the I-Corps training concepts in baseline VentureLab services. These baseline VentureLab services include individual training sessions, showcases, and 'pitch' competitions or short presentations about the entrepreneurial idea to venture investors. Table 1 situates the I-Corps program within VentureLab's baseline services, confirming that the program occurs during the early venture phase of the process. VentureLab's administration of both the national I-Corps training and the local commercialization program supported through GRA seed grants puts it in a unique position for investigating the effects of the I-Corps program relative to a baseline.

The expected effect of I-Corps is that it will lead to more efficient discontinuation decisions, as highlighted in Yu (2019). Our research propositions are that (1) projects going through I-Corps will be more likely to make entrepreneurial decisions to discontinue the venture activity than projects receiving baseline services only and (2) projects going through I-Corps will make faster entrepreneurial decisions to discontinue the venture activity than projects receiving baseline services only.

4. Methodology

4.1 Models

Prior studies, such as Huang-Saad et al. (2017) presented a range of variables to examine, such as learning, patenting, and other conventional entrepreneurship measures. This paper focuses on the discontinuation decision because it is the attribute closest to the design of the I-Corps program during the period of analysis.

The unit of analyses for this study is the VentureLab project. A project is a research-driven entrepreneurial idea that has a name and involves one or more team members. This focus on projects departs from Yu's focus on startup companies. The reason for this differential focus is that VentureLab targets science and technology-driven entrepreneurial explorations from Georgia Tech. These explorations are more upstream and have not necessarily decided to incorporate as a business entity.

This study examines the decision to discontinue the venture activity compared with projects receiving baseline services using the following model:

$$E[P_i|\boldsymbol{X}] = \beta_0 + \beta_1 \times \text{ICorps}_i + \sum \gamma_j X_{j,i},$$

where P_i represents the probability associated with the decision to discontinue pursuit of a science-based entrepreneurial activity; ICorps_i represents participation in the I-Corps program; and $X_{j,i}$ represents a vector of control variables—technology sector, prior NSF funding, team size, presence of female team members—that might affect the relationship between the discontinuation decision and participation in the I-Corps program. β_1 is the estimated difference between a team that participated in the I-Corps program and a baseline team in either the likelihood or hazard of discontinuation.

For the first research proposition about the likelihood to make entrepreneurial decisions to discontinue the project, we used a logit model. The logit model provides likelihood estimates for discontinuation versus continuation as a function of I-Corps participation and control variables. For the second research proposition about the speed of discontinuation, we used a Cox proportional hazard model

Table 1. VentureLab processes with I-Corps services highlighted.

	Research	Discovery		Company	
Stages	Disclosure/Ideation	Customer discovery	Customer validation	Customer creation	Company building
IP	Provisional		Utility	License	
Financial		GRA phase 1	GRA phase 2	Seed	Venture capital
		I-Corps	SBIR phase 1	GRA phase 2	
Technology	Tech Demo	MVP Test	Prototype	Production	
Market	Ecosystems	Product	Sales	First	Scale
	Business thesis	Market fit	Validation	Customers	
People	Researchers	Startup team		Launch CEO	Management team

Source: https://venturelab.gatech.edu/process/.

to compare the hazard of discontinuation between I-Corps versus baseline projects, controlling for sectoral, team size, and team member characteristics.

The Cox proportional hazard model is useful for estimating the hazard of encountering events, particularly for right-censored data (Allison 2014), such as discontinuation and business incorporation, which are key features of the I-Corps program relative to baseline projects. Under the proportional hazard assumption, the model estimates the discontinuation hazard ratio between I-Corps projects and baseline projects. The hazard ratio is the ratio of the two hazard rates. Instead of directly estimating the hazard rate for the baseline projects, the estimated hazard ratio provides time-invariant hazard difference between the I-Corps projects and baseline projects. We tested this proportional hazard assumption in the analysis.

4.2 Data

The data for this study began from the VentureLab program's customer relationship management (CRM) system, which is a customized version of the SalesForce standard CRM. VentureLab principals enter information into the CRM including participation in I-Corps. One of the principals supplements this information by scraping data from Crunchbase (about investments); secretaries of states of Georgia, Florida, Delaware, and California (about incorporations); SBIR (about SBIR awards); and GRA (about its commercialization awards); and the NSF awards database (about I-Corps and other awards from NSF).

We started from the CRM which contained detailed information about every project managed under the Georgia Tech VentureLab as of January 2019. The CRM links 10 relational databases comprised of projects, participants, programs (including I-Corps participation), investments, affiliations, incorporation status, and other topics (such as patents). We aggregated these data into 271 unique projects. We validated variables that were deemed crucial to our analyses using both manual curation and automated methods such as web scraping.

4.3 Variables

The dependent variable—discontinuation of entrepreneurial activity—was measured two ways: based on 'dormant/dead' status and incorporation status. Many of the VentureLab projects have their final status recorded as 'dormant' or 'dead' in the CRM. We used this status to represent informal discontinuation of the project. Incorporation represents a more formal hurdle. The CRM included incorporation status in a 'business_type' file which we linked back to each project. Only 80 projects were ever incorporated according to the original CRM data. However, when we hand-curated randomly selected projects, we found a non-trivial number of projects that were incorrectly classified in the CRM as unincorporated. We did not find such case for the reverse (incorporated cases turned out to be not incorporated). We used the Georgia Corporations Division website (https://ecorp.sos.ga.gov/BusinessSearch), which provides search access to all the entity's information of record with the Secretary of State of Georgia.[1] We manually searched all 271 projects in Georgia Corporations Division. We searched them manually because of firm name ambiguities and the relatively manageable number of projects in our dataset. We coded webpage URLs for all projects that were identified from the Georgia Corporations Division. Each webpage provides detailed information about the incorporated firm including its entity name, business type, formation date, dissolution date (if there was any), registration status, and a unique ID. Using unique IDs from coded URLs, we applied a python script to scrape the aforementioned information and coded them in our aggregated dataset. In the end, we found that 127 projects (47% of all projects) were ever incorporated, a far greater number than the 80 projects (29% of all projects) indicated as such in the CRM.

The independent variable—I-Corps project participation versus baseline services (through the variable I-Corps)—is defined as receipt of I-Corps team funding (i.e. the $50,000 I-Corps team grant) or not. The baseline case is all projects that did not receive I-Corps team funding (but may have received other early-stage funding such as from the GRA). In the VentureLab relational database, the investment dataset includes investment information about funding dates and types received by every project. We identified 82 projects that received I-Corps funding and 189 projects that received only baseline services. We additionally obtained funding date information from the CRM or from the NSF award search website (https://nsf.gov/awardsearch/).

We controlled for factors that theoretically associate with our dependent variable and relate to the project's likelihood of receiving an I-Corps grant. We controlled for heterogeneity in the relationship between discontinuation and participation in I-Corps based on technology sector. The GRA has an explicit bioscience focused program (Youtie and Cassidy 2015), while the NSF as a whole does not (although certain individual funding programs target bioscience). The original information in VentureLab's administrative database records the team's technology sector using a 20-field text format. We manually standardized this information by allocating the 20 fields into the six major technology categories from the National Bureau of Economic Research (NBER)—Computers and Communications, Drugs and Medical, Electrical and Electronics, Chemical, Mechanical, and 'Others' (Hall et al. 2001; Jaffe and Trajtenberg 2002). We omitted the 'Others' category because all of our projects fell into one of the first five categories. A set of dummy variables for these five NBER major technology categories are introduced into the analysis as control variables.

Second, we introduced a binary variable that takes the value of 1 if PIs of a team of interest had an NSF grant before receipt of an I-Corps or other early commercialization grant (nsf_experienced). This variable is designed to control for the eligibility condition of teams for applying for an I-Corps grant—PIs are required to have NSF funding before applying for the I-Corps grant—while no such eligibility exists for the baseline projects. We identified project team members that received NSF grants prior to I-Corps activities. We downloaded 4,203 NSF grants that were awarded to Georgia Tech from the NSF Award Search website (https://nsf.gov/awardsearch/advancedSearch.jsp). We then matched 216 unique PIs from 271 project teams to 586 NSF awards. We retrieved award date information and identified whether these PIs received NSF grants prior to receipt of an I-Corps team award.

Third, we took into account variations in the team size (through the variable team_size) that affect the relationship between I-Corps participation versus baseline services and discontinuation decisions. I-Corps has a three-person team requirement while VentureLab does not require a particular team size for its baseline services. The notion of a lone entrepreneur has been amended in studies that promote the benefits of teams in navigating information and resources (see Klotz et al. 2014, for a review). However, Greenberg and Mollick (2018) find that individuals do better than teams at the initial point of starting a company. The VentureLab CRM does not have a verified team size variable; team composition can change over time and these

changes are not always picked up in the early creation of a team record in the CRM. We measured team size by using the number of contacts in the CRM's name directory that are linked to a particular project.

Finally, we introduced a binary variable that captures whether there is any female team member (through the variable women). This variable controls for the existence of policy initiatives to support women's entrepreneurship that may affect the relationship between discontinuation and I-Corps participation. Studies of female entrepreneurs in science and technology highlight the under-representation of 'women' at individual, organizational, institutional, and policy levels (Kuschel et al. 2020; Poggesi et al. 2020). VentureLab does not have any particular initiatives to promote women's entrepreneurship, but nationally, I-Corps has provided special awards for greater inclusion of women in entrepreneurial activities (National Science Foundation 2017) and reports out the share of projects with at least one female team member (National Science Foundation 2019). The gender control variable is represented as a dummy variable, taking a value of 1 if the team includes at least one female team member; zero otherwise.

We excluded projects that have no information on the dates of I-Corps awards. We also excluded baseline projects that began before the start of I-Corps in 2011. As a result, our dataset contains information on 130 projects. Seventy-five (58%) projects were in the group that received I-Corps awards and 55 (42%) projects were in the baseline group. All the observations in the dataset are projects that started their commercialization exploration activity with GRA Phase-1 or I-Corps grants.

4.4 Analysis

Two types of analyses are performed. The logit analysis estimates the likelihood of discontinuation as a function of I-Corps participation and control variables. We separately run the analysis for the two measures of discontinuation: (1) dead or dormant projects and (2) projects that are not formally incorporated as a business. This approach allows us to test the robustness of any significant coefficients by seeing if they remain consistently significant across the two ways of operationalizing discontinuation.

For the second analysis about the speed of discontinuation, we employ a variable that takes the difference (in counts of days) between the dates associated with the Dormant/Dead status or incorporation status and the I-Corps grant or baseline services (days to discontinuation). The challenge for estimating day counts is to derive initial and end dates. We used two approaches to approximate the initial dates: (1) earliest appearance in the CRM and (2) earliest funding date. Under the first approach, we estimate the initial day counts for Dormant/Dead status based on the earlier of the 'team established' or 'created' date fields in the CRM; we estimate the end date using the CRM's 'last date modified' field. These fields are reasonable proxies for the timing of a project as captured by the CRM, notwithstanding the possibility that older projects' initial activities might have not been well captured in the CRM. For incorporation status, we estimated the start date using the earlier of the 'team established' or 'created' date fields. We estimated the end date using the date of first incorporation. Under the second approach, we used the earlier of GRA funding or I-Corps funding as the start date. First receipt of funding for commercialization is another reasonable proxy in that it reflects external support for initial commercialization activities such as development of prototypes and testing with potential customers, notwithstanding the possibility that other early commercialization activities might have occurred prior to receipt of this early external funding (such as activities that were self-funded or funded by friends and family) (Liao et al. 2008). The end dates are the same as the above.

To advance the robustness of our model, we considered two measures of the decision to discontinue. The first is comprised of projects that drop a science-driven entrepreneurial activity but do not inform VentureLab associates; VentureLab labels these as 'dormant' projects. VentureLab associates may also be informed of the end of the project; these are labeled as 'dead' projects. Dead projects are most similar to the discontinuation decision following market readiness explorations (Naffziger et al. 1994), which was highlighted in the I-Corps designation of 'go/no go' prior to the programmatic shift toward entrepreneurial and market variations. The variable ('deaddormant') associated with dead or dormant projects takes a value of 1 if the project is dead or dormant; otherwise zero.

The second dependent variable measure is comprised of projects that do not formally incorporate as a business. Yu (2019) used business incorporation as an indicator of the likelihood of going out of business more quickly than non-accelerator companies. We do not use business incorporation quite like Yu did because our dataset is more upstream and has fewer business incorporations. We use projects that do not formally incorporate as another proxy for discontinuation. Business incorporation ('ever_incorporated') takes a value of 1 if the project has incorporated into a formal business; otherwise 0. The interpretation of this variable should be reversed because we want to measure discontinuation.

I-Corps participation is based on receipt of either an I-Corps team grant or an acknowledgment in the VentureLab database that the team participated in I-Corps. This variable ('I-Corps') takes a value of 1 if the team has participated in I-Corps; otherwise zero. The control variables consist of technology sector represented as a set of dummy variables for each sector ('chemicals', 'computers and communication', 'drugs and medical', 'electrical and electronics', 'mechanical'); prior NSF funding also represented as a dummy variable ('nsf_experienced'); team size ('team_size') which counts the number of contacts in the database that are associated with a project; and presence of one or more female team members ('women').

5. Results

5.1 Descriptive statistics

Table 2 presents the summary statistics for I-Corps projects compared with the baseline. The percentages of 'deaddormant' and 'ever_incorporated' are similar but are higher for I-Corps projects than for baseline projects under the CRM definition than under the first commercialization grant definition.

The average team size is higher for I-Corps projects than baseline projects under both definitions. The use of the three-person team may explain why the I-Corps projects have somewhat larger teams, although measurement error stemming from use of the number of contacts recorded in the CRM name directory may be a factor in I-Corps team size averages not being closer to three.

Women are more prominent in I-Corps projects than baseline projects. At least one woman was a team member in about a quarter of the I-Corps projects versus only 7% of the baseline projects. This difference can be explained by the active support in the I-Corps system for greater inclusion of women in entrepreneurial activities (National Science Foundation 2017), while such programs are not

Table 2. Summary statistics.

Baseline project teams using first grant 2011 or later

Variables	*N*	Mean	Standard deviation	Min	Max
Deaddormant	55	0.29	0.46	0	1
ever_incorporated	55	0.29	0.46	0	1
team_size	55	1.27	0.68	1	5
Women	55	0.07	0.26	0	1
nsf_experienced	55	0.56	0.50	0	1
Sector dummies					
Chemicals	55	0.16	0.37	0	1
Computers and communication	55	0.24	0.43	0	1
Drugs and medical	55	0.33	0.47	0	1
Electrical and electronics	55	0.13	0.34	0	1
Mechanical	55	0.15	0.36	0	1

Baseline project teams using first appearance in CRM 2011 or later

Variables	*N*	Mean	Standard deviation	Min	Max
Deaddormant	43	0.23	0.43	0	1
ever_incorporated	43	0.23	0.43	0	1
team_size	43	1.33	0.75	1	5
Women	43	0.07	0.26	0	1
nsf_experienced	43	0.53	0.50	0	1
Sector dummies					
Chemicals	43	0.19	0.39	0	1
Computers and communication	43	0.21	0.41	0	1
Drugs and medical	43	0.30	0.46	0	1
Electrical and electronics	43	0.14	0.35	0	1
Mechanical	43	0.16	0.37	0	1

I-Corps project teams using first grant 2011 or later

Variables	*N*	Mean	Standard deviation	Min	Max
deaddormant	75	0.27	0.45	0	1
ever_incorporated	75	0.25	0.44	0	1
team_size	75	1.39	0.98	1	7
Women	75	0.21	0.41	0	1
nsf_experienced	75	0.73	0.45	0	1
Sector dummies					
Chemicals	75	0.11	0.31	0	1
Computers and communication	75	0.44	0.50	0	1
Drugs and medical	75	0.13	0.34	0	1
Electrical and electronics	75	0.13	0.34	0	1
Mechanical	75	0.19	0.39	0	1

I-Corps project teams using first appearance in CRM 2011 or later

Variables	*N*	Mean	Standard deviation	Min	Max
deaddormant	73	0.25	0.43	0	1
ever_incorporated	73	0.26	0.44	0	1
team_size	73	1.40	1.00	1	7
Women	73	0.22	0.42	0	1
nsf_experienced	73	0.73	0.45	0	1
Sector dummies					
Chemicals	73	0.11	0.31	0	1
Computers and communication	73	0.44	0.50	0	1
Drugs and medical	73	0.12	0.33	0	1
Electrical and electronics	73	0.14	0.35	0	1
Mechanical	73	0.19	0.40	0	1

Table 3. Logit results.

	Based on first grant 2011 or later		Based on first appearance in CRM 2011 or later	
Variables	(1) deaddormant	(2) ever_incorporated	(3) deaddormant	(4) ever_incorporated
I-Corps	−0.371	−0.311	−0.301	0.031
	(0.469)	(0.450)	(0.539)	(0.528)
team_size	−0.307	−0.039	−0.290	0.007
	(0.255)	(0.277)	(0.249)	(0.277)
Women	−0.030	−0.081	−0.046	0.077
	(0.637)	(0.594)	(0.677)	(0.600)
nsf_experienced	0.411	0.689	0.428	0.739
	(0.459)	(0.446)	(0.511)	(0.493)
Chemicals	1.050	−0.026	1.116	0.060
	(0.953)	(0.682)	(0.973)	(0.725)
Computers and communication	2.228***	−0.933	2.031**	−0.803
	(0.798)	(0.590)	(0.805)	(0.632)
Drugs and medical	1.084	−1.081	0.312	−1.037
	(0.872)	(0.692)	(0.972)	(0.769)
Electrical and electronics	0.295	−1.246	0.339	−1.506*
	(1.074)	(0.763)	(1.075)	(0.890)
Mechanical	–	–	–	–
Constant	−1.972**	−0.551	−1.991*	−1.038
	(0.950)	(0.764)	(1.033)	(0.877)
Observations	130	130	116	116

Log-odds units reported. Robust standard errors in parentheses.
*P < 0.1, **P < 0.05, ***P < 0.01.

explicitly part of the VentureLab or GRA commercialization programs.

Because I-Corps grants are promoted to NSF PIs, I-Corps project team members are more likely to have had earlier NSF grant experience. Seventy-three per cent of I-Corps projects had team members with earlier NSF grant experience compared with less than 60% of baseline projects.

Both groups had projects in the five technology sectors, but the distributions are different between the I-Corps and baseline projects. The drugs and medical device sector is more common among baseline projects, reflecting the focus that the GRA has on that sector (Youtie and Cassidy 2015). The computer and communications sector is more common among I-Corps projects, although more than 20% of the baseline projects also have ventures in this technology sector.

5.2 Logit regression

Relative to the first research proposition, Table 3 presents logit regression estimates of the log odds of discontinuation—Dormant/Dead or non-incorporation—as a function of I-Corps participation and control variables. We reported robust standard errors to deal with the possibility of heteroscedasticity in the error terms, although we also ran the regressions without robust standard errors, finding the same results. The correlations among the independent variables are below 0.40 (see the Appendix for these correlation matrices).

In each of the four columns that measure discontinuation slightly differently, the coefficient associated with I-Corps is negative and statistically insignificant at the 0.10 level. These results indicate no evidence of the overall likelihood of discontinuation being associated with I-Corps participation. I-Corps and baseline projects do not differ in their overall likelihood to discontinue their venture pursuit, regardless of how discontinuation is measured. Except for a few of the technology sectors, none of the control variables are statistically significant in these models as well.

5.3 Cox proportional hazard regression

Although the overall likelihood of discontinuation is unrelated to I-Corps participation, we may see a relationship if we take into account both the occurrence and the timing of discontinuation through Cox proportional hazard regression (Allison 2014). Another rationale for the use of Cox regression is that our dataset is right-censored. Projects enter the database continuously throughout the length of time we observe them. The projects that were recorded in the CRM and/or were awarded I-Corps grants (or, for baseline projects, other commercialization grants) in the more recent years might not have had enough opportunity to experience discontinuation events. The discontinuation events among recent projects could be observable if we had a longer time period for observation. We can take into account this right-censoring, or lack of a discontinuation event, by using Cox hazard regression for examining the second research proposition.

Table 4 presents the descriptive information for this regression. The numbers of observations and subjects are the same, indicating that each project has a single record. The median exit (discontinuation) for baseline projects ranges from 991 to nearly 1,590 days depending on the way the starting date is measured and for I-Corps projects from 777 to 1,160 days. The average failure (i.e. discontinuation) rate is from 0.21 to 0.29 for baseline projects and 0.21 to 0.26 for I-Corps projects depending on the starting measurement used.

We fit a Cox proportional regression model using the Breslow method for dealing with ties as there are very few ties (fewer than 30% of the sample); we also ran the analysis using the Efron method

Table 4. Time data descriptives.

	Observations/subjects	Median exit time	Failures (count)	Failures (mean)
Baseline	55	1,590	16	0.29
I-Corps	75	777	20	0.27
Baseline	52	992	13	0.25
I-Corps	71	618	15	0.21
Baseline	43	1,197	10	0.23
I-Corps	69	1,130	18	0.26
Baseline	42	1,160	9	0.21
I-Corps	69	1,029	18	0.26

Table 5. Cox regression model results.

	Based on first grant 2011 or later		Based on first appearance in CRM 2011 or later	
Variables	(1) dormant_duration	(2) incorp_duration	(3) dormant_duration	(4) incorp_duration
I-Corps	1.966*	1.262	1.613	1.601
	(0.703)	(0.600)	(0.652)	(0.896)
team_size	1.080	1.093	0.916	1.009
	(0.229)	(0.223)	(0.194)	(0.196)
Women	0.868	1.045	0.764	1.211
	(0.439)	(0.611)	(0.412)	(0.625)
nsf_experienced	1.608	1.405	1.490	1.811
	(0.617)	(0.638)	(0.675)	(0.914)
Computers and communication	1.989	0.322*	1.769	0.341
	(1.307)	(0.193)	(0.946)	(0.221)
Drugs and medical	1.153	0.434	0.755	0.425
	(0.685)	(0.227)	(0.565)	(0.250)
Electrical and electronics	0.650	0.000***	0.683	209
	(0.591)	(0)	(0.607)	(0.202)
Mechanical	0.512	0.662	0.492	0.645
	(0.481)	(0.448)	(0.447)	(0.442)
Observations	130	123	112	111

Hazard ratio reported; robust standard errors in parentheses.
*P < 0.1, **P < 0.05, ***P < 0.01.

and the results did not much differ. We used robust standard errors in the Cox regression to deal with possible bias resulting from heteroscedasticity in the error terms.

Table 5 reports the differential rate at which a project team will undergo discontinuation conditional that the project is still active. In the first column, the coefficient associated with the I-Corps variable is greater than unity and statistically significant at the 0.10 level. The hazard ratio of an I-Corps team discontinuing (represented as dead or dormant) is 1.966, which suggest that an I-Corps team is almost twice as likely to discontinue as a baseline team in standardized unit time.

We tested that the proportional hazards assumption is met using Schoenfeld residuals. The global and covariate-specific tests were not significant, indicating that we cannot reject the null hypothesis that the hazards are proportional for this model; in other words, no evidence exists that the proportional hazards assumption in this model was violated.

The coefficients associated with I-Corps participation in the other three models were not significant at the 0.1 level. However, the coefficients are all greater than unity across the models, indicating that the inconsistency in statistical significance should not completely discount the significant finding presented in the first column of Table 5. Furthermore, given the relatively small sample size and the possibility of measurement error in the dependent variables, it cannot be concluded that I-Corp participation had no impact on the time to decision for discontinuation. Accordingly, we argue that our analyses results offer modest evidence showing that I-Corp projects discontinued faster than baseline projects.

Why is the first model's coefficient associated with quicker I-Corps project discontinuation significant relative to the lack of significance in the other three models? The first model's operationalization of start and discontinuation dates using first NSF grant and implicit or explicit closure of a project in the CRM most closely mirrors the I-Corps project process which is based on an NSF grant (a requirement to apply for an NSF team award) and ends with a possible discontinuation decision. The other models rely on the first date of appearance in the CRM, which depends upon the program to record this information consistently and faithfully, or on the use of business incorporations, which are not formally a design element of the I-Corps program the way they are in private accelerators such as studied by Yu (2019).

5.4 Estimating savings from faster discontinuations

Although our Cox regression result does not provide robust evidence of the effect of the I-Corps program on project discontinuation speed, it can be useful to calculate the extent of savings from a faster discontinuation period associated with I-Corps projects using our

estimation results. We performed a calculation that substitutes the longer baseline project discontinuation periods and monetizes this longer period through a simple calculation. This calculation begins with the 20 I-Corps projects that were discontinued in the 2011–2018 timeframe. If we apply the median days to discontinuation associated with baseline projects—1,590 days—to the 20 I-Corps projects, the total days to discontinuation would equate to 31,800 days. This number of days is far greater than the median days to discontinuation associated with I-Corps projects—777 days—which, when applied to these 20 I-Corps projects, would equate to 15,540 days.

We then took the difference between these two totals to estimate the potential number of days saved across the 20 I-Corps projects by I-Corps methodologies. A simple subtraction of I-Corps median day product from the median day product associated with baseline projects suggests that I-Corps could have saved a total of 16,260 days to discontinuation.

Applying simple daily rates for VentureLab principals' and professors' time allocation to these projects can give us a sense of the value of these savings. If VentureLab principals devoted half a day for every 20 days of elapsed time, the value of I-Corps savings would be roughly $406,500 (at a fully burdened daily rate of $1,000 a day based on a typical VentureLab annual salary of $125,000). If professors devoted the average amount of permissible consulting time of a day for every 5 days of elapsed time (using the same fully burdened daily rate), the value of I-Corps savings would be $3,252,000. Together these two totals amount to roughly $3.6 million over the eight-plus-year period of observation.

This estimate illustrates the kinds of monetization of I-Corps program impacts that can be performed. The illustration includes some assumptions concerning the similarity of the discontinued I-Corps and baseline projects. The two groups have not been matched on all the covariates in this study in part because of modest numbers of projects on which this estimate is based. The analysis also overlooks negative savings from discontinued projects that should have received continued guidance and mentoring, although it also does not account for opportunity costs of VentureLab specialists being able to shift to other projects more quickly.

6. Discussion

This study has examined the likelihood and time to discontinuation of I-Corps projects and those of a baseline group. Relative to the first research proposition, this study found that the overall likelihood of discontinuation was the same for both groups. Relative to the second research proposition, we found some evidence, albeit not robust, that I-Corps projects were more quickly able to discontinue than baseline projects under one of the measurement assumptions. This finding, notwithstanding robustness issues, suggests that I-Corps may enable more efficient decisions in pursuing entrepreneurial ventures.

A key factor in this finding is the application of a measurement approach for the discontinuation timing based on the earliest NSF research grant for the starting point and, for the ending point, explicit ending of a science-driven entrepreneurial activity ('dead' projects) or implicitly ending of this activity without a formal 'no go' ('dormant' projects). These measures seemed to most closely approximate the I-Corps starting (based on receipt of an I-Corps Teams grant available to NSF investigators) and ending point. Using first business incorporation as a starting point, for example, is not significantly associated with time to discontinuation in our models perhaps because it is not built into the I-Corps design during the study period.

One interpretation of the study's findings is that the I-Corps model around discontinuation decisions may have discouraged project teams' pursuit of commercialization possibilities. Our study suggests that the I-Corps grant helped teams to make more efficient discontinuation decisions, albeit within the limitations of the findings. The purpose of the I-Corps program is to provide training and mentorship to develop teams' sensing capabilities to access information channels about market/customer needs in the face of uncertainty. The I-Corps program gave teams additional resources to undergo training and receive mentoring to enhance market evaluation capabilities around their entrepreneurial application. There is no reason to believe that the I-Corps grant, training, and mentoring deprived recipient project teams of pursing market entry possibilities. We argue that I-Corps program appears to help teams make more efficient discontinuation decisions rather than discouraging commercialization. Moreover, I-Corps is shifting away from a complete discontinuation approach and more toward an exploration of variations in venture launching.

The I-Corps program does appear to offer benefits stemming from learning how to sense and screen ideas with uncertain market potential. This screening function may produce savings benefits when considering the extent of public resources allocated for science-based entrepreneurship. One way to calculate this benefit is to estimate the amount of human capital investment (of technology transfer professionals and professors) that could have gone to these I-Corps ideas if they had not been discontinued as quickly. The total savings effects of faster I-Corps project discontinuation are estimated at more than $3.6 million over the eight-year-observation period. One caveat is that the 20 discontinued I-Corps projects may not all have been discontinued due to the introduction of the I-Corps program. As a result, our analysis provides an upper limit value of the gains from the I-Corps program. In addition, the negative effects of discontinued projects that should have received ongoing assistance are not considered. On the other hand, we are not including savings from state or federal commercialization grants conferred on discontinued projects in our savings estimate. We also are not monetizing opportunity costs from slower movement of advisors to the next project.

7. Conclusions

Before we discuss the implications of our paper, we acknowledge the limitations of our analysis. Projects in the I-Corps and baseline groups have the opportunity to receive similar services from the same group of VentureLab professionals. Team members in both groups can elect whether to go through I-Corps. I-Corps applications may be riskier and more upstream although baseline applications may be similarly risky, and their choice may only reflect a lack of interest in going through the I-Corps process. I-Corps has more of an entrepreneurship training orientation while basic mentorship and GRA funding, available to baseline and I-Corps project team members, are available through a state economic development program. Both I-Corps projects, through training, mentorship and market exploration support, and baseline projects, through entrepreneurial mentoring and GRA funding for technical application development, offer similar content (i.e. support services) and highlight similar outcomes around company formation. These similarities between I-Corps and baseline services means that there are likely to be spillovers between the two groups we cannot observe but that muddy

comparisons. This kind of comparative analysis is difficult to obtain in technology transfer studies outside of randomized control designs. The I-Corps versus baseline approach used here, notwithstanding these shortcomings, offers a useful method for assessing outcomes in a more balanced manner than descriptive studies lacking such a benchmark.

Another weakness of this study is that we did not include direct measures of learning, which is a main goal of I-Corps. These kinds of measures are more difficult to ascertain from unobtrusive secondary databases and to attach a timeframe for the Cox proportional hazard regression. The role of training and learning as an ultimate end goal has been called into question, for example, by Lukosiute et al. (2019) who criticizes accelerators for being locked-in on education to the detriment of starting companies. On the other hand, although we do not directly measure learning, we do focus on the improved decision-making efficiency effects of I-Corps training, which likely arise from new capability obtained by participants that help them to reduce uncertainties, better understand entrepreneurial information channels, and sense market potential more rapidly. This study also does not present a cost–benefit calculation to see if the federal and/or state programs pay for themselves.

This study is based in the I-Corps declared 'go/no go' model. As previously noted, I-Corps is adding other decision options to this model to allow for different resource and time allocations. Our analysis was able to identify projects that discontinued using fields from the VentureLab CRM. According to VentureLab specialists, project team members have always been free to pursue entrepreneurial activities even if they have been formally deemed to be a 'no go', and some do continue their pursuit. We addressed this situation by not calling these decisions 'go/no go' decisions but rather dead or dormant projects that have been discontinued. However, given the possibility that project team members can pursue entrepreneurial opportunities even after formal discontinuation decisions, the discontinuation decision has always been a fluid concept, and this fluidity is being recognized in the I-Corps addition of other decision points alongside 'go/no go'.

A final limitation is that this analysis is set in the Atlanta innovation ecosystem. Atlanta has become prominent in high technology rankings (Kanapi 2018). Midtown Atlanta around Technology Square at Georgia Tech (where VentureLab has its main offices near to the Georgia Tech technology incubator Advanced Technology Development Center and several technology venture supporting groups) has been recognized as an innovation district where universities, large companies, startups, and intermediary organizations are located close to mass transit, dense mixed development, and Internet hubs (Katz and Wagner 2014). However, Atlanta it is situated in the southeastern USA which is not a traditional location for innovation (Youtie and Shapira 2008).

Our paper has made a theoretical contribution that extends the literature on accelerators, particularly outcome analysis of accelerators, to the public sphere and early-stage, science-driven applications. This paper's contribution focuses on a public accelerator, in contrast to that of mainstream accelerator studies of private accelerators, and pre-company (for the majority of the observations) projects, which are at a more upstream, science-driven, and perhaps uncertain stage. It demonstrates the methodological benefits and challenges of focusing on an outcome—the discontinuation decision—that is most proximate to the intrinsic design of the program.

For policymakers, this paper adds to the pool of information concerning designing public accelerators for academic research commercialization such as I-Corps. For program managers, the paper demonstrates how administrative CRM data can be supplemented with external publicly available information to make it useful as an unobtrusive resource in program assessment. We hope other I-Corps groups are able to conduct and share similar evaluation findings to see if our results are robust across different local programs and innovation ecosystems. It is interesting that the shift in the I-Corps program design away from a 'go/no go' decision is at odds with our results about the value of discontinuation as an outcome metric. The pursuit of entrepreneurial changes has limits, as Arora et al. (2019) demonstrate in their finding of an inverse U-shaped relationship between the breadth of changes and sales growth in new green goods venture firms. Our study suggests that further consideration should be given to discontinuation as a useful outcome metric for science-driven public accelerators.

This method is generalizable to other science-based commercialization programs within and outside of the I-Corps community. Most programs have internal customer and activity tracking systems such as the CRM referenced in this paper that can be used for program evaluation if connected with other publicly available datasets such as external incorporation or research grant awards. This paper has demonstrated how to make these connections and use these datasets to supplement internally generated data. The importance of multiple measures is presented to deal with noisy tracking data. We also have shown how a benchmark for comparison can be developed from these data.

Generalizing from the results that I-Corps projects had a modestly quicker ability to discontinue than baseline projects is important for demonstrating the value of the program. The weak nature of these results is understandable given the small number of projects in a single commercialization program. We also are cautious about generalizing our results beyond the I-Corps program because not all accelerators may be capable of or have as a goal speeding the discontinuation decision. Nevertheless, these results can be important in presenting a systematic approach to careful program justification amid studies showing limited returns from some university commercialization programs (see Bozeman et al. 2015, for an overview). The results suggesting that I-Corps may support more efficient entrepreneurial venture decisions can be useful as NSF gives greater attention to these kinds of technology programs.

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Note

1 Most startups in the VentureLab CRM first files incorporations to the state of Georgia.

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Appendix

Table A1. Correlation Matrices

Using first grant 2011 or earlier ($n = 130$)

	deaddormant	I-Corps	team_size	Women	nsf_experienced	Chemicals	Computer/ communications	Drugs/ medical	Electrical	Mechanical
Deaddormant	1.00									
I-Corps	−0.03	1.00								
team_size	−0.06	0.07	1.00							
Women	0.02	0.19**	−0.04	1.00						
nsf_experienced	0.08	0.18**	−0.06	0.08	1.00					
Chemicals	−0.04	−0.08	−0.10	−0.04	−0.06	1.00				
Computer/ communications	0.30	0.21**	0.10	0.13	0.02	−0.29***	1.00			
Drugs/medical	−0.03	−0.23***	−0.08	−0.12	0.02	−0.20**	−0.39***	1.00		
Electrical	−0.14	0.01	0.06	0.02	0.04	−0.15*	−0.29***	−0.20**	1.00	
Mechanical	−0.19	0.05	−0.01	−0.02	−0.02	−0.18**	−0.33***	−0.24***	−0.18*	1.00

Using first grant 2011 or earlier ($n = 130$)

	ever_incorporated	I-Corps	team_size	Women	nsf_experienced	Chemicals	Computer/ communications	Drugs/ medical	Electrical	Mechanical
ever_incorporated	1.00									
I-Corps	−0.04	1.00								
team_size	−0.04	0.07	1.00							
Women	−0.02	0.19**	−0.04	1.00						
nsf_experienced	0.10	0.18**	−0.06	0.08	1.00					
Chemicals	0.12	−0.08	−0.10	−0.04	−0.06	1.00				
Computer/ communications	−0.09	0.21**	0.10	0.13	0.02	−0.29***	1.00			
Drugs/medical	−0.06	−0.23***	−0.08	−0.12	0.02	−0.20**	−0.39***	1.00		
Electrical	−0.08	0.01	0.06	0.02	0.04	−0.15*	−0.29***	−0.20**	1.00	
Mechanical	0.14	0.05	−0.01	−0.02	−0.02	−0.18**	−0.33***	−0.24***	−0.18**	1.00

Using first appearance in CRM 2011 or earlier ($n = 116$)

	deaddormant	I-Corps	team_size	Women	nsf_experienced	Chemicals	Computer/ communications	Drugs/ medical	Electrical	Mechanical
deaddormant	1.00									
I-Corps	0.02	1.00								
team_size	−0.05	0.04	1.00							
Women	0.02	0.20**	−0.05	1.00						
nsf_experienced	0.07	0.19**	−0.06	0.08	1.00					
Chemicals	0.01	−0.11	−0.11	−0.04	−0.08	1.00				
Computer/ communications	0.30	0.23**	0.12	0.11	0.01	−0.30***	1.00			
Drugs/medical	−0.12	−0.22**	−0.08	−0.10	0.03	−0.19**	−0.36***	1.00		
Electrical	−0.11	0.00	0.06	0.03	0.03	−0.16*	−0.30***	−0.19**	1.00	
Mechanical	−0.16	0.04	−0.02	−0.03	0.01	−0.19**	−0.35***	−0.23**	−0.19**	1.00

Using first appearance in CRM 2011 or earlier ($n = 116$)

	ever_incorporated	I-Corps	team_size	Women	nsf_experienced	Chemicals	Computer/ communications	Drugs/ medical	Electrical	Mechanical
ever_incorporated	1.00									
I-Corps	0.03	1.00								
team_size	−0.02	0.04	1.00							
Women	0.01	0.20**	−0.05	1.00						
nsf_experienced	0.13	0.19**	−0.06	0.08	1.00					
Chemicals	0.12	−0.11	−0.11	−0.04	−0.08	1.00				
Computer/ communications	−0.05	0.23**	0.12	0.11	0.01	−0.30***	1.00			
Drugs/medical	−0.08	−0.22**	−0.08	−0.10	0.03	−0.19**	−0.36***	1.00		
Electrical	−0.12	0.00	0.06	0.03	0.03	−0.16*	−0.30***	−0.19**	1.00	
Mechanical	0.14	0.04	−0.02	−0.03	0.01	−0.19**	−0.35***	−0.23**	−0.19**	1.00

*P < 0.1, **P < 0.05, ***P < 0.01.