



Effect of Entrepreneurial Mindset on Funding Opportunities for Fundamental Research

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Abstract

Proliferation of *Lean Launchpad*, a curriculum designed by *Steve Blank* and adopted by National Science Foundation as *Innovation-Corps program*, has created myriad opportunities for commercialization of existing technology and funding innovative ideas which otherwise may have never *seen the light of the day*. Identifying the merits of funding research based on value proposition and customer demand, key components of the *Business Model Canvas*, has created a paradox for Endowment Funds, Family Offices and even Federal Funding agencies on whether to continue support for fundamental research in hi-tech laboratories or to think like a Venture Capital investor hoping to *hit a home-run*. In a world where the focus is on market viability of research, is the future bleak for fundamental scientific curiosity? Are we on the right path turning Endowment Funds, Family Offices and Federal agencies into Venture Capitalists? Is there any motivation for researchers to get their *hands dirty* at fundamental scientific curiosity when you can just apply a business model canvas to almost everything? This paper explores the question whether universities with higher federal funding for fundamental research are also able to create more opportunities for entrepreneurship.

Keywords: *Lean Launchpad, Entrepreneurship, Innovation-Corps, Federal Funding*

Introduction

America faces a challenge to remain a leader in global market due to a mismatch of talent availability in STEM fields¹. Innovation capacity is a national concern for U.S. competitiveness². Innovative thinking should be an expectation of the university community and all students should be exposed to it early in their university experience, through a variety of educational formats and delivery methods³. Previous investments in STEM education have not resulted in desired level of innovativeness⁴. Prompted by such concerns, the American Society for Engineering Education (ASEE) partnered with the federally funded National Science Foundation (NSF) to evaluate the effectiveness of lean startup approach in enacting educational transformation. With a goal to improve innovativeness in STEM education, ASEE launched Innovation Corps for Learning (I-Corps-L), a program to evaluate NSF's Innovation-Corps model of fostering entrepreneurial mindset in STEM education.

ASEE - NSF Innovation-Corps - Learning

President Obama in 2011 State of Union Address launched Startup America program with a focus on research community to help stimulate the economy through innovation and entrepreneurship. Inspired by the then administration's focus on entrepreneurial initiatives, the

NSF launched a new model for funding research at higher education institutions. The new model, known as Innovation-Corps (I-Corps), was based on Lean Launchpad, an existing framework of startup creation, credited mostly to a Stanford University professor Steve Blank and his protégé Eric Ries.

Professor Blank ⁵ based the foundation of NSF I-Corps program in the scientific approach of testing the hypothesis with empirical data. He acknowledged that the lean startup approach finds its roots in trial-and-error approach which is natural to scientific research but alien to management professionals. He testified to the Congressional Committee on Science, Space and Technology ⁶ that an unexpected result of this program was an impact on the professor's own thinking about how they teach their science and engineering students. Since the launch of NSF I-Corps in 2010, more than 800 teams have completed the NSF curriculum from 192 universities in 44 states resulting in the creation of more than 320 companies that have collectively raised more than \$83 million in follow-on funding ⁷. The American Innovation and Competitiveness Act, 2016 praised the NSF I-Corps efforts with France Cordova, NSF Director announcing a 14% jump in program funding.

Academic opinion is divided: *those who made money support it; others critique it*

Caulfield et al. ⁸ explore how lack of accountability due to absence of comprehensive models that explain, measure and quantify intended beneficial impacts has led to a shift from innovation-diffusion based research knowledge transfer to an active intervention based knowledge translation.

Stone and Lane ⁹ critiqued the assumed causal link to innovation formed due to investments in research and development. Lack of accountability due to absence of comprehensive models that explain, measure, and quantify intended beneficial impacts has led to a shift from innovation-diffusion based research knowledge transfer to an active intervention based knowledge translation. Three models have been identified for this purpose: end-of-grant, integrated and prior-to-grant. It is encouraged that researchers conduct a prior-to-grant assessment of knowledge to be transferred after the grant using a proof-of-concept prototype ⁹.

Breznitz and Ram ¹⁰ identified technology commercialization as an emerging third role that universities are expected to play, the first two traditionally being teaching and research. They examined legislative, financial, and cultural settings in which each university operates. Legal and financial constraints defined as external factors were found to affect public universities with an obligation to "pay back" society and taxpayers. Entrepreneurial activity, physical organization and management define the internal factors that affect university's ability to transfer technology for commercialization ¹⁰.

Chung ¹¹ questioned the need for such an inefficient way of commercializing technology in an academic environment and noted that in 2012, there were 591 new commercial products created with an average \$111 million spent per new product created by Association of University Technology Managers. The researcher raised serious concerns on the effectiveness of commercializing technology through existing methods of funding entrepreneurial education ¹¹.

Anderson ¹² wrote a Master Thesis at Copenhagen Business School to explain the differences in new Lean-based experimental approach to entrepreneurship. However, the big limitation to this research appears to be the case-study based approach which limits external validity. The author integrates an important aspect of failure which was traditionally viewed as end of a startup (and by extension the end of a research project), however this has changed with new experimental approaches that allow investigators to document failure as the premise of learning process ¹². This may be useful for Principal Investigators (PIs) sourcing private investment in funding for research projects. A useful link to Stone and Lane ⁹ who advocate the use of prior-to-grant assessment as a means for translating knowledge to viable outcomes.

Lindkvist and Stjernberg ¹³ concluded that Lean Startup Methodology was better suited for customer validation while Design for Six Sigma was better suited for achieving product validation. The authors used three tools for product validation - Quality Function Deployment (QFD), Failure Mode and Effects Analysis (FMEA) and Design of Experiments (DOE) ¹³.

Youtie and Shapira ¹⁴ argued that public values and economic development are not always in opposition. They discuss how Lean startup methodology ensures that the societal benefits of technology development are achieved through commercialization of research. Public values mapping of I-Corps components may be achieved by asking questions such as "What societal problem does the technology solve?" ¹⁴

Industry perspective: *Bimodal Transformation of Research Institutions*

Bimodal Transformation is a concept promoted by Gartner Inc. for exploring two modes of project delivery at Information Technology firms – mode 1 representing traditional waterfall model for software delivery, while mode 2 representing Agile delivery of prototypes with higher customer engagement in software development. However, it was realized that this model may not be restricted to IT firms and manifestations of this concept may be adopted involving concepts such as agile development, rapid prototyping, technology acceptance, and heavyweight-lightweight technology. Denning ¹⁵ criticized the US manufacturing firms for if agile was only meant for software startups and this lead to the complete annihilation of the industry. GE adopted this approach in 2013 with internal initiatives, Simplification and Fastworks ¹⁶. While Simplification aims to remove clutter from existing processes, Fastworks is GE's way of

implementing lean startup and agile development methods by bringing in lean launchpad coaches Eric Ries and David Kidder.

Casselman¹⁷ surveyed two target groups representing early adopters at 44 established companies. A trend like the adoption of agile methods in mid-2000s was observed with only early adopters using lean startup techniques at established firms. The author also noted a lack of formal framework for adoption of lean startup methods at established firms instead of the trial-error based method applied to highly uncertain new product offerings. In this paper, we propose studying the effectiveness of Innovation-Corps program through the lens of Bimodal transformation, a mode 1 representation based on fundamental research and a mode 2 representation through Lean Launchpad program started at various universities as a part of NSF's efforts to introduce innovativeness in US universities through technology commercialization.

Horlach et al.¹⁸ conducted a literature review on Bimodal transformation. They found that Gartner's publications of this concept received highest direct and indirect references (106) with McKinsey (18) and Boston Consulting Group (4) being a distant second and third. They also found that only one academic publication¹⁹ used agile in some form of coupling although the author had disassociated himself from the use of the term "Bimodal" itself. The paper described how and to what extent heavyweight (databases) and lightweight (mobile apps) was used in healthcare sector. The rest of the publications represented blogs, news articles, white papers, etc.²⁰ acknowledged the biggest roadblocks to Bimodal transformation is establishing a culture and promoting mode 1 employees to mode 2. Gartner also predicted that by 2017, 75% of technology organizations will have Bimodal capabilities.

Methods

The current research attempts to view existing attempts towards scientific research at higher education institutions and universities in US as mode 1 while latest trends in bringing innovation to the existing process of research through commercialization of technology and launching startups at universities as mode 2. While mode 1 is assumed to be known because universities have contributed to basic research for a long time, mode 2 is new and unknown with many universities still struggling to incorporate innovativeness through commercialization as a part of mainstream research efforts.

To test the hypothesis that Bimodal transformation of STEM research at US universities leads to a distraction from core principles of STEM research, the authors collected funding related data from National Science Foundation, National Institutes of Health, and US Patents and Trademark office. The data collected is expected to reflect the following principles of Bimodal transformation:

1. Mode 1: Existing research at universities, represented by number of patents filed and funding received from NSF by universities for research
2. Mode 2: Technology commercialization through lean launchpad, represented by funding received under NSF I-Corps program and number of startups launched

If the hypothesis is true, then the researchers expect a negative correlation among the mode 1 and mode 2. This would translate into a negative correlation among funding received for basic sciences and funding received under NSF I-Corps. A negative correlation would suggest that introduction of the Bimodal transformation through NSF I-Corps program has resulted in a negative impact on the funding received for basic science at the above universities. A similar correlation is expected for number of patents filed and number of startups launched.

Data collection

The researchers intend to prove the hypothesis that there is a negative correlation between mode 1 and mode 2. Based on literature review conducted above, the researchers established that mode 1 may be represented by obtaining the data for funding received by US universities for research from NSF. The effort is summarized as:

1. The researcher accessed the website <https://dellweb.bfa.nsf.gov/Top50Inst2/default.asp>
2. Select the “Data for” = “University”
3. Select the “Fiscal Year” = 2016
4. Select the “Managing Organization” = “NSF total”
5. Select the “Funding Organization” = “NSF total”
6. The funding information for total NSF funds released for each institution is displayed by state.
7. The researcher only collected data for funds related to “Research Support” and discarded the data for “Education and Human Resources” and “Major Research Equipment”. A total of 1543 rows of data was extracted.

On the other hand, mode 2 is represented through the dataset obtained from NSF I-Corps:

1. The researcher went to the website <https://www.nsf.gov/awardsearch/advancedSearch.jsp>
2. Search for element code = “I-Corps”
3. There is a total of three element codes corresponding to I-Corps:
 - a. I-Corps - Sites 8046 with 17 rows of data
 - b. I-Corps - Nodes 8045 with 73 rows of data
 - c. I-Corps - Program 8023 with 295 rows of data
4. The researcher compiled all three files into one and removed duplicates. Then a pivot table was used to merge “Awarded amount to date” based on university. A filter was

placed on the year 2016 to ensure that it matches with the same time-period as for mode 1 data.

5. Apart from “Drury University” all other universities had a corresponding match with mode 1. A total of 105 universities were finally obtained with an overall funding of \$2.3 billion obtained from NSF for mode 1 and \$18.6 million obtained from I-Corps for mode 2.

Data Presentation

The research intends to test the hypothesis that funding received for mode 1 is not correlated to funding received for mode 2 for Bimodal transformation of research in universities. Experience and literature review has shown that technology commercialization initiatives by universities through NSF I-Corps program may be considered as a mode 2 activity. The researchers collected data through NSF website. A positive correlation is observed between the two modes, with funding coming from the same source, NSF.

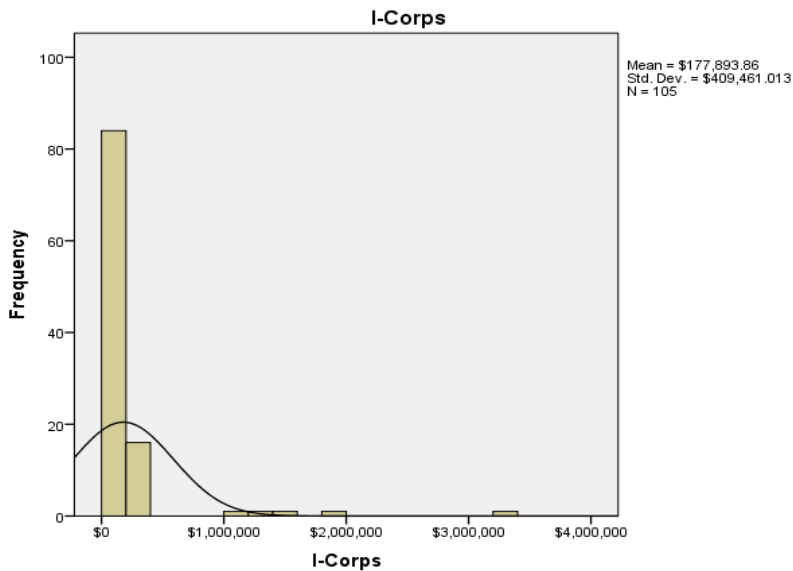


Figure 1: NSF expenditure on I-Corps by university

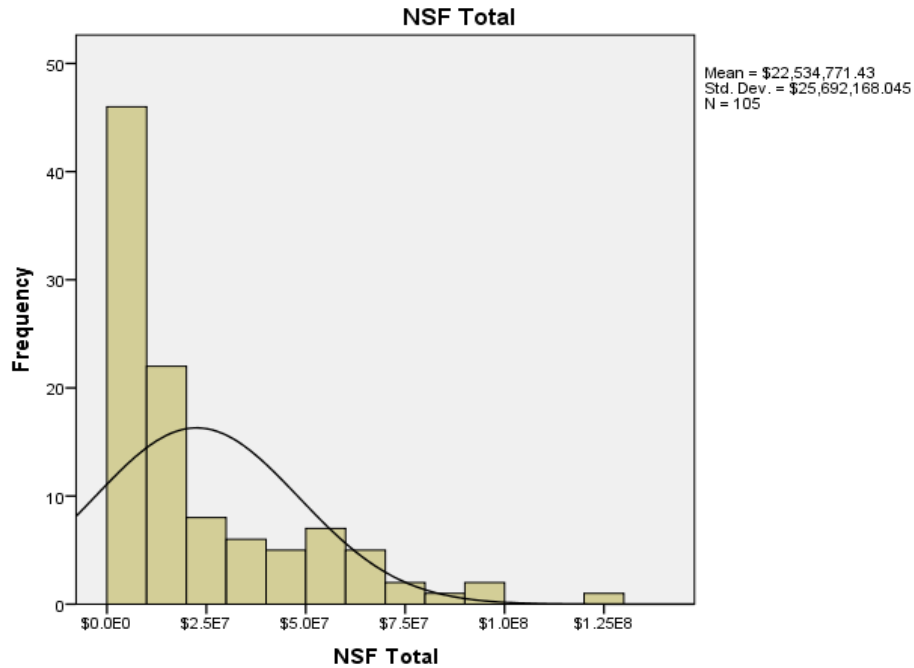


Figure 2: NSF total expenditure on research by university

Correlations

		I-Corps	NSF Total
I-Corps	Pearson Correlation	1	.204*
	Sig. (2-tailed)		.037
	N	105	105
NSF Total	Pearson Correlation	.204*	1
	Sig. (2-tailed)	.037	
	N	105	105

*. Correlation is significant at the 0.05 level (2-tailed).

Figure 3: Pearson correlation of NSF expenditure on I-Corps and total research expenditure by university

Discussion

An interpretation of the statistical results may imply that not all universities with high amount of NSF funding for traditional research have been able to receive high funding through I-Corps program. Some of the reasons may include:

- a) Universities with high amount of NSF funding may not need to focus specifically on the commercialization of technology.

- b) Universities with high amount of NSF funding have other sources of technology commercialization apart from I-Corps.
- c) Universities with high amount of NSF funding may have applied for increased I-Corps funding but their existing technology commercialization efforts were insufficient.

ASEE I-Corps for Learning may explore and investigate why an increase in NSF funding has not led to a simultaneous increase in I-Corps funding for top NSF funded institutions. This points towards a grave danger for the future of traditional research as most-funded research institutions struggle to match NSF funding with Technology Commercialization efforts. American manufacturing firms have been criticized for not embracing this change and assuming “if agile was only meant for software startups”. Denning¹⁵ noted this lack of commercialization efforts lead to the complete annihilation of the industry. Highly-funded research institutions may be on a similar path as US manufacturing industry.

GE tried to mitigate the risks in technology commercialization approach with internal initiatives-Simplification and Fastworks¹⁶. To match up with emerging concepts of lean startup and agile development, GE hired lean launchpad coaches Eric Ries and David Kidder to change the discussion from “can this product be built?” to “should this product be built? We proposed that large universities heavily funded for fundamental scientific research by NSF could bring in experts from ASEE I-Corps for Learning community to shift the conversation from “can this research be done?” to “should this research be done?”

Conclusions

Bimodal transformation of universities involves existing known research parameters such as research for basic science represented by mode 1 while introducing new paradigms of unknown innovations and commercialization of technology represented by mode 2. While extensive literature is available on the definition of Bimodal transformation and benefits of technology commercialization for universities, the authors did not find any research that links the two concepts. Through the current research the authors also attempt to test the hypothesis that there exists a positive correlation between mode 1 and mode 2.

While there are studies that provide anecdotal evidence to investigate the potential of I-Corps model for fostering an entrepreneurial mindset within education community, our approach provides a data-driven objective method to evaluate the research question. A weak yet positive correlation between funding for I-Corps and NSF funding for research is observed. The research suffers from a limitation due to the availability of only 105 data points for comparison of I-Corps and NSF funding for the same university or research institution.

Future studies may include parameters such as number of patents filed, expenditure on basic research and number of doctorates awarded for mode 1. For mode 2, a relevant data metric may include number of startups from a university, expenditure on applied research and revenue from technology commercialization.

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