NBER Innovation Policy Grant Proposal

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Title: The U.S. Scientific War Effort of World War II and its Enduring Effects on U.S. Innovation and Innovation Policy

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"Although its part in the winning of the war was its greatest contribution … the full impact of its work must await the judgment of the future…" (Irvin Stewart, Secretary of the OSRD)

Description. World War II was a momentous time in U.S. science, perhaps unrivaled by any other. In preparation for war, President Roosevelt authorized the formation of the National Defense Research Committee (NDRC) in 1940, later expanded into the Office of Scientific Research and Development (OSRD), and appointed Vannevar Bush its director, who effectively served as the first national science advisor and lay the groundwork for Federal support for science, which he documented in the seminal report *Science: The Endless Frontier* (Bush 1945). The OSRD was responsible for managing the U.S. scientific war effort, which encompassed a wide range of subject matter, including but not limited to weapons development, jet propulsion, communications, electrical engineering, applied mathematics, optics, chemistry, medicine, and – notoriously – atomic fission. Over the course of the war, the OSRD entered into roughly 2,500 R&D contracts with industrial and academic contractors, with a cumulative value of over $560 million at the time, equivalent to *$7.4 billion* in today's dollars.

This project will study multiple dimensions of the scientific war effort that offer lessons for innovation policy today. At the moment, there are three questions I seek to answer, each of which I believe is big enough to be its own paper: (1) How did military investments in science influence the rate and direction of U.S. innovation? I would especially like to evaluate to what extent the OSRD breathed life into new fields of science and invention and spawned years of follow-on innovation. (2) How important are intellectual property rights in government R&D contracts? (3) How was the wartime experience of the OSRD translated into a framework for science policy following its decommission?

Data. At the heart of this project is a dataset of the universe of OSRD contracts, which are preserved at the National Archives (NARA) in College Park, MD. Over the course of several visits to NARA in the last 8 months, I have collected scans which give a complete record of OSRD contracts, and – for all but the still-classified atomic fission project – the inventions developed under these contracts and the patent applications filed on these inventions. These records can be used to link individual contracts to inventions and to patents on these inventions, which I can in turn link to USPTO patent classes, to identify the areas where the OSRD was active and how much it invested in each.

The contract-level data also include the patent clause of each contract. Over the course of the war, the OSRD experimented with two patent clauses, one giving the contractor first-rights to patent inventions developed under contract ("Long form"), and one giving the government first-rights ("Short form") – effectively putting inventions in the public domain, since the government does not typically enforce its patents. These clauses are still in use (U.S. FAR 2015), and there remains an active debate over whether the fruits of government-funded research should be public property.

The NARA collection also includes narrative records (mainly correspondence) which provide detailed insight into internal policy debates at the OSRD which set many precedents for national science policy. Immediately after the war, Bush proposed the creation of a "National Research Foundation" to "promote research through contracts or grants to organizations outside the Federal Government" (Bush 1945). The NSF was accordingly established by legislation in 1950 as an agency that looks and operates like, and fundamentally remains, a peacetime version of the OSRD.

Research Plan. To address the first question, I plan to (i) compare post-war patenting in patent classes that received different degrees of OSRD research investment, (ii) compare forward citations of OSRD-funded patents against non-funded patents within the same class, and (iii) compare backward citations of OSRD-funded patents to non-funded patents in the same class. The first exercise will shed light on how OSRD investments shaped the direction of post-war innovation. The second exercise will evaluate the amount of innovation that directly built on OSRD-funded inventions. This is a distinct test: whereas the goal of the first exercise is to determine whether OSRD investments caused entire fields of science to take off, the second exercise asks whether inventions created under OSRD research directly generated more follow-on than others in the same technological class. The third exercise explores to what degree OSRD research was breaking new ground versus building on prior art (e.g., repurposing).

To study the second question of how the patent clause affects R&D contract outcomes, I plan to compare the inventive output of short- and long-form contracts: inventions disclosed, patents filed, patents granted, and forward citations. While patent clauses were not randomly assigned – the OSRD typically used the short-form clause for academic contractors, medical research, and classified projects, and the long-form with industrial contractors – there is within-subject matter, within-contractor, and occasionally within-contract variation that can be used to make more appropriate comparisons. I also intend to exploit variation over time in the OSRD's tendency to (i) use each clause, and (ii) exercise its rights to patent short-form inventions, as a source of variation in (i) the patent clause itself and (ii) the contractor's likelihood of having a residual claim. Narrative records suggest that these tendencies varied over the course of the war, as the OSRD developed its patent policy.

The third question will most likely result in an essay rather than an empirical paper, but I think it would be valuable to connect modern science policy to its wartime roots. There are three things I would like to draw out: (i) what features of modern policy were developed during the war, and how they came about, (ii) whether any features are the result of accident and path dependence, and (iii) how much of the OSRD internal policy debate is still unresolved today. This work would build on previous essays by historians of science but add more depth from primary source material. My current intention here is that this could be academic in nature, but accessible to a general/non-technical audience.

How the grant will be used. I intend to use the grant to hire contract labor and/or research assistance. I recently had the focal records transcribed, and I would like to use RAs to (i) review and make corrections to the transcriptions; (ii) link OSRD inventions to patents, using the title, inventors, and application serial numbers on the OSRD invention disclosure forms; (iii) collect data on citations of and to OSRD-funded patents and, if possible, of and to other (non-OSRD) patents; (iv) clean/organize the data into operational datasets; and (v) conduct some preliminary analysis.

I expect data collection for this project to be a lengthy but relatively straightforward process which will yield intellectual returns that are many multiples of the cost.

References:

▪ Bush, 1945. "Science: The Endless Frontier." A Report to the President by Vannevar Bush, Director of the Office of Scientific Research and Development. ▪ Stewart, 1949. "Organizing Scientific Research for War: The Administrative History of the Office of Scientific Research and Development." ▪ U.S. Federal Acquisition Regulations (FAR), accessed 2015. Subsections 52.227-11 and 52.227-13.

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Academic Employment

Starting 2016 **Harvard Business School, Boston, MA**
Assistant Professor

2015 - 2016 **National Bureau of Economic Research, Cambridge, MA**
and **Harvard Business School, Boston, MA**
Post-doctoral Fellow

Education

2015 **University of California–Berkeley, Berkeley, CA**
Ph.D. in Economics
Committee: Ben Handel (chair), Barry Eichengreen, John Morgan, Steve Tadelis

2008 **Tufts University, Medford, MA**
B.A. in Mathematics and Economics

Fields of Interest Economics of Innovation; Contracts, Incentives, and Organizations; Economic History and the History of Technology

Working Papers

Creativity Under Fire: The Effects of Competition on Creative Production (submitted)

Performance Feedback in Competitive Product Development
(revise & resubmit at *The Rand Journal of Economics*)

Scale versus Scope in the Diffusion of New Technology (submitted)

Railroad Gauge Standards and Internal Trade in the 19th Century U.S.

Work in Progress

Based on a dataset of the universe of WW2 Government R&D Contracts:
The Effects of Military R&D on Nascent Technology: Evidence from WW2
Patenting Rights, Incentives, and R&D Contract Performance
Vannevar Bush, the OSRD, and the Origins of U.S. Science Policy

Acquired Knowledge: The Effects of the Post-War Expropriation of the German Scientific Apparatus on U.S. Invention

Peer Effects in the Production of Ideas: Evidence from Classical Music
(with Karol Jan Borowiecki)

Teaching Experience

University of California, Berkeley (2012, 2014)
Undergraduate Econometrics (x2)

Fellowships, Grants, and Awards

2015	UC Berkeley Competition Policy Center Dissertation Prize
2015	UC Berkeley Outstanding Graduate Student Instructor award
2014	Economic History Association Graduate Fellowship
2013	All-UC Economic History Group Research Grant
2012-2013	Berkeley Economic History Lab Research Grant (x2)
2011-2015	National Science Foundation Graduate Research Fellowship
2010-2014	University of California Regent's Intern Fellowship
2004	National Merit Scholar, Robert C. Byrd Scholar

Presentations

2016-2017	*Scheduled:* Harvard University (Econ), LMU-Munich, INFORMS
2015-2016	FRB New York, CEPR Workshop on Incentives, Management and Organisation, INFORMS, Bates White, Federal Trade Commission; Haverford College, Queen's University, Yale University, MIT Org Econ Lunch; *Scheduled:* Georgetown Railroad Economics Colloquium
2014-2015	UC Berkeley (Econ/Haas), Microsoft Research, Carnegie Mellon (SDS), Columbia Business School, Harvard Business School, Rensselaer Polytechnic Institute, Washington University in St. Louis (Olin), Federal Reserve Board, Indiana University (Kelley), Northwestern University (Kellogg), University of Chicago (Booth), University of Toronto (Rotman/Mississauga)
2013-2014	NBER Summer Institute (DAE poster session), All-UC Hundred Flowers Conference

Other Information:

Affiliations:	American Economic Association
	Economic History Association
Languages:	English (native), Spanish (fluent)
Citizenship:	United States

Assorted Interests:

Classical piano; Colombia (South America); outdoor sports