RIETI-NISTEP Policy Symposium

Open Innovation as a Key Driver of Japan's Industrial Competitiveness

Handout

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Open Innovation and Entrepreneurial Strategy: Lessons for Policymakers

Scott Stern, MIT& NBER

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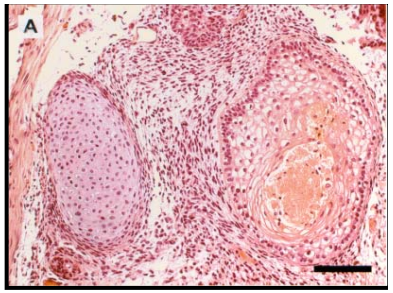
Does Open Innovation Policy Matter? YES!



- In conjunction with co-authors and students, we have undertaken a systematic research program aimed at establishing the *causal* linkage between open-access institutions and follow-on scientific progress and innovation
  - A "Natural Experiments" approach to evaluate the impact of open innovation policies
  - Studies cover diverse settings, including biological resource centers, mouse genetics (JAX), the Human Genome Project, gold mining, etc
- An accumulating body of striking evidence for the impact of open-access institutions and policies enhancing the rate and expanding the scope of follow-on scientific research as well as commercialization of new technologies
- Implies a considerable benefit to the development of *formal* institutions and policies ensuring independent and low-cost access to tools and data to the scientific community and downstream innovators

How do scientists "stand on the shoulders of giants"?

- Long-term economic growth depends on the ability to draw upon an ever-wider body of scientific & technical knowledge (Rosenberg, Mokyr, Romer, Aghion & Howitt, David & Dasgupta)
- Economic historians, institutional economists, and sociologists emphasize the role of "institutions"
  - however, the micro-foundations of knowledge accumulation are, by and large, still a "black box"
  - many challenges to assessing impact of institutions
    - knowledge flows are difficult to track
    - institutions are difficult to identify & characterize
    - knowledge is assigned endogenously (not randomly) to institutional environments

Overall Research Agenda

- **The Micro-Economics of the Scientific Commons**
  - How do open access institutions and policies that support a "scientific commons" contribute to the accumulation of knowledge and scientific research productivity?
  - Under what conditions do researchers (and their funders) have appropriate incentives to contribute to an open-access scientific commons, and what role do institutions and policy play in that process?

- **A Natural Experiments Approach**
  - Exploit (exogenous) changes in institutions governing knowledge generation and diffusion
  - Helps address the "identification problem"
  - Allows us to evaluate the role of institutions on the overall use and nature of follow-on research

The Economics of "Standing on Shoulders"

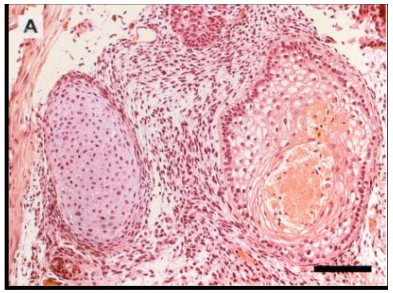
- *Standing on Shoulders* is a key requirement for sustained research productivity, and scientific and technical progress
  - If the knowledge stock does not expand or cannot be accessed, diminishing returns will eventually arise
- The production of knowledge does *not* guarantee its accessibility
  - Knowledge transfer is usually costly (e.g., tacitness, stickiness)
  - Strategic secrecy further limits the available knowledge pool
  - Even if available in principle, relevant calculation is the cost of drawing from the knowledge stock versus "reinventing the wheel"
- Individual incentives to contribute to institutions supporting cumulative knowledge production are limited
  - Direct control rights over a material can allow researchers (or IP rights holders) to hold-up future scientific progress, particularly when downstream applications arise

Getting the Incentives Right

- Establishing a knowledge hub (a scientific commons) within a technical community involves a collection action problem
  - Private incentives are *too low*
  - Role for public funding / cooperation among competitors

- Even if funded, the incentives to participate as a depositor may be too low without explicit norms (or policy!)

The Impact of Biological Resource Centers (with J. Furman), *AER*



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JAPAN COLLECTION OF MICROORGANISMS

BRCs as Economic Institutions

- **Authentication --** The fidelity of discovered knowledge cannot be guaranteed by the initial discoverer but must be able to be replicated
  - **The HeLa Scandals**
- **Long-Term Preservation --** The importance of a given piece of knowledge (and physical materials exploit that knowledge) are often only recognized long after initial discovery
  - **Brock's Unlikely Bacteria (Taq)**
- **Independent Access --** Substantial gap between private and social benefits of providing independent access to data and materials
  - **Gallo and the HIV Virus**

BRCs as Economic Institutions

- From an economic perspective, the establishment of BRCs is subject to an important public goods problem, and effective biomaterials policy requires appropriate incentives and policies to ensure independent and low-cost access to follow-on researchers
- BRCs appear to possess characteristics that suppport the acceleration of knowledge generation and diffusion relative to alternative institutions

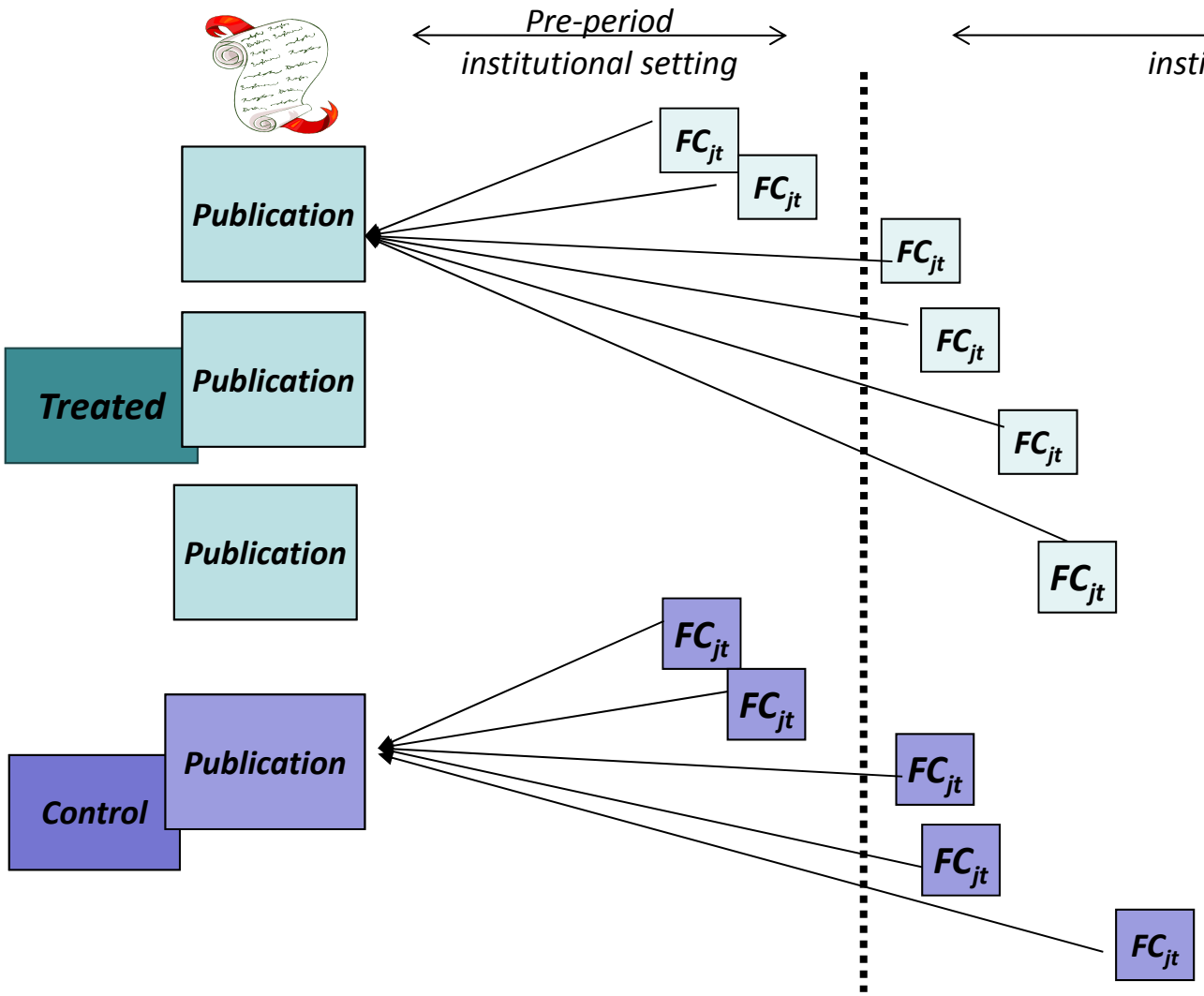
✪ ***But, do BRCs actually enhance the diffusion of scientific knowledge? How?***

Empirical Approach: A "Natural Experiments" Approach to Scientific Knowledge Diffusion

1. BRC Deposits are linked with specific scientific research articles or patents (referred to as "BRC-linked" articles)
2. Each BRC-linked article can be matched w/ article controls
3. Some BRC deposits occur long after initial publication
   - even many years after discovery, control over "refrigerators" can be transferred from specific research labs to BRCs
4. Some post-publication deposits are arguably exogenous
   - e.g., ***special collections*** *"shifted" due to* funding expiration at initial host institutions, faculty retirement, or faculty job change resulting in change in location of "refrigerator"

✪ *Allows us to observe variation in the impact of a single "piece" of knowledge across two distinct institutional environments*

Empirical Framework: Diffs-in-diffs analysis of citations received



Exogenous SHIFT
Measure citations before & after to estimate impact of treatment on treated "diffs-in-diffs" approach

Plot forward citations over time as a measure of scientific knowledge accumulation building on a "piece of knowledge"

How does the rate of citation of a scientific article change after the materials association with that article have been deposited in a culture collection?

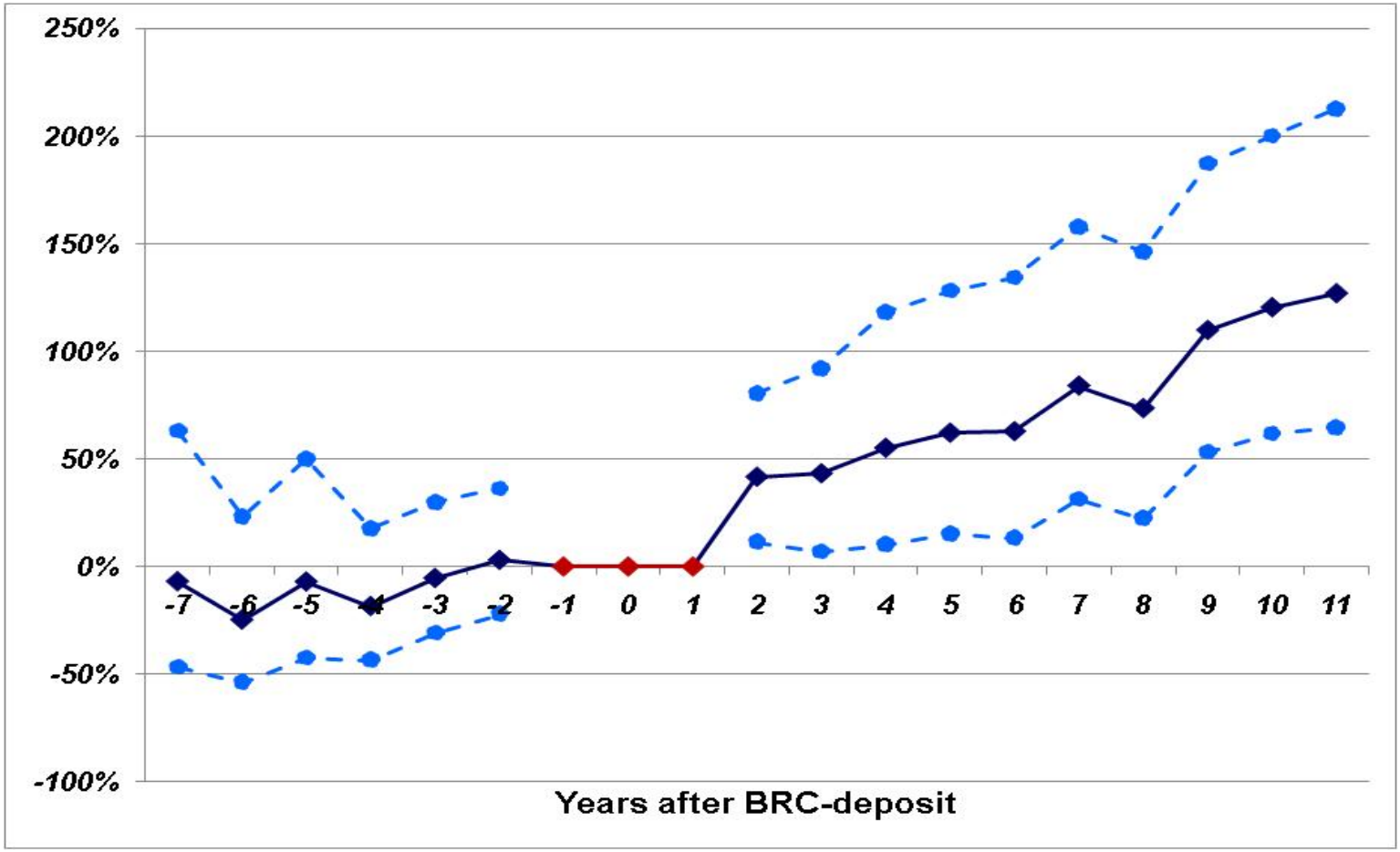
Does BRC deposit matter for follow-on scientific research?

Negative Binomial Models	***Forward Citations***
	(3-4) *Marginal Effects only*
BRC-Article,Post-Deposit (Marginal)	***[2.248] 0.810 (0.360)***
Article FE	***X***
Age FE	***X***
Calendar Year FE	***X***

122 % Boost After Deposit

•Data is based on 289 items from ATCC "special collections" each of Which is linked to citing article, and citations are measured using ISI Web of Science. Control articles are based on "related articles"
Cond FE Neg. Bin. Models, coefficients as IRRs; bootstrapped SEs

Impact of Deposit Grows Over Time and Does Not Exist Prior to Deposit



- This suggests that deposit is, indeed, exogenous and that diffs-in-diffs approach usefully identifies marginal (post-deposit) effects
- Conditional FE NB model

How do BRCs enhance research impact?

- Consistent with the certification role of BRCs, the citation boost from BRC deposit is higher for articles that are initially published in a non-top-tier journal, with lead authors at less highly ranked universities, and for articles with more complex subject matter
- Consistent with the role of BRCs in offering independent access and scale economies, BRC boost is associated with an expansion in the number of distinct institutions citing an article, the number of journals an article is cited in, and the geographic reach of citations.
- Not simply a matter of a "mechanical" change in citation patterns, the boost associated with BRC deposit seems to enhance the citation of related articles by the same authors
- Results robust to a variety of controls and alternative specs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Onco transgenic mouse technology

Cre-lox mouse technology

Of Mice and Academics: The Impact of Openness on Innovation (with Aghion, Dewatripont, Kolev and Murray), AEJ: Policy, forthcoming

A tale of three (blind, obese, diabetic, epileptic…) mice engineering technologies….

…setting to explore impact of changes (negotiated by NIH) that allowed for both greater formal access (via JAX) and lower IP restrictions

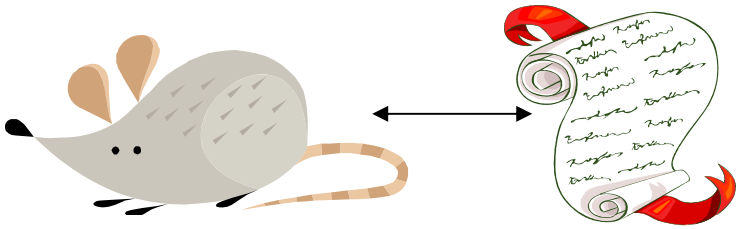
Knock-out mouse technology

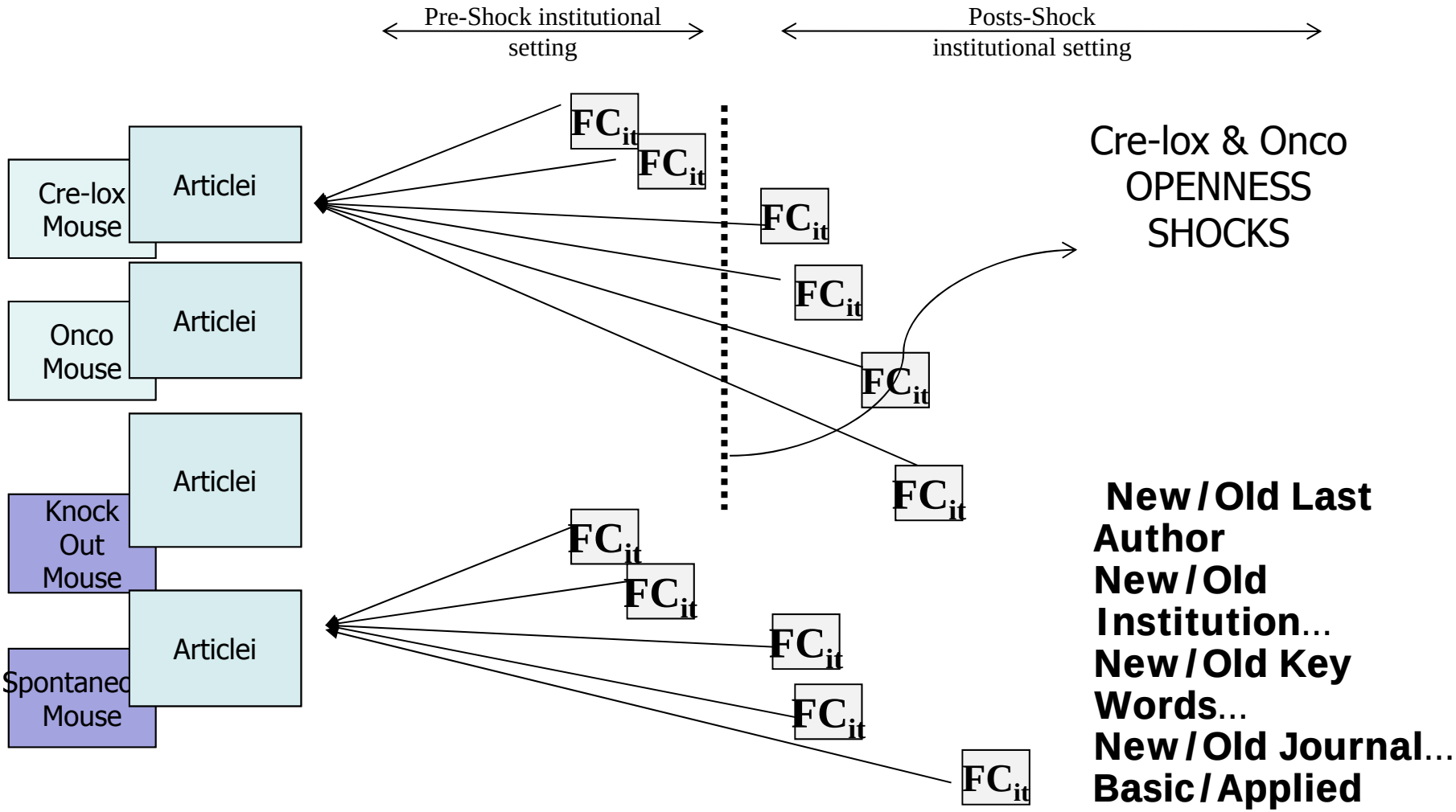
The Experiment: Treatment and Control Groups

	Technology	Shock	Pre-Shock Openness	Post-Shock Openness
Cre-lox Mice	Developed by DuPont -tool to engineer mice with target gene "on or off" in specific tissue (Sauer et al. 1987)	**NIH Cre-lox MoU 1998**	DuPont's IP covered any mouse made using Cre-lox. • Cre-lox mice not shared without costly license. • No JAX distribution	Cre-lox mice available for all researchers at non-profit institutions for internal research • JAX make mice available & manage simple licenses
Onco Mice	Developed at Harvard – transgenic tools to insert an oncogene (Stewart et al. 1987)	**NIH Onco MoU 1999**	Harvard's IP covered any mouse made using transgenic oncogenes. • Onco mice not shared without costly license. • JAX distribution permitted	Onco mice available for all researchers at non-profit institutions for internal research •JAX make mice available & manage simple licenses
Knockout Mice	Developed by Capecchi - "knock-out" methods allow for gene to be deleted (Thomas & Capecchi 1987)	**NONE**	• Capecchi patent on "knockout" methods but no IP claims made on scientists. • < 50 patents on specific "knockout" mice (all post 1999). • Mice available via JAX	NONE DIRECTLY
Spontaneous Mice	First developed by Castle at Harvard – mice selected &	**NONE**	• No IP limiting openness • Mice available via JAX	NONE

EMPIRICAL APPROACH

Estimating Annual Forward Citations to each Mouse-Article





Analysis: Effectiveness of Formal Institutions for Changing Access to Research Mice

Neg. Binomial	Last Authors		Key Words	
	Annual Citations with New Last Author	**Annual Citations with Old Last Author**	**Annual Citations with New keywords**	**Annual Citations with Old keywords**
Post Shock	**1.380*** **	1.14	**1.260*** **	0.977
Conditional Fixed Effects for Article, Margin-Age and Margin-Calendar Year, Window Effects				

26% Boost After NIH Agreement formalizes Access & lowers IP

- The impact of institutional change concentrated in citations by "new" last authors and in papers using new key words
- Robust to "New Institution" v."Old Institution", Reprint Authors, Journals etc.

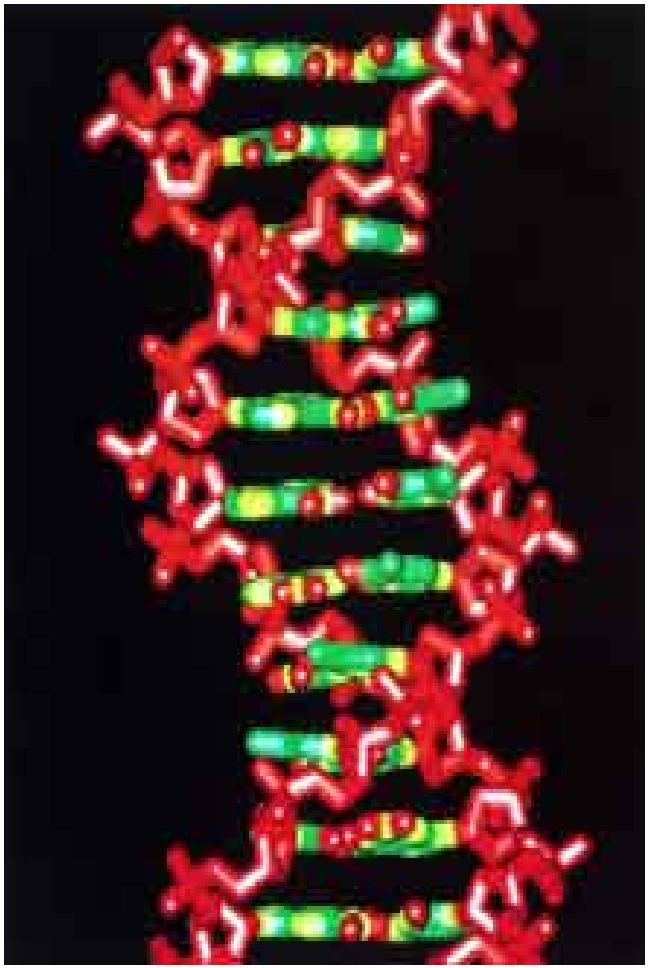
Murray, Aghion et al., 2009

In other words, an increase in openess (and reduced opportunities for hold-up) in mouse genetics resulted in a significant increase in the diversity of new research lines and experimentation exploiting these novel research tools

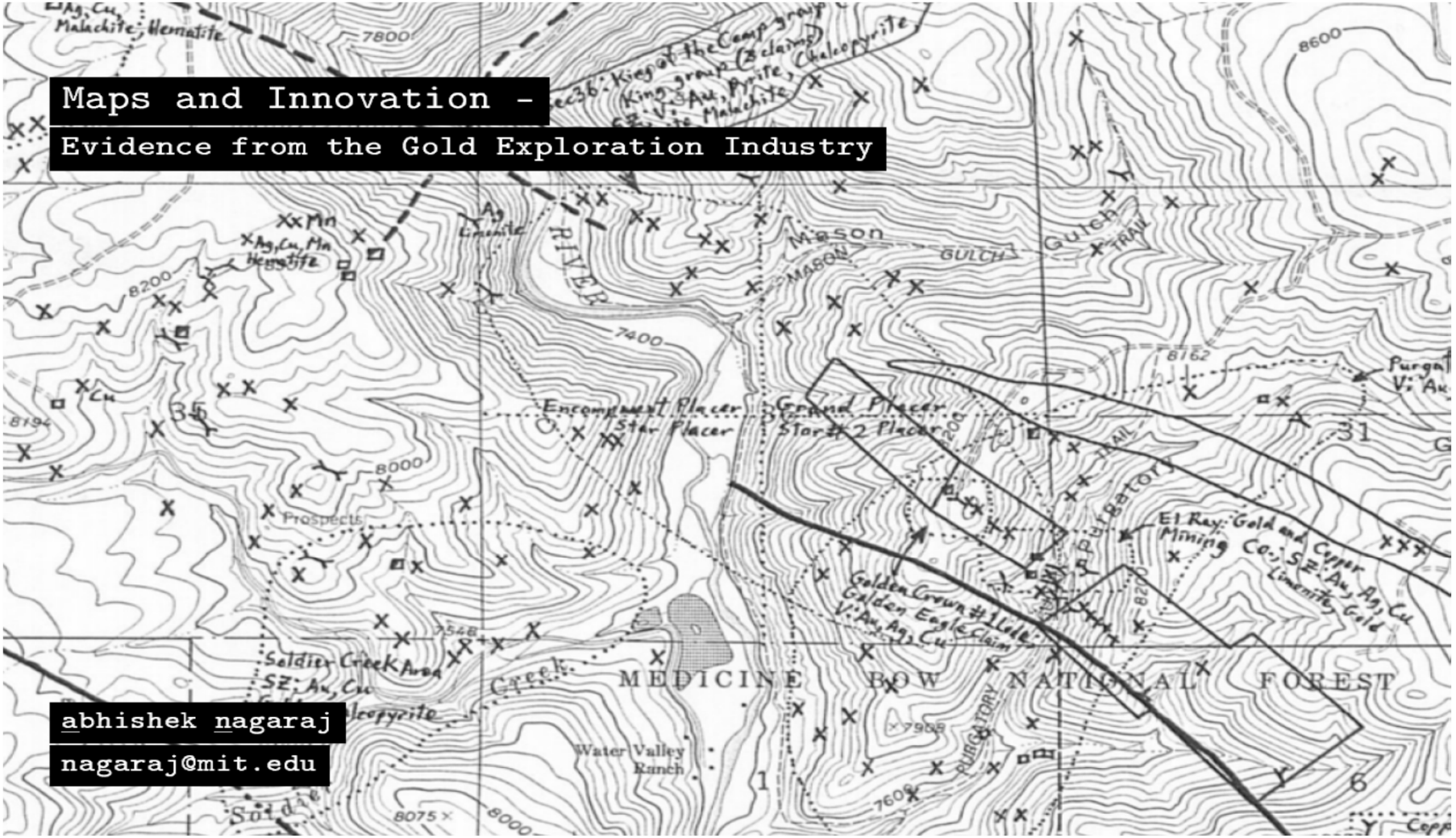
But how do these findings about scientific research "translate" to more downstream outcomes such as commercialization and start-up success?

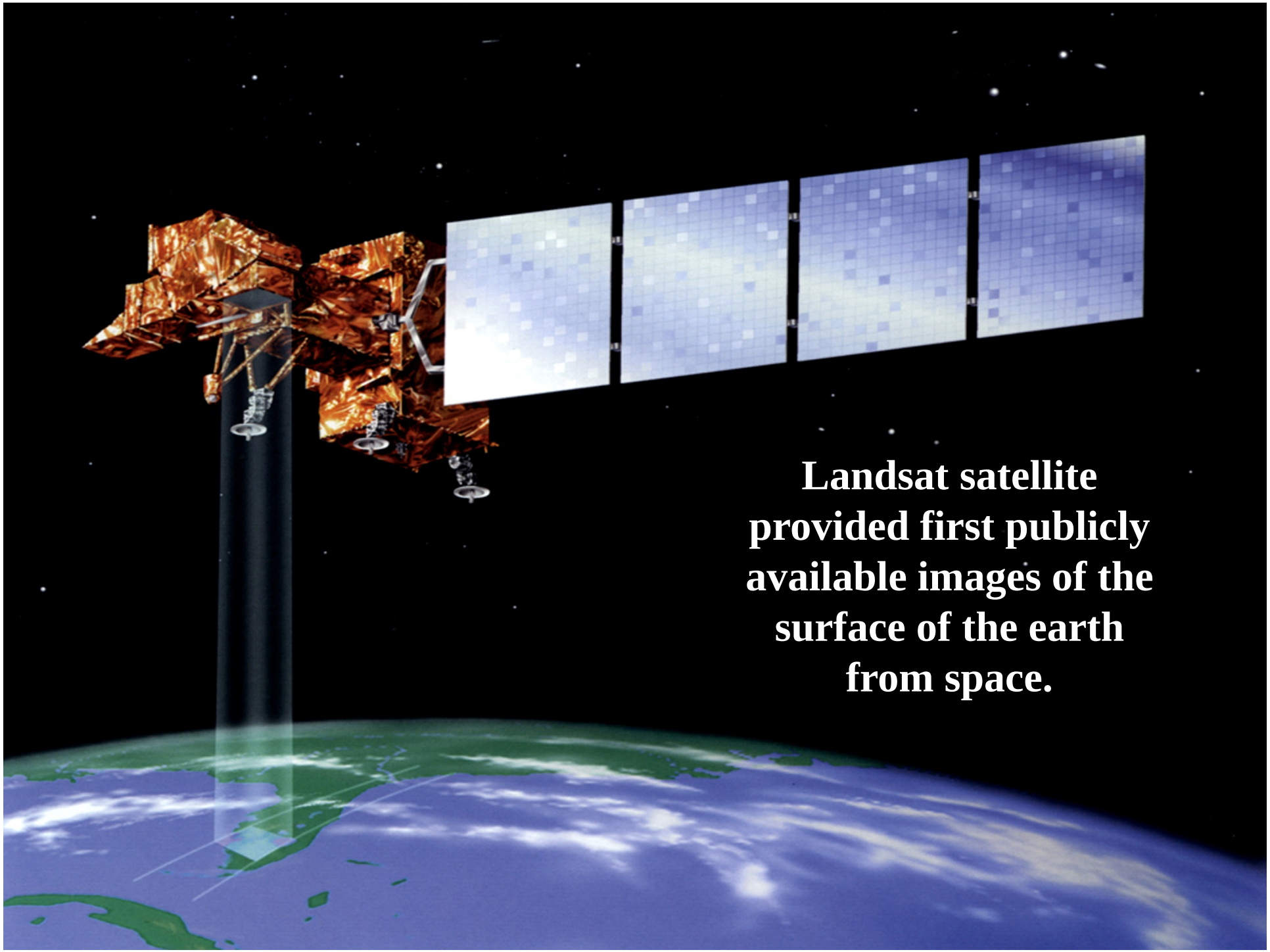
Intellectual Property Rights and Innovation: Evidence from the Human Genome, Heidi Williams, MIT, *JPE, 2012*

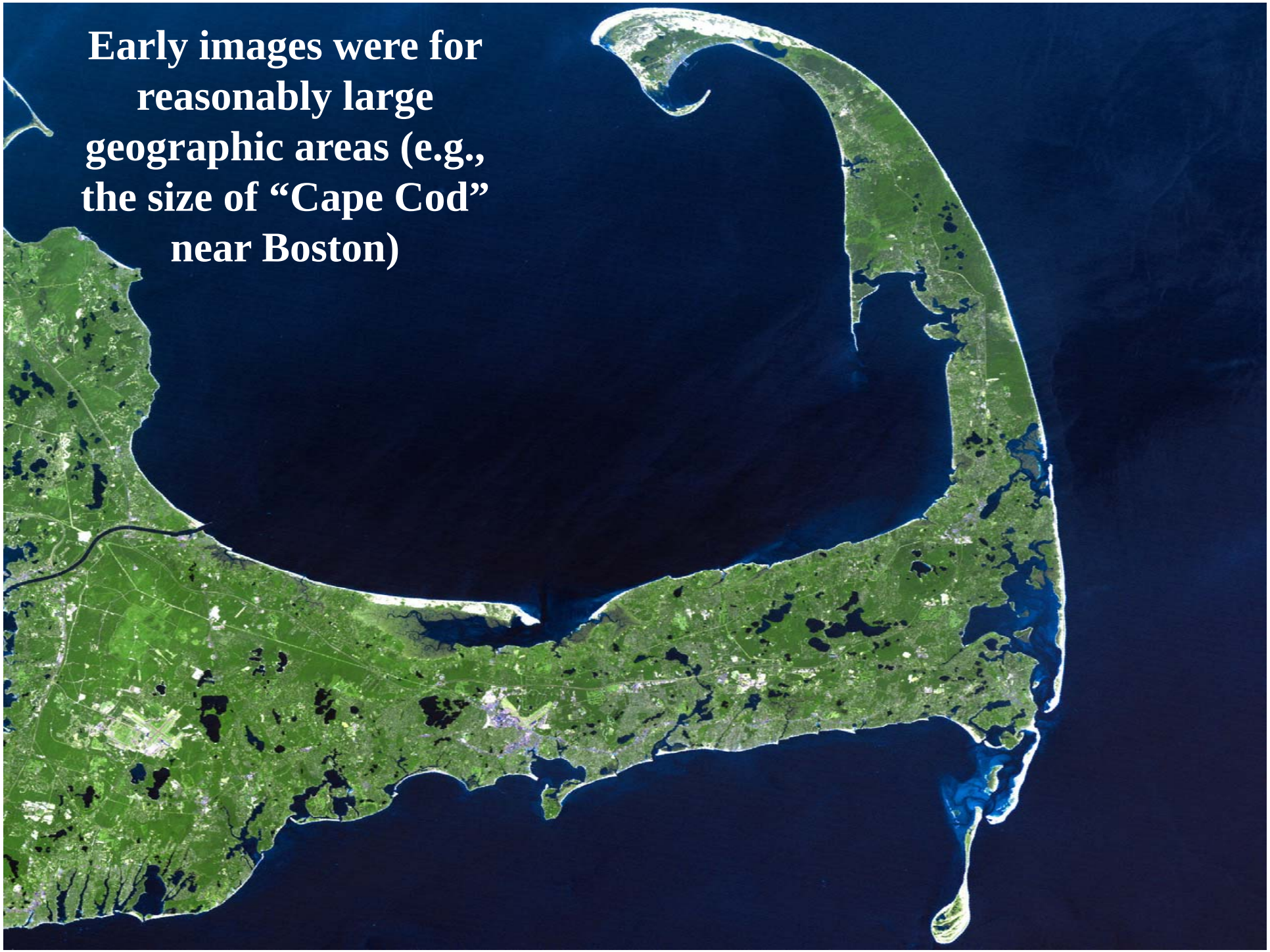
- During the final years of the HGP, competition between HGP and Celera, with *temporary* licensing rights for Celera sequences occuring prior to HGP coverage
  - Only lasted 2 years at most
- Williams examines whether follow-on research on individual genes in the post-HGP era were impacted by Celera IPR claims
- Preliminary results suggest an ~30% reduction in subsequent publications, phenotype-genotype linkages, and diagnostic tests for genes first sequenced by Celera



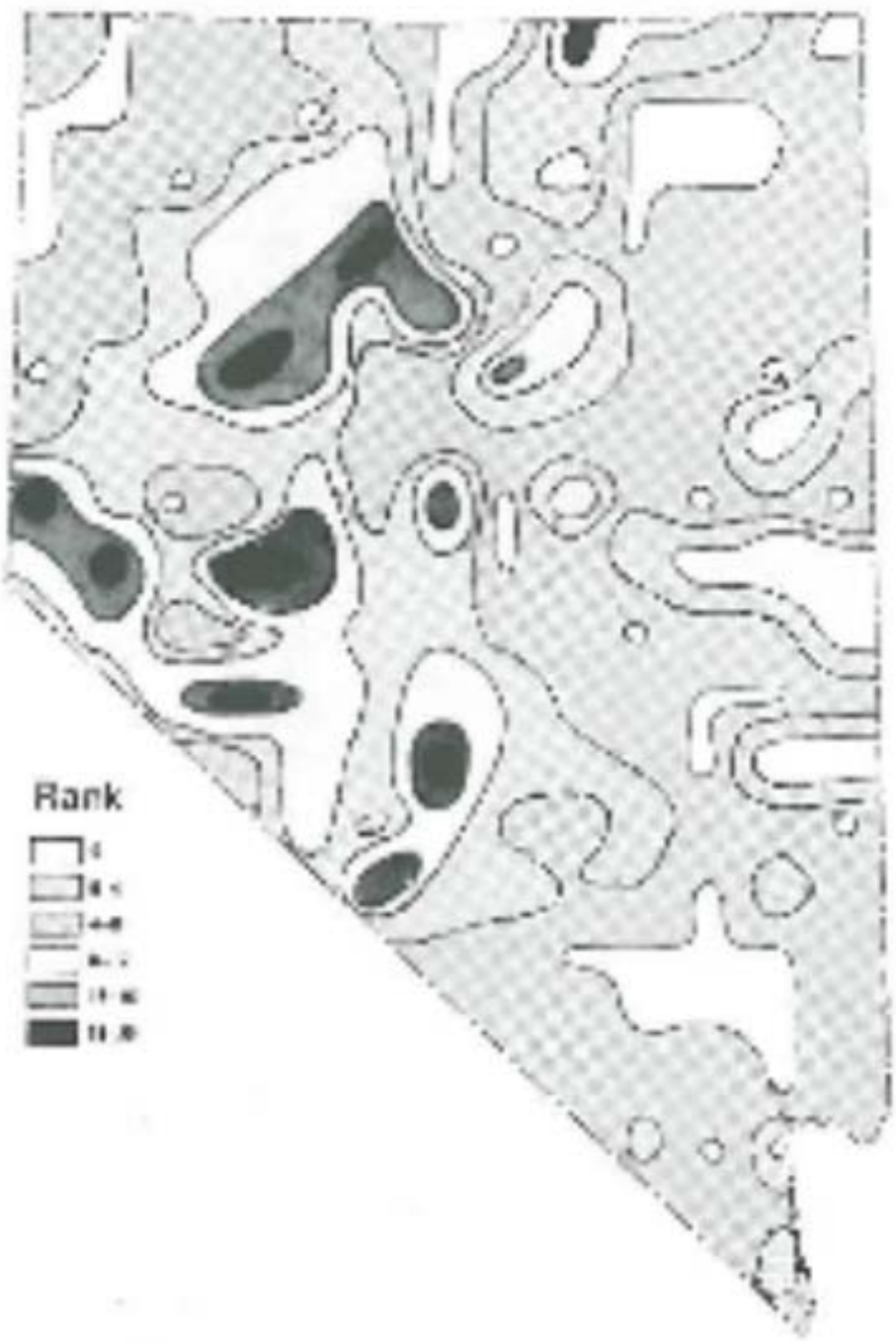
Maps and Innovation: Evidence from the Gold Exploration Industry, Abhishek Nagaraj, MIT Sloan, 2015




Landsat satellite
provided first publicly
available images of the
surface of the earth
from space.


Early images were for reasonably large geographic areas (e.g., the size of “Cape Cod” near Boston)

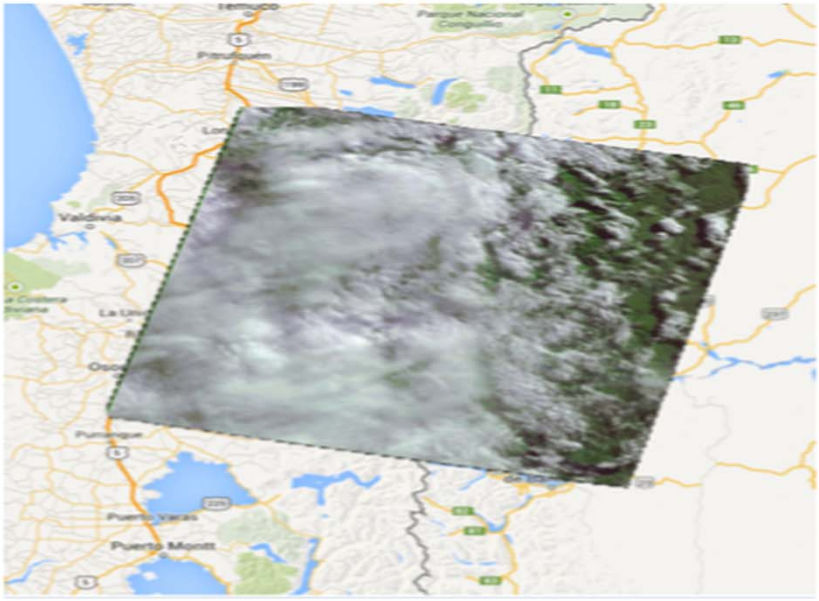
It is possible to use the information from these images to develop a "heatmap" for potential new gold discoveries (and other resources)



How did the availability of "open" maps impact discovery and entrepreneurship in the gold industry?

- Nagaraj takes advantage of the fact that the timing of a "clear" image from the Landsat program had a large random element
  - Wide variation in the date at which photos were taken
  - Clear images depended on "no cloud cover" images

(1) Block 25177, Chile
Cloud free imagery available
Amax Gold Discovery reported in 1980



(2) Block 24988, Chile
No cloud free imagery available by 1983
No discovery reported till date

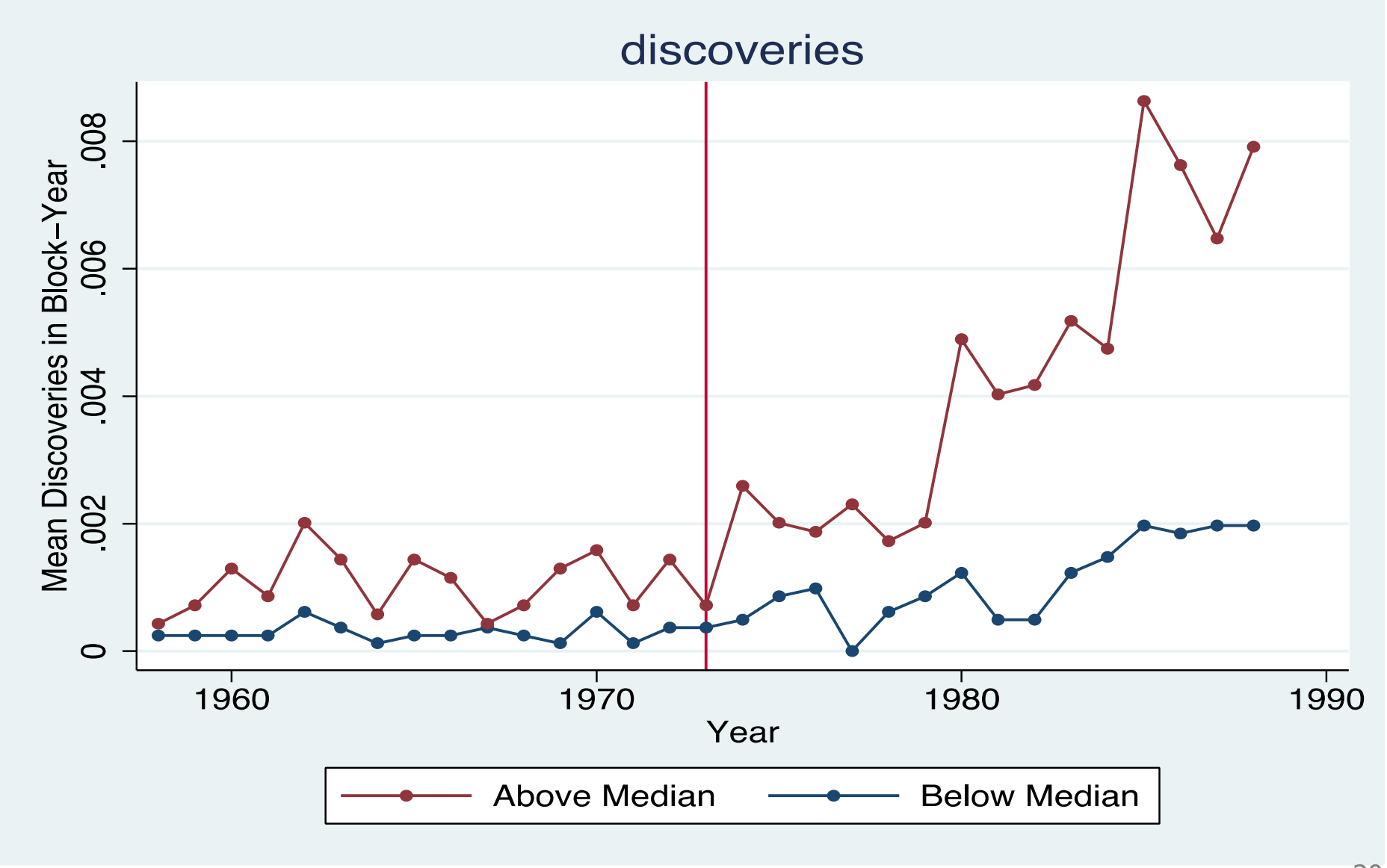
How did the availability of "open" maps impact discovery and entrepreneurship in the gold industry?

- Nagaraj takes advantage of the fact that the timing of a "clear" image from the Landsat program had a large random element
  - Wide variation in the date at which photos were taken
  - Clear images depended on "no cloud cover" images

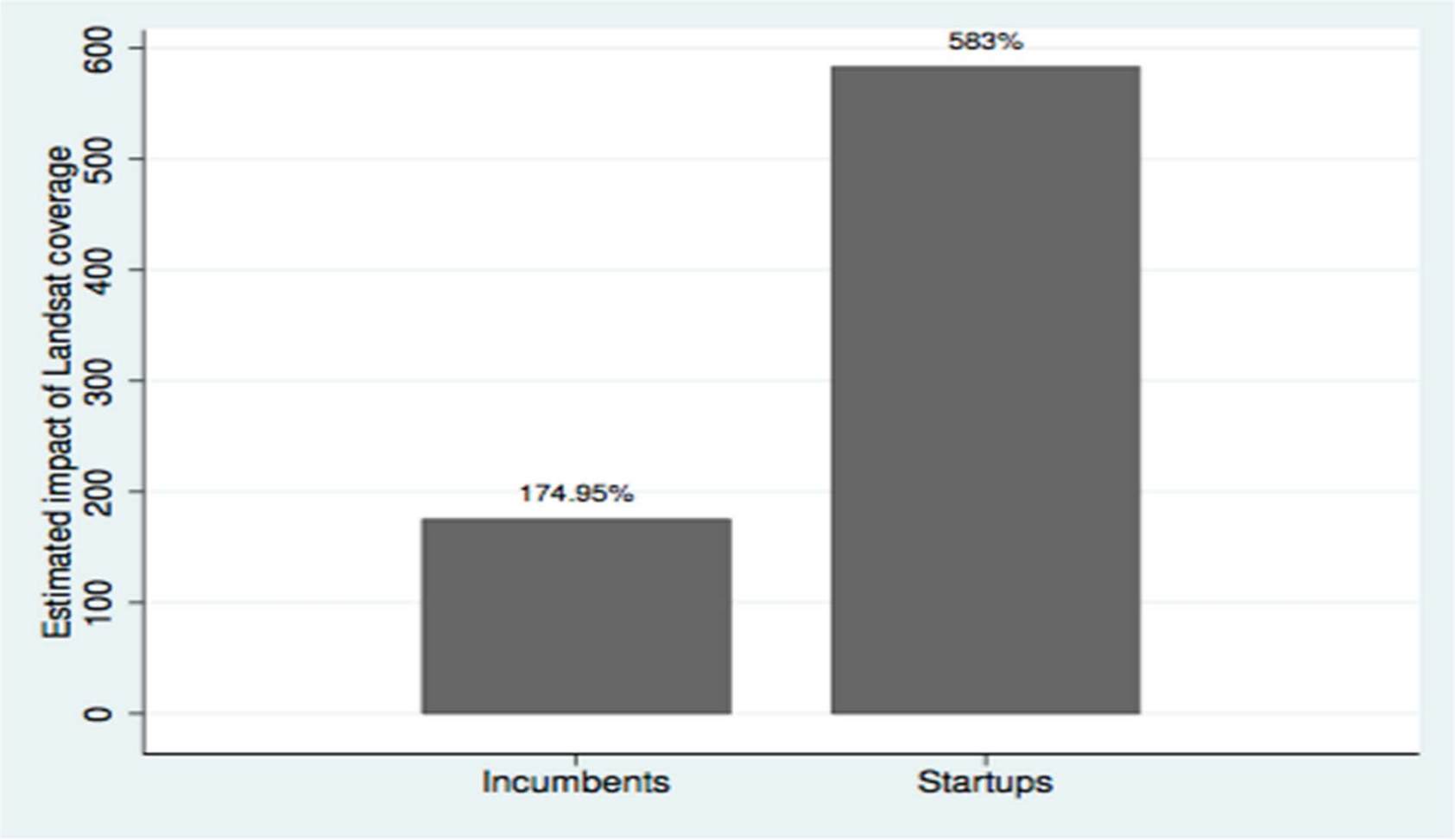
- Nagaraj then compares the rate of gold discovery and mining from locations with access to "open" public images with those where a public image is not yet available

- Explores not only the impact on gold discovery and investment, but on whether these new opportunities are taken advantage of by entrepreneurs (speculators) or established firms (vertically integrated mining firms)

There is a large and persistent difference in the rate of discovery depending on the availability of an open-access map



Entrepreneurs are Far More Likely to Take Advantage of Open Access Maps than Established Firms



Lessons for Policymakers

- An emerging body of evidence that, if incentives and resources can be provided for the development of upstream tools and data, there is a strong policy case for ensuring low-cost and independent access to these tools and data for follow-on innovators
- Not simply an increase in the “level” of innovation, but an increase in more exploratory, more diverse research conducted by a broader research community
- Low-cost independent access tools seem to be particularly beneficial for entrepreneurs, who are particularly able to leverage these tools for innovative follow-in investment and discovery