The Value of Public Satellite Imagery for Climate Change Research and Deforestation: Evidence from the Landsat Commercialization Act of 1984

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Abstract

What is the economic value of publicly-provided satellite imagery? We evaluate this question by estimating the impact of the commercialization of Landsat data between 1985-1994 on climate-change research, and then tracing out the impact of this research on changes in deforestation activity at a global scale. Rather than rely on theoretical models of the value of information, we adopt an empirical and quasi-experimental approach, where we establish a causal link between the lack of low-cost Landsat imagery on climate-change research (esp. deforestation studies) and realized increases in forest cover. Specifically, we exploit block-level gaps in Landsat coverage driven by lack of data collection and cloud-coverage in numerous regions around the world combined with discontinuous changes in the cost of access to Landsat images after the Land Remote-Sensing Commercialization Act of 1984. We match these variations to a novel database that tracks over 100,000 scientific publications that use Landsat imagery (with a special focus on deforestation studies) as well as global 30-m resolution forest cover change data. Our "big data" approach leverages novel machine learning algorithms that detect geographical entities from scientific texts and matches forest cover data to specific Landsat WRS grid-cells. Our preliminary findings hint that the public-provision of Landsat imagery enabled important scientific research in climate-change (esp. around deforestation) and this new, understanding translated into local improvements in forest cover with implications for carbon models. Our work provides some of the first data-driven estimates of the realized value of public Landsat imagery in fueling climate-change research, improving forest cover, with corresponding economic estimates of the value of publicly-provided imagery in dollar terms.

Project Description

What is the economic value of satellite imagery? And what is the value of this information when it is provided for free in the public sector as compared to when it is provided at considerable cost in the private sector? Answering these questions, using comprehensive, empirical data and econometric analyses would help inform credible cost-benefit calculations that are crucial for the public-sector in the allocation of scarce resources of earth observation programs. These questions are even more timely given the real possibility that the privatization of future earth observation systems is under consideration at various levels of the US government and given the rise of an emerging private market in the provision of remotely-sensed data via microsatellite companies.

Unfortunately, providing credible answers to these questions is difficult. The ideal way to answer this question would be to run the following experiment: divide the globe into thousands of equally sized cells and randomly provide satellite imagery to some cells and not others and then trace out the impact of this experiment on meaningful outcome variables of interest. While such an experiment is difficult to run in practice, in this project we propose a research design that helps approximate this ideal closely. We then apply this methodology to studying the longest-serving remote sensing program -- Landsat -- and its impact on the emergence of the field of climate and environmental change research, with a special focus on deforestation studies. Specifically, we exploit block-level gaps in Landsat coverage (Figure 1) driven by lack of data collection and cloud-coverage in numerous regions around the world combined with discontinuous changes in the cost of access to Landsat images after 1985. In addition to data on scientific publications, we use newly emerging high-resolution data on forest gain and loss to estimate the impact of Landsat imagery on reduction in deforestation activity through greater awareness and the implementation of local deforestation abatement policies.

In some preliminary work (as highlighted in Figures 2, 3 and 4) -- we are discovering that free Landsat access matters greatly for environmental and climate change research. Figure 1 shows the “chilling effect” that the privatization of Landsat had on scientific research over thousands of research articles. We have then matched each paper the location they are studying and the location of the authors of the articles. As is evident from Figures 2 and 3, the de-privatization of Landsat after 1992, led to a flowering of research globally and saw the entry of researchers in many different countries in using Landsat information. Figure 4 provides a conceptual framework for our hypothesis. Basically, we argue that the publication of key papers using Landsat information, especially in the developing world, led to awareness about deforestation and consequently policy action and on-the-ground change. A good example is one of the most highly cited papers in this area “*Tropical Deforestation and Habitat Fragmentation in the Amazon: Satellite Data from 1978 to 1988*” (Skole and Tucker, 1993, Science) that highlighted issues around deforestation in the Amazon. Today, it has been recognized that this awareness, made possible by Landsat data made open after the 1990s, enabled the recovery in forest cover in this region observed today. We hope to investigate whether this relationship can be generalized to other regions around the world.

Contribution

Our work makes a number of different contributions to different audiences. We contribute to the economics of science and innovation literature by assessing the relationship between costs of data access and the number of scientific publications and collaborations over time. Our work speaks to how access to data can create new collaborations and change scientific careers. Methodologically we propose a new quasi-experimental framework for assessing the value of remote sensing data. We argue that “all maps are imperfect”, and that these imperfections can be used to study the value of these maps. We explain how imperfections in Landsat coverage help in this regard. We also show how to effectively use machine learning techniques to gather information on the real-world uses of satellite imagery. We contribute to the literature on the economics of satellite data by providing new estimates of the value of Landsat. Finally, we speak to work on deforestation and climate change, by helping uncover the role of free and open remote-sensed information in improving policy over time.

Project Budget:
$20,000

Graduate student support and salary	$10,000
Data collection, cleaning and programming:	$5000
Travel and Conference Support	$5,000
Grand Total	**$20,000**

Figure 1: Illustration of unintentional but varying Landsat coverage over time
(from Goward et. al 2006)

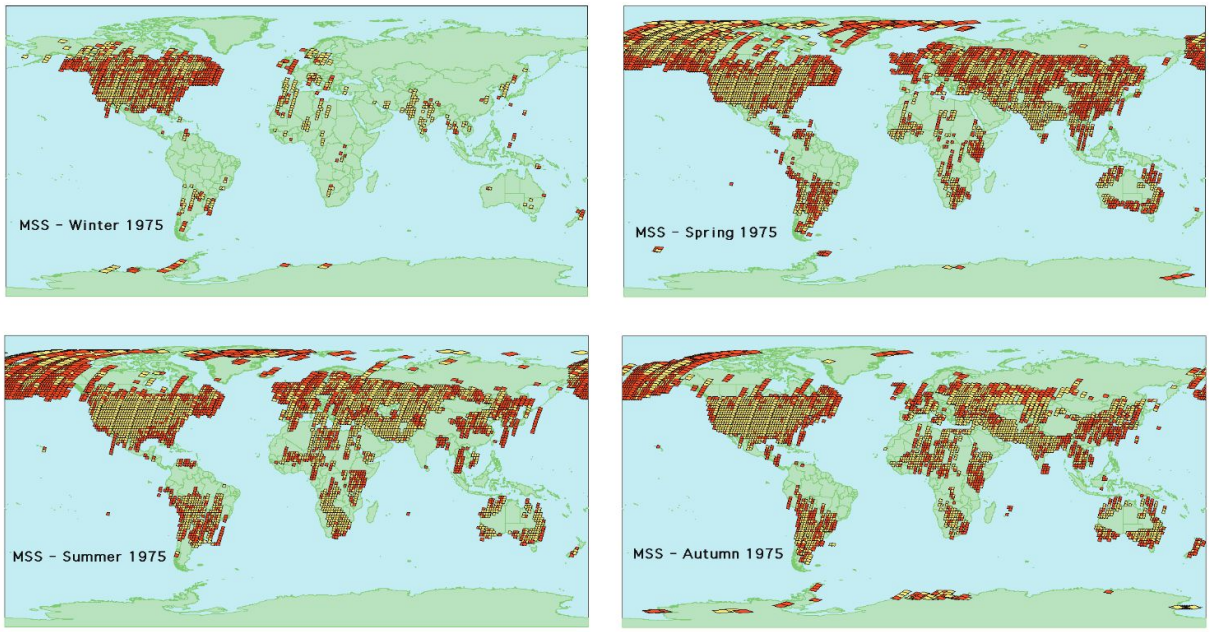


Figure 2: Annual Publications Using Landsat Data Before 2000
(Red bars indicate publications during "privatization" era of 1985-1995)

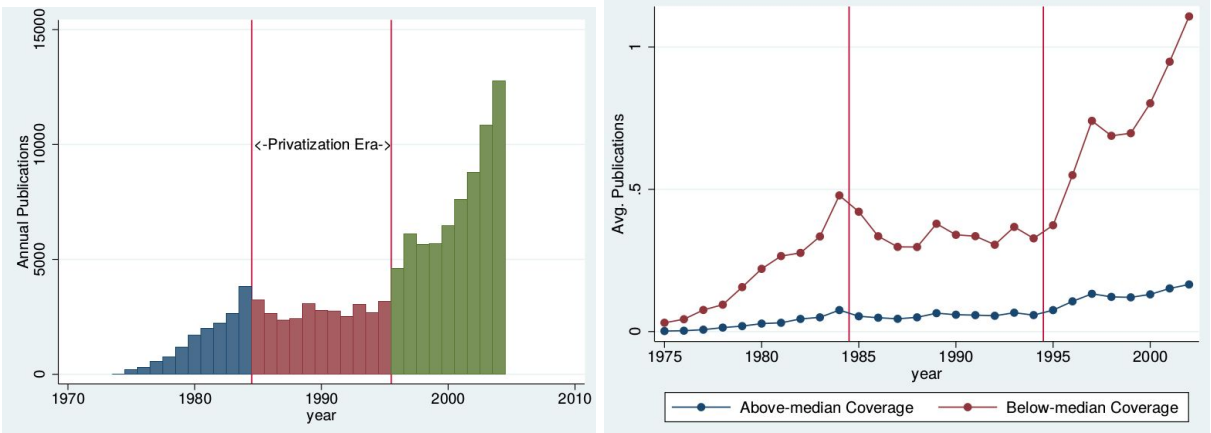


Figure 3: Locations of Climate-Change Research Using Landsat Data

Panel A: Privatization Period (1985-95) *Panel B: Public Period (1995-2005)*

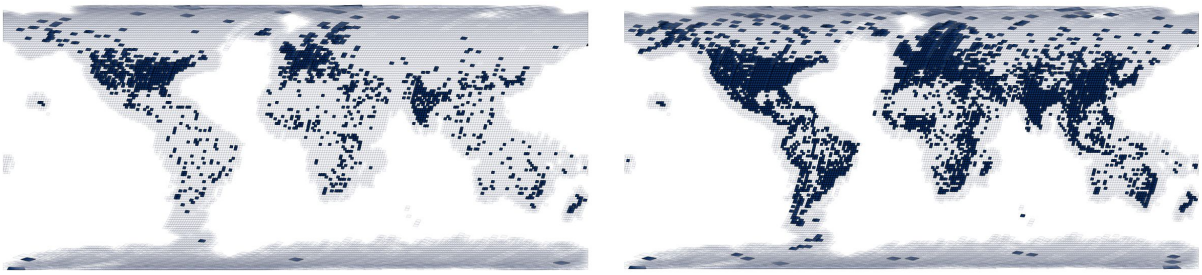


Figure 4: Locations of Authors of Climate-Change Research Using Landsat Data

Panel A: Privatization Period (1985-95) *Panel B: Public Period (1995-2005)*

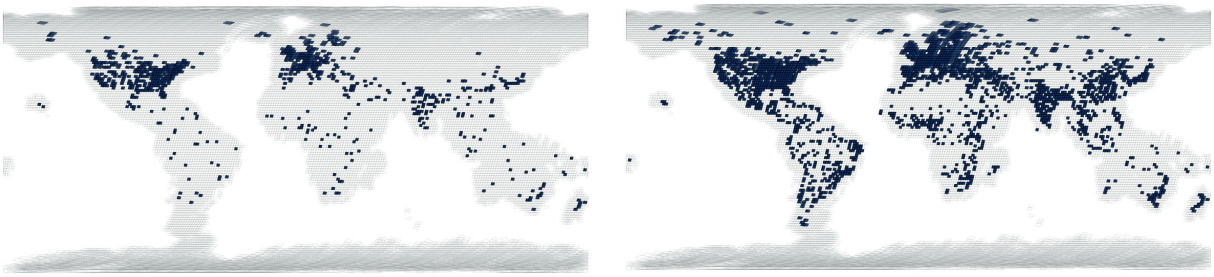
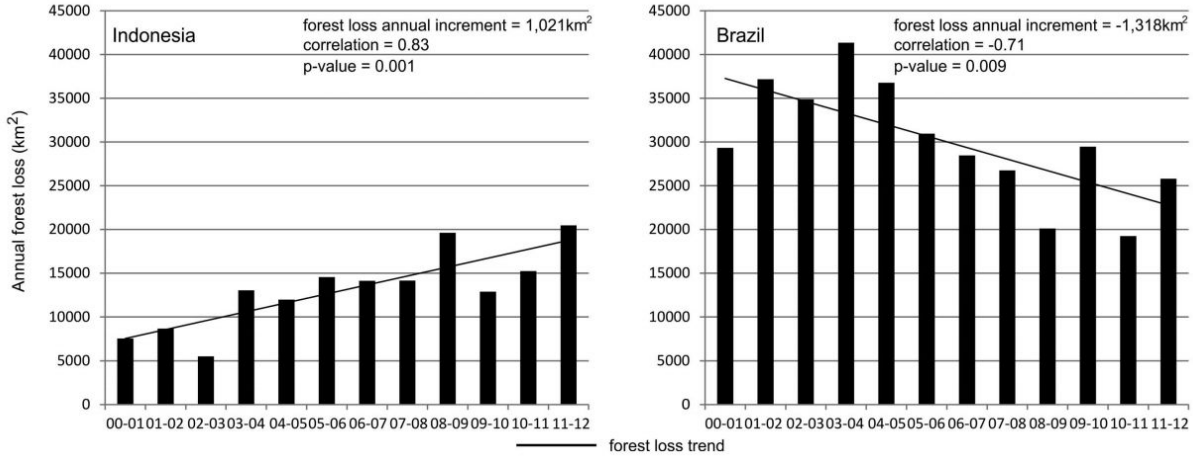


Figure 5: Annual forest loss totals for Brazil and Indonesia from 2000 to 2012.



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ACADEMIC APPOINTMENTS

Assistant Professor, University of California Berkeley *2017–*
Haas School of Business, Management of Organizations (MORS)

Post-doctoral Scholar, National Bureau of Economic Research *2016-17*
NBER Digitization Program

EDUCATION

MS/PhD, Massachusetts Institute of Technology, Sloan School *2016*
Tech. Innovation, Entrepreneurship and Strategic Management (TIES)
Dissertation title: Essays on the Impact of Digital Information on Innovation

MBA, Indian Institute of Management Calcutta *2010*

B.Tech., College of Engineering, Pune (Computer Science) *2008*

REFEREED JOURNAL ARTICLES AND CONFERENCE PROCEEDINGS

Does Copyright Affect Reuse? Evidence from Google Books and Wikipedia
Management Science (forthcoming)
Media Mentions: The Atlantic, JetLaw, Techdirt, Wikipedia Signpost

Do Wiki-pages have parents? An article-level inquiry into Wikipedia's inequalities (with P. Seetharaman, R.Roy and A. Dutta)
Workshop on Information Technology Systems (WITS), 2009

WORKING PAPERS

The Private Impact of Public Maps—Landsat Satellite Imagery and Gold Exploration (revise-and-resubmit, Management Science)

Information Seeding and Knowledge Production in Online Communities: Evidence from OpenStreetMap (revise-and-resubmit, Management Science)

Deterring the New, Motivating the Established—The Divergent Effect of Platform Competition on Member Contributions in Digital Mapping Communities (*with Henning Piezunka*) (revise-and-resubmit, Organization Science)

The Map is Not the Terrain: The Antecedents and Consequences of Endogenous Geographic Information (*with Scott Stern*) (requested by the Journal of Economic Perspectives)

Quantifying entrepreneurship using domain name registration data: Methods and applications for Oxford and Cambridge, UK (*with Sibo Wang*)

HONORS AND GRANTS

Best Paper Prize (Nominee), Strategic Management Society Paris Conference, 2018
Institute of Business Innovation Grant, 2018
UC Berkeley Dean's Office Special Grant, 2018
Best Emerging Scholar Paper Award (Nominee), World Open Innovation Conference, 2017
Wiley Blackwell Outstanding Dissertation Award, Behavioral and Policy Sciences (BPS), July 2017

Technology and Innovation Management (TIM Division) Outstanding Dissertation Award, July 2017
Fisher Center for Business Analytics Research Award, 2017
Kauffman Prize, Best Student Paper, REER 2015
MIT Initiative on the Digital Economy (IDE) Grant, 2015
Ewing Marion Kauffman Dissertation Fellowship, 2014
J. Roberts Beyster Fellowship, 2014
NESTA Innovation Research Grant, 2014
Sloan Foundation Research Grant, 2014
Center for Digital Business Summer Research Grant, 2014
MIT Energy Fellowship, 2012

INVITED PRESENTATIONS AND CONFERENCES

2018-19(scheduled): 16th ZEW Conference on the Economics of Information and Communication Technologies, Academy of Management (showcase symposium), Open and User Innovation Conference (NYU), 13th Meeting of the Urban Economics Association (Columbia University)

2017-18: Strategy Research Forum (Paris), Harvard Business School Digital Initiative Discussion & Symposium (DIDS), NBER Digitization Winter Meetings (discussant), Organization Science Winter Conference, World Open Innovation Conference 2017, Berkeley-Haas Faculty Seminar, Searle Roundtable on Economics of Mass Digitization—Northwestern University, State of the Map-US Conference, Institute for Personality and Social Research (IPSR) Berkeley, Academy of Management Conference, Korea Institute of Science and Technology (KAIST), Digital Infrastructure Research Meeting (Sloan Foundation), Society for Institutional & Organizational Economics Conference (Columbia University)

2016-17: Univ. of Utah/BYU Winter Strategy Conference; Organization Science Winter Conference; NBER Digitization Winter meetings (discussant); Washington University in St. Louis Strategy Seminar; Social Science and Technology Seminar, Stanford Institute of Economics and Policy Research (SIEPR), Stanford; Academy of Management Conference; NBER Summer Institute (cross-listed across programs Innovation, Productivity, Development, and Entrepreneurship, IT and Digitization)

2015-16: 9th Economics of Entrepreneurship & Innovation (EEI9) Conference; Kauffman Emerging Scholars Conference; Organization Science Winter Conference; Strategy, Fuqua School, Duke University; Harvard Business School (TOM-EM joint seminar); Strategy, UCLA Anderson; Economic Analysis & Policy, UC Berkeley Haas; Management of Organizations, UC Berkeley Haas; Dept. of Management, Wharton School, U-Penn; Organizations & Markets, University of Chicago Booth; Dept. of Management and Organizations, NYU Stern; Dyson School, Cornell University; Dept. of Management & Technology, Bocconi University; Strategy Area, Ross School, University of Michigan; Management & Organizations, USC Marshall; Strategy Department, Harvard Business School; Logistics, Business & Public Policy, UMD Smith School; Strategy & Entrepreneurship, UCL School of Management; NBER Productivity Seminar; Strategic Management Department, Fox School, Temple University; 15th Roundtable for Engineering Entrepreneurship Research (REER); MIT Economics "Labor Lunch"; MIT Sloan TIES Seminar; MIT Economics Summer Applied-Micro Lunch; Economic Sociology Working Group

2014-15 & before: Laboratory for Innovation Science and Policy Lunch; Open and User Innovation Workshop (HBS); Academy of Management Annual Meetings; Cyberscholars Working Group (Yale); NBER Summer Workshop on Economics of IT and Digitization; Third Annual Research Roundtable on the Law and Economics of Digital Markets, Searle Center (Northwestern Law); Fourth Workshop for Junior Researchers on the Law & Economics of Intellectual Property and Competition Law (Munich); Gordon Research Conference on Science & Technology Policy; Wikimania International Conference, Washington DC; Workshop on Information Technology Systems (WITS)

TEACHING AND SERVICE

Instructor: Entrepreneurial Strategy (Berkeley Haas, Spring 2018)
Reviewer for American Economic Review, Journal of Political Economy, Journal of Economics and Management Strategy, Management Science, National Science Foundation, Organization Science Academy of Management, Best Student Paper Awards Committee 2018
Academy of Management, TIM Doctoral Dissertation Workshop 2018
Academy of Management, STR Doctoral Dissertation Workshop 2018

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