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Personal Information: Date of birth: 8/3/1987, Sex: Male, Citizenship: U.S.

Undergraduate Studies:
B.S., Earth, Atmospheric and Planetary Science, Massachusetts Institute of Technology, 2009
B.S., Political Science, Massachusetts Institute of Technology, 2009
Minors: Economics, Mathematics

Graduate Studies:
John F. Kennedy School of Government , Harvard University, 2009 to present
Ph.D. Candidate in Public Policy
Dissertation Title: "Essays on Energy Technology Innovation Policy"
Expected Completion Date: May 2015

References:

Professor William Clark
79 JFK Street, Cambridge, MA 02138
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Professor Robert Stavins
79 JFK Street, Cambridge, MA 02138
617-495-1820, robert_stavins@hks.harvard.edu

Professor Laura Díaz Anadón
79 JFK Street, Cambridge, MA 02138
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Professor Joseph Aldy
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Teaching and Research Fields:
Primary fields: Innovation policy, Energy and environmental economics, Policy analysis
Secondary fields: Econometrics, Applied statistics, Applied microeconomics

Teaching Experience:

2013 – 2014	API-202A/Z: Empirical Methods II – Accelerated, Harvard Kennedy School, TF for Professor Amitabh Chandra
2012 – 2013	API-201: Quantitative Analysis and Empirical Methods, Harvard Kennedy School, TF for Professors John Friedman and Erich Muehlegger
2012 – 2013	Master in Public Policy Summer Math Camp, CA for Professor Selin Kalaycioglu
2012 – 2013	Harvard Bok Center for Teaching and Learning, Enrolled in two courses in teaching skills development

2011	Ec 1661: Fundamentals of Environmental Economics and Policy, Harvard University, TF for Professor Robert Stavins
2010	IGA-503M: Governing Science & Technology Risks and Challenges, Harvard Kennedy School, CA for Professor Matthew Bunn

Research Experience and Other Employment:

2011 – present	Harvard Sustainability Science Program, Researcher for the Project on Innovation and Access to Technologies for Sustainable Development
2011 – 2014	Intergovernmental Panel on Climate Change 5th Assessment Report, Chapter Scientist and Contributing Author for Working Group III, *"Chapter 13: International Cooperation: Agreements and Instruments"*
2009 – 2011	Harvard Belfer Center, RA for the Energy Research Development Deployment and Demonstration Project. Principal Investigators: Professors Venkatesh Narayanmurti and Matthew Bunn
2010	MIT Sloan School, RA for Professors Fiona Murray and Scott Sterm
2008 – 2010	MIT Joint Program on the Science and Policy of Global Change, RA for Dr. John Reilly and Dr. Sergey Paltsev
2008 – 2009	MIT Department of Economics, RA to Professor Michael Greenstone
2007, 2009	U.S. Department of Energy, Intern in the Climate Change Technology Program for Robert Marlay, Ph.D.

Professional Activities

Referee for *Energy Economics*, *The Journal of Technology Transfer*, and Cambridge University Press (book manuscript)

Scholarships and Fellowships:

2014 – present	Dissertation Completion Fellowship, Harvard Graduate Society
2012 – present	Research fellow, Belfer Center Energy Technology Innovation Policy group
2009 – present	Pre-doctoral fellow, Harvard Environmental Economics Program
2011 – 2012	Pre-doctoral fellow, Harvard Sustainability Science Program
2010 – 2012	Harvard Graduate Consortium on Energy and the Environment Fellowship
2010 – 2011	Vicki-Norberg Bohm Fellowship, Harvard Kennedy School
2009 – 2011	Doctoral fellowship, Harvard Kennedy School

Publications:

Laura Díaz Anadón, Valentina Bosetti, **Gabriel Chan**, Gregory Nemet, and Elena Verdolini. 2014. "Energy Technology Expert Elicitations for Policy: Workshops, Modeling, and Meta-Analysis." In revision. Belfer Center Discussion Paper #2014-08 available at belfercenter.ksg.harvard.edu/files/etip-dp-2014-08.pdf.

Gireesh Shrimali, **Gabriel Chan**, Steffen Jenner, Felix Groba, and Joe Indvik. 2014. "Evaluating Renewable Portfolio Standards for In-State Renewable Deployment: Accounting for Policy Heterogeneity." Accepted at *Economics of Energy & Environmental Policy*.

Laura Díaz Anadón, **Gabriel Chan**, and Audrey Lee. 2014. "Expanding, and Improving Targeting Of, U.S. Investment in Energy Innovation: An Analytical Approach" in *Transforming U.S. Energy Innovation*. Ed. Laura Díaz Anadón, Matthew Bunn, and Venkatesh Narayanamurti. Cambridge University Press, Cambridge, U.K., and New York, NY, USA, pp. 36–80.

Gabriel Chan, John M. Reilly, Sergey Paltsev, and Y.-H. Henry Chen. 2012. "The Canadian Oil Sands Industry Under Carbon Constraints." *Energy Policy* 50: 540–550.

Gabriel Chan, Robert Stavins, Robert Stowe, Richard Sweeney. 2012. "The SO_2 Allowance-Trading System and the Clean Air Act Amendments of 1990: Reflections on 20 Years of Policy Innovation." *National Tax Journal* 65 (2): 419–452.

Steffen Jenner, **Gabriel Chan**, Rolf Frankenberger and Mathias Gabel. 2012. "What Drives Sates to Support Renewable Energy?" *The Energy Journal* 33: 1–12.

Gabriel Chan, Laura Díaz Anadón, Melissa Chan, and Audrey Lee. 2011. "Expert Elicitation of Cost, Performance, and RD&D Budgets for Coal Power with CCS." *Energy Procedia* 4: 2685–2692.

Graham Pugh, Leon Clarke, Robert Marlay, Page Kyle, Marshall Wise, Haewon McJeon, and **Gabriel Chan**. 2011. "Energy R&D Portfolio Analysis Based on Climate Change Mitigation." *Energy Economics* 33: 634-643.

Research papers in progress:

Gabriel Chan. "The Commercialization of Publicly Funded Science: How Licensing Federal Laboratory Inventions Affects Knowledge Spillovers" (Job Market Paper)

The U.S. federal government invests $126 billion per year in research and development (R&D), 40% of which is allocated to R&D centers it exclusively funds. For over thirty years national policy has required inventions discovered in federally funded R&D centers to be transferred to the private sector to diffuse knowledge and to promote private sector follow-on innovation, but there is limited empirical evidence for whether these policies have worked. I quantify the effect of technology transfer on innovation spillovers in the context of patent licensing at the U.S. National Laboratories using data on over 800 licensed patents since 2000. I demonstrate that licensing increases the annual citation rate to a patent by 31–48%, beginning two years after a license agreement is executed. I find that over 75% of follow-on innovation after a patent is licensed occurs outside of the licensing firm, indicating that knowledge from licensing diffuses broadly. These estimates rely on a novel matching algorithm based on statistical classification of the text of patent abstracts. I explore possible mechanisms for the effect of licensing on knowledge diffusion by examining the quality of patents that cite licensed patents and rule out the possibility of a strong strategic patenting effect. These results demonstrate that transactions over formal intellectual property enhance the benefits of publicly funded R&D in the "market for ideas."

Gabriel Chan, Joern Huenteler, and Xi Lu. "Financing wind energy deployment in China through the Clean Development Mechanism: Additionality and incentives for technological change" (for submission to *Nature: Climate Change*)

In this paper we study the Kyoto Protocol's Clean Development Mechanism using data on all Chinese wind energy projects constructed through the end of 2012. Projects developed under the Clean Development Mechanism must establish their additionality – that they would not have been constructed without additional financial support from the Mechanism – and although additionality claims are verified by a third-party auditing board, calculations depend on several untestable assumptions, such as the expected wind resource quality. In this paper, we evaluate the claims of additionality of projects funded by the Clean Development Mechanism by calculating the internal rate of return for every project utilizing a state-of-the-art methodology for estimating the distribution of wind speeds at a fine geographic granularity. We find that over 50% of registered Clean Development Projects understate their internal rate of return, suggesting strategic manipulation of project approval processes. These results indicate that many Clean Development Mechanism projects are not "additional." Nevertheless, we also find that projects funded through the Clean Development Mechanism tend to utilize wind turbine models approximately 0.75 years more advanced than projects built without this funding.

Gabriel Chan and Laura Díaz Anadón. "Utilizing Expert Elicitation to Quantify Uncertainty in Parametric Models: Assessing the Impact of R&D-Induced Cost Reductions of Energy Technologies" (for submission to *Management Science*)

Effective decision making to allocate public funds for energy technology research, development, and demonstration (R&D) requires considering alternative investment opportunities that can have large but highly uncertain returns and a multitude of positive or negative interactions. We propose and implement a method to

support R&D decisions that propagates uncertainty through an economic model to estimate the holistic benefits of an R&D portfolio, accounting for innovation spillovers and technology substitution and complementarity. Our proposed method improves on the existing literature by: (a) using empirically-grounded estimates of the impact of R&D investments from the most comprehensive set of expert elicitations on this topic to date; (b) using a detailed energy-economic model to estimate three classes of evaluation metrics of an R&D portfolio: system benefits, technology diffusion, and uncertainty around outcomes; and (c) using a novel sampling strategy to capture innovation spillovers. Our results focus on the comparison of a business-as-usual (BAU) R&D portfolio that perpetuates 2009 investments with an R&D portfolio recommended by technology experts with an aggregate budget 2.5-times greater than the BAU portfolio. We find that the median projection of the expert-recommended portfolio in 2030, relative to the BAU portfolio, reduces carbon dioxide emissions by 46 million tonnes, increases economic surplus by $29 billion, and increases renewable energy generation by 39 TWh. However, uncertainty around the estimates is large and overall uncertainty increases with greater investment levels. The use of this method can help scholars and policy makers focus future efforts and debate on the key assumptions that drive benefit analysis of R&D investment portfolios.

We are currently using the results of this exercise in a sampling and optimization framework to generate decision-relevant R&D portfolio allocations that maximize policy objective functions under R&D budget constraints. Preliminary results indicate: (1) while marginal returns to R&D investment decrease, a 10-fold expansion from 2012 levels in the R&D budget for utility-scale energy storage, bioenergy, advanced vehicles, fossil energy, nuclear energy, and solar photovoltaic technologies can be justified by expected returns to economic surplus; (2) the greatest economic returns to public R&D investment are in energy storage, solar photovoltaics, and bioenergy; and (3) at the current budget level, the allocation of energy R&D funds is very different from the optimum.

Gabriel Chan, Zou Ji, and Robert Stavins. "International Climate Policy, Agreements, and Institutions: A Review and Synthesis"

Cooperation on climate change mitigation has become more institutionally diverse over the past decade, reflecting both numerous institutions at multiple scales of governance and the growing inclusion of climate change issues in other policy arenas. At the international level, cooperation under the United Nations Framework Convention has continued to evolve while simultaneously other potential governmental and private sector international fora for cooperation – including linkages between national and regional policies – have arisen. As the level of activity in international cooperation on climate change mitigation has increased, so too has the related scholarly literature. In this article, we present a synthesis of the literature on international climate change cooperation published between 2007 and 2013, building on the work of the Intergovernmental Panel on Climate Change Working Group III Fifth Assessment Report, for which the authors of this article served as Coordinating Lead Authors and Chapter Scientist in the chapter on "International Cooperation: Agreements & Instruments." We highlight the key policy implications of this large body of literature, while focusing on the findings most relevant for the research community. Our scope includes critical evaluation of the ways in which agreements and instruments for international cooperation to address global climate change have been and can be organized and implemented, as well as retrospective analysis of international cooperation that quantifies what has been achieved to date, together with explanations of successes and failures.

Gabriel Chan, Laura Díaz Anadón, Kira Matus, Suerie Moon, Alicia Harley, and Sharmila Murthy. **"**A Framework for Analyzing a Goal-Oriented Innovation System" (for submission to *Research Policy*)

The set of technologies, actors, and institutions engaged in innovation form a complex system that makes empirical evaluation of individual components of the innovation system difficult. In this paper, we propose a comprehensive general framework of an innovation system that can be applied to evaluate individual actors and institutions within the system. We describe the system in terms of stocks (knowledge, inventions, feasible technologies, technologies in limited production/use and technologies in widespread production/use) and flows (invention, selection, initial adoption, production, widespread use, adaptation, and retirement). The flows are substantiated by specific mechanisms which operate non-linearly in the innovation system to connect stocks in various configurations. The stocks consist of technologies, which we describe in terms of their socio-technical characteristics. We apply the framework to develop generalized hypotheses about which socio-technical characteristics create the conditions which enable a well-functioning innovation system. We then describe several case studies conducted as part of a broader study to illustrate how this framework can generate insights about the performance of the global innovation system in delivering the goals of sustainable development.

Laura Díaz Anadón, Kira Matus, Suerie Moon, **Gabriel Chan**, Alicia Harley, Sharmila Murthy, Ahmed Abdel Latif, Kathleen Araujo, Kayje Booker, Hyundo Choi, Kristian Dubrawski, Lonia Friedlander, Christina Ingersoll, Erin Kempster, Laura Pereira, Jennie Stephens, Vanessa Timmer, Lee Vinsel, and William C. Clark. "Innovation and Access to Technologies for Sustainable Development: Diagnosing Weaknesses and Identifying Interventions in the Transnational Arena" (available as Harvard Sustainability Science Working Paper 2014-01)

Sustainable development – improving human well-being across present generations without compromising the ability of future generations to meet their own needs – is a central challenge for the 21st century. Technological innovation can play an important role in moving society toward sustainable development. However, poor, marginalized, and future populations often do not fully benefit from innovation due to their lack of market or political power to influence innovation processes. As a result, current innovation systems fail to contribute as much as they might to meeting sustainable development goals. This paper focuses on how actors and institutions operating in the transnational arena can mitigate such shortfalls.

Conferences and Invited Seminars (includes scheduled)**:**

2014: Lawrence Berkeley National Laboratory, International Energy Agency, Technology Transfer Society Conference, Harvard Kennedy School Energy Policy Seminar, INFORMS Annual Meeting, Harvard Business School Science Based Business Seminar

2013: Harvard Kennedy School Energy Policy Seminar, Harvard Business School Science Based Business Seminar, Atlanta Conference on Science and Innovation Policy, NC State University Camp Resources

2012: International Conference on Science and Technology Indicators, Climate Change Impacts and Integrated Assessment Workshop XVIII

2011: International Energy Workshop

2010: Pacific Northwest National Laboratory, World Student Environmental Summit (keynote), International Conference on Greenhouse Gas Technologies, National Renewable Energy Laboratory

2009: U.S. Department of Energy