Final Progress Report
Sustainability Science Program
September 1, 2008 – August 31, 2009

Name: Kira Matus

Date: July 15, 2009

Field(s): Public Policy

Your degree program, institution and (expected) graduation date:
PhD in Public Policy, Harvard University, June 2009 (awarded)

Faculty host(s) at Harvard name and department: William Clark, William Hogan, Vankatesh Narayanamurti.

Description of SSP-related research activity, including a title: *Green Chemistry: Leapfrog or Bullfrog?*

Abstract (one paragraph):

This research uses green chemistry to explore how potentially "leapfrogging" technologies can be deployed to promote sustainable development. The focus is on the investigation of the global implementation of green chemistry, in order to understand how different policies, institutions, and educational systems affect its adoption, and to compare this to the United States case. Field work in India and China explores: multi-sectoral partnerships and collaborations; communication of knowledge from research institutions to industry, and of knowledge needs from industry to the research community; metrics and standards; and regulation and policy, including the impacts of incentives, regulatory uncertainty, accounting and financial regulations, research funding, and how the interaction of policies can either promote or hinder adoption of innovations. The aim is to construct a framework for the circumstances under which the implementation of green chemistry and other leapfrog innovations are viable.

Identification of the problem you address (1 sentence to a paragraph):

The global population is facing a set of serious challenges. On the one hand, modern technology has enabled a record number of people to exist at an unprecedented level of development. But the ability to feed, clothe and house more than six billion people has come with a cost. The same technologies that have improved agriculture, medicine, and led to modern manufacturing have also been the source of considerable degradation of environmental resources. Furthermore, while the growth over the past 150 plus years has been remarkable, it has also been uneven, leading to ever increasing disparities between those living at the top end of the development spectrum, and the larger numbers whose existence is marked by poverty and want. The remaining challenges associated with large, global development objectives, like such as the UN Millennium Development Goals, cannot be attained without the use of new technologies. For this reason, it is important to understand how technological innovation can be deployed to promote sustainable development, so that quality of life continues to improve without irreversible harm being done to environmental resources.

Key question asked about the problem (1 sentence to a paragraph):

The key question for this research was to understand how policy can better encourage technological innovation that promotes sustainable development. In particular, I worked to develop a new conceptual understanding of the dynamics of technological innovations that provide both private and social benefit.

The methods by which you answered that question (1 sentence to a paragraph):

My approach is a theory informed, historical and dynamic investigation of innovations required to achieve sustainable development. The approach is comparative but also grounded in a global, connected context. This study was undertaken with a view toward identifying a number of the key elements for the construction of a new conceptual framework to understand the dynamics of technological innovations that provide both private and social benefit. I accomplished this by analyzing innovations in the chemical sector, particularly green chemistry, which is "is the design of chemical products and processes that reduce or eliminate the use or generation of hazardous substances (Anastas and Warner, 1998)". Conceptually, I integrated models of public goods provision with models of innovation systems in order to understand how the knowledge and investment capital of multiple actors can be mobilized in ways that create public as well as private goods. Methodologically, I brought a global systems perspective to bear on a case study of the development and spread of green chemistry innovations in the United States, China and India. Empirically, I constructed a qualitative model for the green chemistry innovation system, to identify the major factors that help or impede innovation in that system, and to evaluate the impact on the system (positive or negative) of a variety of potential policy interventions. I developed both system-specific and general insights about the role of policy in encouraging innovation for sustainability in today's complex and globalizing world.

Principle literature upon which the research drew (methodological and substantive, e.g., innovation, incentive-based environmental management, science and technology studies):

- Innovation (business, organizational, and economic)
- Green Chemistry
- Public Policy
- General Economic theory
- Sustainability Science
- System Dynamics
- Standards and Certification
- Public-Private Partnerships/Governance

Empirical data acquisition description (1 sentence to a paragraph):

This research was based largely on qualitative interviews which were conducted in China, India and the United States between 2006 and 2009.

Geographical region studied (if appropriate):

China, India, United States

Recommendations that might be relevant for your problem (1 sentence to a paragraph):

All together, this research led to six key findings in three main categories. These findings are:

i. Globalization

1. *Innovations that promote sustainable development can face additional barriers (compared to other public goods innovations) because their costs and benefits are particularly "leaky" across spatial and temporal boundaries.*
2. *Like the problems that many innovations for sustainable development seek to address, the system of innovation for sustainable development itself is highly transnational.*
3. *Regardless of local contexts, technical barriers present a common challenge to the development and implementation of innovations for sustainable development.*

ii. Context

4. *The different human resources and human capabilities found in any particular country context, as well as economic organization (how firms are structured, what is being produced) impacts whether, how, and in what ways innovations occur.*

iii. Intervention Strategies

5. *Efforts to foster innovation for sustainable development need to include analysis of the where in the innovation system interventions are effective.*
6. *Innovation for sustainable development requires smart, strategic engagement between different combinations of stakeholders.*

- A description of the final product(s) you have/are aiming to produce (e.g., article in X journal):

There are several final products. The first is my dissertation, which is complete. In addition, this research has provided the basis for several articles, based on working papers, that I will be submitting to the appropriate journals (including Environmental Science and Technology, the Journal of Green Chemistry, and possibly others).

- Description of major other intellectual or professional advancement activity(ies) over the past academic year, including working title(s) (e.g., PhD qualifying paper, dissertation, non-SSP research project paper, job search):

This has been a busy year. I completed and successfully defended my dissertation, while also conducting a job search. In addition, I was commissioned to write a working paper for a National Academy of Sciences workshop entitled "Standardization, Certification and Labeling: Lessons from Theory and Practice," which is also currently in publication as a CID working paper. Finally, I also helped to develop and teach sections of the HKS course IGA-104, "Managing a Living Planet."

Please list citations for reports, papers, publications and presentations that built on your fellowship research (please list full citations here, paragraph length abstracts, and attach copies of URLs if possible):

<u>Presentations:</u>

At the 13th Green Chemistry and Green Engineering Conference, June 23-25, 2009

Xin Xiao , Chinese Academy of Sciences, Institute of Process Engineering, Bejing, China
Kira JM Matus , Kennedy School of Government, Harvard University, Mclean, VA

In China, the barriers to implementation of green chemistry vary from those found in the United States. In China, there appear to be more challenges arising from competing priorities between economic growth and environmental protection, along with the technical challenges from possessing a smaller base of experienced scientists and engineers. China, where rapid growth in production capacity presents an important opportunity for green chemistry implementation, is still catching up with the United States in terms of the education, training and experience of its scientists and engineers. Overall, the research found six major challenges facing green chemistry innovators in China. They are economic and financial barriers, competing agendas between growth and environmental sustainability, training barriers, research funding barriers, barriers that arise from the system of bureaucratic incentives, and engineering capacity barriers. Despite the challenges, there is growing attention of the need to integrate green chemistry throughout the Chinese chemical enterprise. Understanding the nature of these barriers is important, because it allows for policy-makers to intervene in ways that will help to remove or mitigate them. [POSTER]

Kira JM Matus , Kennedy School of Government, Harvard University, Mclean, VA
Over the past decade, green chemistry and engineering in China have been growing at an impressive pace. This presentation will look at the position of green chemistry and engineering in the Chinese system of higher education, based on recent visits to a dozen universities and research centers around China. One area of interest is methods of integrating green chemistry and engineering into the curriculum, including the availability of green chemistry and engineering specific degree programs, and other aspects of green chemistry in the classroom setting. In addition, this presentation will give an overview of academic green chemistry and engineering research. This includes the relationship between academia and industry, and the implications for students at the graduate level.

Lin Kaatz Chary, PhD., MPH , Great Lakes Green Chemistry Network, Gary, IN
Several states such as Michigan, California, and Maine have moved forward to implement green chemistry initiatives at the state level. Other states are active in banning PBDEs and other hazardous chemicals and are now looking for tools and policies to promote safer substitutes. This panel will present an update on state efforts to implement green chemistry strategies, including informed substitution methodologies.

Moderator: Kira Matus, Harvard University
Speaker 1: Michael Wilson and Megan Swartzman, UC Berkeley
Speaker 2: Tracey Easthope, Ecology Center, Ann Arbor, MI

Working Paper

Standardization, Certification and Labeling: Lessons from Theory and Practice
Kira Matus
CID Graduate Student and Research Fellow Working Paper No. 37, In Press

The use of standards, certification, and labeling has been growing in a number of areas, as consumers demand more information about the products that they use. From a consumer perspective, they have become increasingly common in relation to information regarding nutrition, safety, and most recently, the environmental impact of a range of products. Certification has become a popular tool in environmental policy, and is widely seen as one method to influence purchasing behavior, and through the power of markets, reputation, and branding, the environmental behavior of firms.

While there are many environmental certifications and labels that have grown in visibility and popularity (LEED for buildings and USDA Organic for foods, among others), they are not a policy panacea. There are a variety of issues that need to be addressed regarding their effectiveness, ranging from how they are developed, who ensures their veracity, and whether they actually produce a positive impact. This background paper will start by looking at general public policy theory, to help explain how standards, certification and labeling function as compared to other potential policy tools. Then it will address some key issues that have emerged both from the underlying theory and actual empirical experience. Understanding both the theory and the reality of these efforts to date are key to developing a deeper understanding of when and how standards, certification and labeling can be used with the greatest positive impact.

Principal collaborators outside Harvard (list name and institution):

- Paul Anastas, Yale University
- Suojiang Zhang, Chinese Academy of Sciences Institute of Process Engineering
- Xin Xiao, Chinese Academy of Sciences Institute of Process Engineering
- Derek Vollmer, National Academy of Sciences
- Jennifer Young, Green Chemistry Institute
- Robert Peoples, Green Chemistry Institute

List any awards or grants that you have received this year for the current or coming year. Please provide details regarding title of award, financial amount, and date of award:

n/a

If you are moving to a new position, please list your contact information there:

TBD

Please attach an updated CV.

Lastly, we'd welcome your thoughts on what parts of your fellowship experience you found most and least valuable (e.g., the Sustainability Science Seminar, interacting with other fellows, participation in collaborative research projects, working in an interdisciplinary community…).

I think that the following excerpt from the acknowledgements section of my dissertation says it best.

None of this would have been possible without my adviser and committee chair, Dr. Bill Clark.

He recruited me to the Kennedy School PhD program, but also provided me with a home for four years in the Sustainability Science Program. Both he and Nancy Dickson have created a remarkable group of fellows from so many backgrounds. My research has only benefited from the amazing collegial atmosphere (and financial resources) that they have worked so hard to assemble. Prof. Clark has presented me with so many opportunities to get involved with intriguing research projects and interesting (and life-consuming) teaching opportunities that it's a miracle that I managed to ever do work on my dissertation. His guidance has been indispensible, and without such a dedicated adviser and staunch advocate, I am sure that my time at Harvard would not have been nearly as enjoyable, or successful.

The Sustainability Science Program has been my home at Harvard. Thank-you to Nancy Dickson, who does such a great job of taking care of all of us fellows, while also making sure that the money, the grants, the publications, and the thousands of other details get taken care of. And of course, a big thank-you to Mary Anne Baumgartner, who can move mountains, and without whom the last year would have been logistically impossible. To my fellows, who are graduating one by one, thank you for all of the input, the lunches, and the support.

The Sustainabilty Science Program (in one form or another) was my home for four-years at Harvard, and without it, I do not think that the experience would have been as useful, fruitful or enjoyable. It is a rare group, and I look forward to staying involved with my fellow alumni for a long time to come.