Final Progress Report
Sustainability Science Program
Term: September 1, 2014 – July 31, 2015

Name: Christian Binz

Your fields:
Economic Geography, Innovation Studies

Your degree program, institution and graduation date:
Ph.D. in Geography, Eawag: Swiss Federal Institute of Aquatic Science and Technology, University of Bern and Chinese Academy of Sciences, 2012

Faculty hosts at Harvard name and department:
Henry Lee, Harvard Kennedy School of Government
Laura Diaz-Anadon, Harvard Kennedy School of Government

Description of SSP-related research activity:
Low-carbon leapfrogging in China: An international innovation system perspective

Abstract: China has become a world leader in booming clean-tech sectors like wind power and solar photovoltaics (PV). The speed with which China has built up these industries is unprecedented and China is quickly catching-up with Western technology providers. Yet, our theoretical understanding on how these Chinese industries could leapfrog to the global technological frontier so quickly is still embryonic and several important research questions remain underexplored: How did China catch-up with Western technology so fast? What role did domestic and international factors play in industry formation? What policies were instrumental in pushing these sectors? This project addresses these questions based on a comparative case study design. Qualitative expert interviews with key Chinese stakeholders are combined with an extended literature review to create new theories on how local and international stakeholders jointly formed a supportive environment for low-carbon leapfrogging in China. The project contributes directly to innovation system literature and recent theorizing in evolutionary geography. By creating an international perspective on the leapfrogging process, it allows deriving new policy advice and sketching new strategic options for key stakeholders in the wind and solar PV sector. Combining the lessons from China with insights from previous projects around the world will enable important advances in scholarship with direct practical application.

Identification of the problem you address:
The technological catch-up of Chinese wind power and solar PV sectors has been well described in recent literature, but it remains unclear how China could leapfrog to the global technological frontier so quickly. Several studies point to the importance of international network connections of Chinese entrepreneurs, but no detailed account exists on how Chinese entrepreneurs combined their global network connections with China's competence in knowledge-intensive and innovative manufacturing to build up new clean-tech sectors.

Key question asked about the problem:
How did Chinese entrepreneurs in the solar PV and wind power leverage domestic and international network connections to facilitate technology leapfrogging?

The methods by which you answered that question:
I am using qualitative expert interviews to answer the question. Interviews with 30 industry experts, site visits and an extended literature review are used to reconstruct in detail how the Chinese solar PV and wind power industries emerged. Comparing the two cases is used to derive stylized lessons on the key determinants of successful leapfrogging processes in latecomer economies. In addition, in a new collaborative SSP project I am also using patent analysis to reconstruct the knowledge base of the Chinese solar PV sector.

Principle literature upon which the research drew:
The research draws on three main lines of literature: Evolutionary economic geography, innovation studies, as well as technology transfer and development studies.

Empirical data acquisition description:
Data acquisition was based on an interview campaign in China between December 2014 and February 2015. Interviews were conducted with senior experts in the Chinese solar PV sector as well as with experts with overview knowledge on Chinese cleantech sectors. Interviews were conducted in Beijing and the Yangtze River Delta Region. Based on the data availability, the current state of the literature and recommendations from other scholars, the interviews focused mainly on the solar PV sector whereas a comparison with the wind power sector is achieved based on existing data from (and cooperation with) scholars at Qinghua University and the SSP/ETIP program. Patent data on the solar PV sector was derived from the Derwent global patent database. In total, a set of 86,000 patents was collected, cleaned and codified to allow for a geographic analysis of recent shifts in the knowledge base of solar PV patenting.

Geographical region studied:
China: Beijing, Shanghai, Changzhou, Baoding

Recommendations that might be relevant for your problem:
The results from my fieldwork campaign proved very useful in developing a new analytical framework for the early development stages of new industries in latecomer countries. Based on the interviews in the Chinese PV sector we could show for the first time that the key resources for industry formation do not have to be created in the latecomer country itself, but can be accessed and anchored from other regions in an extensive global technological innovation system. The patent analysis so far suggests that a shift in the knowledge base of PV technology towards China is happening, but that it lags behind Western countries in terms of patent quality. Finally, policy support for solar PV and wind power strongly differed in China, with the bottom-up, private enterprise-driven and internationalized trajectory in solar PV showing more promising long-term results than the traditional import-substitution model that was applied in the wind sector.

A description of the final product(s) you have / are aiming to produce:
Two scientific papers are projected to be published as a direct outcome from my personal work in the SSP program, one as a result of a collaborative project with Tang Tian and Joern Huenteler:

- *Unrelated diversification and technology leapfrogging in latecomer countries: The emergence of the Chinese solar PV industry*. Final draft, to be submitted to Global Environmental Change very soon. This paper applies the data from the interviews in the Chinese solar PV sector to develop new theoretical propositions on how new industries emerge in space and on the role of domestic and international resources in early industry formation.
- *Globalization and technological leapfrogging: A comparison of solar PV and wind power in China.* Paper outline under preparation, to be submitted to Technological Forecasting and Social Change. This paper will be developed in cooperation with wind power scholars at ETIP/SSP/Qinghua (e.g. Kavita Surana, Joern Huenteler, Yuan Zhao, Su Jun) to make a more policy-focused argument by comparing the outcomes of catching-up policies in the Chinese wind and PV sector to derive specific success/hindering factors for low-carbon leapfrogging strategies.
- *Spatial Dynamics in the Knowledge Base of Emerging Cleantech Sectors - A patent analysis in solar PV.* First paper draft available, to be submitted to TFSC/Energy Policy/Journal of Cleaner Production by Feb. 2016. This paper is developed in cooperation with Tang Tian, Joern Huenteler and a research assistant from HKS. The paper analyzes the global patenting activity in the solar PV sector from 1968-2012 to identify and explain spatial shifts in the knowledge base of this emerging cleantech industry and improve industrial life-cycle theories in economic geography and transition studies.

In addition to these direct outcomes, two additional SSP-related paper projects might be realized in the mid-term future (after my involvement in the SSP program):

- *Where cleantech industries emerge – a global TIS life-cycle perspective.* This paper would synthesize the insights from several case studies in the power and water sector to make a more general argument on how clean-tech industries emerge and on how and why they move in space.
- *Dynamics of coupled socio-technical-environmental systems - Promising trading zones between Sustainability Science and Sustainability Transitions literature*. This paper would be developed with Bill Clark and try to identify promising conceptual trading zones between Sustainability Science and Sustainability Transitions literature, two closely related, but so far highly isolated streams of literature.

Description of major other intellectual or professional advancement activities over the past academic year:

- Non-SSP journal paper: Establishing Legitimacy for Innovative Technology: California's Experience with Potable Water Reuse. Published in Environmental Science & Technology, 49, 7552-7561.
- Non-SSP book chapter: Cities as mediators between local niches and global networks – How onsite water recycling developed in three Chinese cities. In press in: Urban Sustainability Transitions, Frantzeskaki et al. (Ed.), 2015, Routledge
- Non-SSP journal paper: Legitimation of disruptive innovation - How support for potable water reuse was constructed in California (re-submitted to Technological Forecasting & Social Change with minor revisions).
- Non-SSP journal paper: Path creation, system building and anchoring – The emergence of an on-site water recycling industry in Beijing. Re-submitted to Economic Geography with major revisions.
- Non-SSP journal paper: Barriers to innovation in urban water utilities - Attitudes of Californian wastewater managers towards innovation. Under review at the Urban Water Journal.
- Non-SSP journal paper: Global Innovation Systems and Sustainability Transitions - Towards a transnational perspective. To be submitted to Research Policy
- Organized a special sessions stream and plenary panel discussion on clean-tech path creation at the 2015 annual meeting of the Association of American Geographers (April 21-25 in Chicago, IL)
- Provided background materials and participated in the Harvard-Qinghua workshop on "Energy Technology Innovation Policy in the Backdrop of the U.S.-China Emissions Deal" (June 18-19, 2015 in Beijing, China).
- Developed a research proposal together with Dr. Rainer Quitzow from FU Berlin to be submitted to the Thyssen Foundation in Germany. Title: 'A systemic perspective on the formation of global production networks – The cases of wind power and solar PV'.

Please list citations for reports, papers, publications and presentations that built on your fellowship research:

- Binz, Christian; Chan, Gabriel; Doblinger, Claudia; Huenteler, Joern; Shi, Dongbo; Tang, Tian; Xu, Lei; Diaz Anadon, Laura (2015): Background materials on the Workshop on Energy Technology Innovation Policy in the Backdrop of the U.S.-China Emissions Deal. Belfer Center for Science and International Affairs, Cambridge (MA).
- Full paper presentation: 'Low-carbon leapfrogging in China - a global innovation system perspective'. Presentation held at Qinghua University's School of Public Policy and Management Research Seminar. 12/18/2014.
- Invited panelist: Tufts China-US Symposium on "Common Ground" between the US and China. 04/10/2015
- Invited panelist: 'Insights from a technological innovation system perspective'. Input to an expert panel on 'Forging Green Path Creation: EEG, GPNs and Sustainability Transitions.' AAG Annual Meeting, Chicago, 04/21/2015
- Full paper presentation: 'Beyond regional branching: The emergence of the Chinese solar PV industry'. Workshop on related variety and the product space, Harvard Kennedy School, Centre for International Development, 04/20/2015
- Full paper presentation and session organizer: 'Beyond regional branching: Path transplantation in the Chinese solar photovoltaics industry'. AAG annual meeting, Chicago, IL, 04/21/2015.
- Full paper presentation: 'Low-carbon leapfrogging and globalization: How China developed its solar PV industry'. ETIP/Consortium Energy Policy Seminar. Harvard Kennedy School of Government. 04/27/2015

Please describe any collaborative activities with other SSP Fellows that you are involved with.

In March 2015, I started a collaborative research project with Tang Tian and Joern Huenteler (from the ETIP program). Our project analyzes patent counts in the solar PV sector to reconstruct global shifts in the knowledge base of solar PV module manufacturing. The project is ongoing and the joint paper due in early 2016. Apart from that, I have been in close (but informal) exchange with Liu Zhu, Tang Tian and several Fellows from the ETIP program (mostly Joern Huenteler, Xu Lei and Kavita Surana) and gave inputs on several of their publication projects. I was also involved in conceptual discussions about the innovation system concept with Meredith Niles, Rachel Garrett and Lucilla Spini.

Principal collaborators outside Harvard:
Directly SSP-related collaborators:
Prof. Su Jun, Qinghua University, School of Public Policy and Management
Xia Di (PhD student), Qinghua University, School of Public Policy and Management, former ETIP Fellow (supported the interview organization, joined for industry expert interviews in the YRD Region)

Non-SSP related collaborators:
Prof. Bernhard Truffer – Eawag, Switzerland, Former SSP/ETIP Visiting Fellow
Prof. Lars Coenen – CIRCLE, Lund University, Sweden
Prof. Ron Boschma – CIRCLE, Lund University, Sweden
Prof. Cristina Chaminade – CIRCLE, Lund University, Sweden
Dr. Rainer Quitzow, FU Berlin, Germany
Prof. Liu Xielin, UCAS, Beijing, China
Prof. David Sedlak – UC Berkeley, CA
Dr. Michael Kiparsky – UC Berkeley Wheeler Center for Law

List any awards or grants that you have received this year for the current or coming year:
08/28/2014: Nominated for the Best Paper Award at the 2014 Sustainability Transitions Conference in Utrecht, NL (3 out of 150 papers nominated).
11/10/2014: Swiss National Science Foundation, Early Postdoc.Mobility Grant. Title: Globalization of cleantech industries - Reconstructing China's integration into the global innovation networks of wind power and solar photovoltaics. Amount: 90,000 US$, running for 1.5 years, starting in July 2015.
03/13/2015: SSP Fellows Collaboration Grant. Title: Spatial Dynamics in the Knowledge Base of Emerging Clean-tech Sectors: A patent analysis of globally leading solar PV manufacturing firms. Amount: 5,435 US$, running until December 31, 2015.

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