

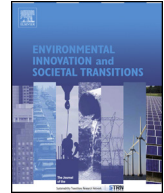


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Contents lists available at ScienceDirect

Environmental Innovation and Societal Transitions

journal homepage: www.elsevier.com/locate/eist



Dynamics of a policy-driven market: The co-evolution of technological innovation systems for solar photovoltaics in China and Germany

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ARTICLE INFO

Available online xxx

Keywords:

Emerging economies
Geography of innovation
Global diffusion of innovation
Lead markets
Technological innovation systems

ABSTRACT

The rise of Chinese solar energy firms has taken many experts by surprise. German policy makers and researchers alike had suggested that the country's ambitious deployment policies would translate into a competitive advantage for the German solar photovoltaics industry. This paper argues that these expectations rested on an outdated model of the international diffusion of innovation. Building on the technological innovation system (TIS) framework and the related system functions approach, the paper thus proposes a new approach for capturing the global dynamics of innovation and industrial development in emerging technology fields. Focusing on a period of dynamic growth in the field of crystalline-based PV technologies, the paper highlights how a set of dynamic and mutual inter-dependencies between an industrialized country (i.e. Germany) and an emerging economy (i.e. China) have driven the development and diffusion of technology in the field.

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1. Introduction

The dynamic development of the solar energy sector over the past decade has been closely linked to Germany's ambitious deployment policies. The German solar feed-in tariff triggered an unprecedented

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<http://dx.doi.org/10.1016/j.eist.2014.12.002>
2210-4224/© 2015 Published by Elsevier B.V.

Please cite this article in press as: Quitzow, R., Dynamics of a policy-driven market: The co-evolution of technological innovation systems for solar photovoltaics in China and Germany. *Environ. Innovation Soc. Transitions* (2015), <http://dx.doi.org/10.1016/j.eist.2014.12.002>

phase of market expansion and enabled the large scale mobilization of private investment for the production and installation of solar photovoltaic (PV) systems. From this perspective, Germany's solar energy policy has been a resounding success. The scale of deployment and the speed with which system prices have been reduced have vastly exceeded expectations (Hoppmann et al., 2014). Moreover, Germany's success inspired other countries to follow suit and introduce similar support schemes, enabling a global market for solar PV to take shape.

Simultaneously, important claims made by the proponents of Germany's ambitious deployment policy have not been fulfilled (BMBF, 2011). Market support was justified with the expected economic advantages for Germany (Bundesregierung, 2002). In the official justification of the revised Renewable Energy Act of 2008, the government cites the policy's role in generating so-called "first mover advantages" for German firms (Bundesregierung, 2008a). In a similar vein, Germany's environment ministry has formulated a strategy for "lead market" development via ambitious demand-side support for renewable energy technologies (Bundesregierung, 2008b). Following the reasoning of Jänicke and Jacob (2004), it argues that policy-induced lead markets for renewable energy technologies are accompanied by competitive advantages for domestic firms. Critics on the other hand claim that German deployment support has merely supported the build-up of a PV industry in China.¹

As this paper will demonstrate, both lines of argument imply a linear concept of innovation and diffusion, which fails to capture the dynamic interaction between the two countries that has shaped the sector over the past two decades. The debate on lead markets draws on an outdated model of innovation and diffusion, which no longer adequately reflects the dynamics of an increasingly integrated, global economic system. Based on a simplistic lead-lag market model, its proponents have assumed that internationalization of demand drives a subsequent internationalization of supply (Beise, 2004; European Commission, 2006; Jänicke and Jacob, 2004; Quitzow et al., 2014). Following from this, firms in the lead market are expected to have an early mover advantage when new technologies diffuse globally. However, as China's rapid rise in the field of solar PV has revealed, this pattern no longer applies to important emerging technology fields. Rather than acting as mere adopters of technology, China and other follower countries have assumed active roles in shaping technology trajectories.

This paper proposes a novel framework to capture these emerging global dynamics of innovation and diffusion. To do so, it draws on the technological innovation system (TIS) literature and the related approach for analyzing TIS functional dynamics. Focusing on a period of dynamic growth in the field of crystalline-based PV technologies, the proposed framework is used to highlight how a set of dynamic and mutual inter-dependencies between an industrialized country (i.e. Germany) and an emerging economy (i.e. China) have driven development and diffusion of technology in the field. It demonstrates how uneven policy, market and industry dynamics in these spatially distinct entities have co-evolved and reinforced each other, thus enabling the dynamic market growth and industry expansion at the global level. This perspective serves as a complement to the contribution from Dewald & Fromhold-Eisebith in this special issue, which points out how processes at different yet overlapping spatial scales have influenced and mutually reinforced the development of Germany's TIS for solar photovoltaics (PV).

The paper begins with a review of the current debate on geographic dimensions in the analysis of TIS dynamics. Building on this, the paper proposes a novel analytical approach to capture geographical differences and cross-country inter-dependencies in the analysis of TIS functional dynamics. Next the empirical research case and methods of data collection are briefly presented. The analytical framework is then applied for the analysis of the TIS for solar PV in China and Germany. The paper closes with a synthesis of key findings and a number of policy-related conclusions.

2. Considering geographical dimensions of TIS dynamics

The system functions approach for analyzing TIS development, as proposed by Bergek et al. (2008) and Hekkert et al. (2007), has emerged as a useful framework for analyzing the dynamics of innovation

¹ See for example "The Sun Rises in the East: German Solar Firms Eclipsed by Chinese Rivals," *Spiegel Online*, September 07, 2011. Accessed on May 27, 2014 at <http://www.spiegel.de/international/business/the-sun-rises-in-the-east-german-solar-firms-eclipsed-by-chinese-rivals-a-784653.html>.

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