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Low-carbon innovation and technology transfer in latecomer countries: Insights from solar PV in the clean development mechanism

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ABSTRACT

This paper examines the organizational arrangements for technology supply in solar photovoltaic projects in the Clean Development Mechanism (CDM). It shows that while lower middle-income countries typically import solar PV equipment into CDM projects, China, India and Thailand have begun to use new organizational arrangements for technology transfer which reflect the overall industry maturity in the solar PV sectors in these countries. This has great potential for long-term climate change mitigation efforts. However, the initiation of these new organizational arrangements often preceded the supply of technology into CDM projects. This raises important questions about the role of CDM in spearheading the development of technological capabilities required for sustainable development. The paper uses these findings to add to the literature about technology in CDM and to the wider policy debates over the future of the global climate regime. Technology transfer does not become less important as developing countries' capabilities mature, but the nature of technology transfer changes over time. This suggests a need to differentiate between countries at different levels of development. Lower middle-income countries may have greater needs for building technological capabilities whereas cooperative activities may be suitable for upper middle-income countries that already have capabilities to address climate change.

1. Introduction

The global community is currently discussing how new policies, instruments and funds can aid the global response to climate change in a 'Climate Regime Mark II' by 2020 as a replacement of the current Kyoto Protocol (or 'Climate Regime Mark I'). Understanding the role of technology transfer matters in this regard because there is strong recognition that policy debates need a deeper understanding of the arrangements through which technology is developed and deployed internationally (Berkhout et al., 2010; Ockwell et al., 2008).[1] This article seeks to inform those policy debates by seeking insights from technology transfer in the Clean Development Mechanism (CDM). The CDM is a 'project-based' mechanism under the Kyoto Protocol devised to encourage production of emission reductions in developing countries. To stimulate sustainable development, CDM should facilitate low-carbon technology transfer from advanced to developing economies in connection with implementation of emission reduction projects (UNFCCC, 2002). Depending on how technology is supplied and deployed, CDM projects may stimulate technological learning and related upgrading of capabilities to mitigate climate change both within and potentially beyond the individual CDM project. In other words, understanding the technological learning results of CDM projects is important to assess the dynamic opportunities for virtuous cycles of mitigation capabilities, technology cost reductions and further greenhouse gas reductions. Insight on these issues could further help to understand how opportunities diverge between lower middle income countries and emerging economies that have very different preconditions for engaging with advanced technology as well as different capabilities for contributing to mitigation of climate change.

1.1. Technology and sustainable development in CDM

The Clean Development Mechanism was established with the 1997 Kyoto Protocol of the United Nations Framework Convention on Climate Change (UNFCCC) and is currently in effect as an element of the second commitment period from 2013 to 2020. The CDM was established with a double objective. First, it created a mechanism whereby developed countries could comply with their national greenhouse gas reduction commitments by implementing emissions reduction projects in developing countries. CDM provides a financial incentive – through generation of tradable certified emissions reductions – to implement low-carbon projects in developing countries. Secondly, it sought to promote sustainable development in low and middle income CDM project 'host countries'. Although developing countries do

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[1] The term 'policy debates' is used in a broad sense, including negotiations in the United Nations Framework Convention on Climate Change (UNFCCC) over reform of CDM and the future of mitigation action as a whole, and the political and academic debates regarding technological capabilities and capacities for mitigation actions by emerging economies such as China and India.

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not have emissions reductions commitments, the CDM has to assist these countries in achieving a low-carbon development pathway.

However, the results of the twin objective of CDM are much debated. First, while CDM is increasing the costs effectiveness of developed countries' Kyoto Protocol compliance, there is some controversy because it is questioned whether some CDM projects are additional to baseline emissions scenarios. Some CDM projects are already so cost-effective that they would have been implemented without the CDM revenue stream (Schneider, 2009). Secondly, there is a debate over whether CDM has been more effective in reducing mitigation costs than in advancing sustainable development (World Bank, 2010; Castle, 2012). Several studies show that so-called 'co-benefits' associated with CDM, such as job creation or improved air quality, are often absent or rather limited (Nussbaumer, 2009; Olsen and Fenhann, 2008; Sutter and Parreño, 2007).

The same discussion is ongoing about one particular co-benefit: transfer and development of technology (UNFCCC, 2012). The guidelines for CDM stipulates that 'clean development mechanism project activities should lead to the transfer of environmentally safe and sound technology and know-how' (UNFCCC, 2002). Before approval, CDM project design documents have to include a description of 'how technology will be transferred, if any'. Hence, technology transfer is a potential by-product of CDM projects, not a formal obligation. There is agreement, however, that technology transfer in CDM projects can help developing countries to address the climate mitigation challenge.

1.2. Research focus

A substantial body of literature has addressed the extent of technology transfer in CDM projects (e.g. de Coninck et al., 2007; Dechezlepretre et al., 2009; Dechezleprêtre et al., 2008; Haščič and Johnstone, 2011; TERI, 2012; UNFCCC, 2010, 2012). Much of this research is consistent with the technology transfer definition by the Intergovernmental Panel on Climate Change, that technology transfer comprises a "broad set of processes covering the flows of know-how, experience, and equipment" between various types of actors (IPCC, 2000, p. 3).[2] Effectively, however, much CDM research has focused on a subset of the definition: import of mitigation equipment into developing countries. Flows of equipment (and associated know-how) deliver primarily mitigation capacity to technology importing countries, which is the main purpose of CDM. But alone they add little to these countries' innovation capacity or technological learning (Bell, 1990, 2009). In other words, most technology transfer in CDM literature shed little light on actual organizational arrangements for technology transfer and the impact of technological learning and innovation.

To do so, it is necessary to search beyond simply import of equipment and assess the full a variety of organizational arrangements underlying CDM projects. It is not sufficient to only distinguish between local and foreign technology. This insight comes from recent studies which showed that technology used in CDM projects does not just come from cross-border trade in off-the-shelf products. It is also delivered through organizational arrangements such as subsidiaries of multinational enterprises, joint ventures or licensing of technology (Hansen, 2011). These organizational arrangements for technology transfer have been described as 'conventional' in that technology flows more or less unidirectional from developed to developing countries and that they require little interaction and effort by recipients.[3] Recent non-CDM literature has further identified 'unconventional' transfer which involve even more complex processes of technology transfer, implying that flows are not unidirectional and that collaborative interaction and developing country effort are high (Lema and Lema, 2012; Fu and Zhang, 2011).

This study extends the CDM technology transfer literature by examining conventional and unconventional transfer and local innovation through what we term 'organizational arrangements' for local and international technology supply in CDM. We examine whether, how and ultimately why firm-level organizational arrangements differ between countries hosting CDM projects. This study is empirically based on research of solar photovoltaic (PV) technology in CDM projects. Solar PV is a useful sector for examining organizational arrangements for technological learning in CDM because it is implemented in different types of developing countries and solar PV is likely to become an important source of low-carbon electricity in developing countries. It is pertinent to examine this because the bulk of solar PV CDM is located in relatively advanced emerging economies. Given that some emerging economies have solar PV industries, it is relevant to examine the role of the CDM in opening up new organizational arrangements at the country level.

The paper is guided by the following research questions: What are the key organizational arrangements in solar PV CDM projects? Are there differences between CDM solar host countries with respect to the degree to which they utilize different types of organizational arrangements? To what extent do CDM projects spearhead new arrangements that have not previously been utilized in host countries?

To answer these questions, the paper is structured as follows. The next section develops the analytical framework for analysis. It draws on the literatures on technological capabilities and international technology transfer. Section 3 describes our methodology which uses 'observed' organizational arrangements as the basis of analysis. In contrast to the previous methodological paradigm that used CDM internal data (projects 'claims') (e.g. de Coninck et al., 2007; Dechezleprêtre et al., 2008; Seres et al., 2009; UNFCCC, 2012) we also draw significantly on CDM external data and contextual information. Section 4 presents the empirical findings describing the organizational arrangements and their distribution between countries. Case studies of China, India and Thailand are analyzed due to their simultaneous importance in solar PV CDM projects and their "latecomer" status.[4] This section also examines whether CDM appears to instigate new organizational arrangements or not. Section 5 concludes the paper and discusses the implications for policy makers and scholars interested in climate and energy related to technology transfer and innovation in developing countries.

2. Low-carbon innovation and technology transfer in latecomer countries

This section develops a framework for examining organizational arrangements used in the CDM. In order to do so we begin with the role of technological development in latecomer settings and subsequently we explore the role of international linkages in this respect. Finally, we present a typology of local innovation and conventional and unconventional transfer that may be used for delivery of technology into CDM projects.

2.1. Sustainable development, learning and innovation in latecomer settings

The accumulation of relevant technological and innovation capabilities adds to countries' ability to engage in climate change mitigation, not only as a user of low carbon technology but also a producer and innovator (Bell, 2012; Ockwell et al., 2013). Merely importing and installing solar panels or other green technologies

[2] For a discussion and critique of the term, see Lema and Lema (2012, p. 39f).

[3] Such mechanisms are also important for the transfer of low carbon technology outside the CDM (e.g. Brewer, 2008; Less and McMillan, 2005; Popp et al., 2011).

[4] South Korea is not included as a case country. Although South Korea is a non-Annex 1 (developing) country in the UNFCCC and a considerable host to solar PV projects, it is also an OECD country and we do not give it particular attention.