



# Technological capacity building through energy aid: Empirical evidence from renewable energy sector

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## ABSTRACT

This study looks at foreign aid as a channel to transfer clean technologies to developing countries, including those with smaller economies. The focus is on the technological knowledge transfer through the technical cooperation of foreign aid. As transferred knowledge accumulates, the recipient country's technological capacity increases. To better understand this accumulating capacity, this study explores the effect of foreign aid as a channel of technology transfer on the recipients' technological capacity in the renewable energy sector. To investigate the effect of hands-on assistance, the empirical model estimates the long-term effects of foreign-aid disbursements for non-hydro renewable energy (NHRE) projects. I find that foreign aid for technical cooperation in NHRE projects catalyzes investments in NHRE capacity in low-income countries with a long incubation period. The findings confirm that hands-on cooperation, as emphasized by developing countries, contributes to their capacity building, although only in countries with low capacity to begin with. This study contributes to the ongoing discussions on the effectiveness of technology transfer channels for clean energy.

## 1. Introduction

International climate change and aid communities have recognized the importance of raising the technological capacity of clean energy in developing countries. In 2008, nations adopted the Bali Action Plan, which emphasizes recipients' capacity building through environmentally sound technology transfer. The U.S. Agency for International Development (USAID) launched its flagship program “Enhancing Capacity for Low Emission Development Strategies (EC-LEDS)” to support developing countries through technical assistance and knowledge sharing (USAID, 2013). Within the World Bank and United Nations, the discussions on sustainability emphasize the deployment of and capacity-building for clean energy technologies in developing countries (Sustainable Energy for All, 2012; World Bank, 2014).

Clean energy helps countries to move toward sustainable development, yet it often requires more advanced technologies than traditional carbon-intensive energy. Thus, raising technological capacity for use of advanced clean energy technology becomes one of the prerequisites for sustainable development. However, low technological capacity has prevented some developing countries from benefiting from advanced technologies. Low-income developing countries with small markets are less likely to attract technology transfer from the private sector through channels such as foreign direct investment or licensing in the energy

service industry (i.e., electricity).<sup>1</sup> Therefore, foreign aid, flowing in the public sector, becomes a potential channel for technology transfer among developing countries with small economies, providing them an opportunity to increase their technological capacity. Focusing on this function, this study examines the effect of foreign aid on the technological capacity to generate clean energy.

Despite the increasing attention on clean energy, studies focusing on the energy sector within foreign aid are rare (for example, Kretschmer, Hübler & Nunnenkamp, 2013). In the foreign aid literature, many studies focus on the education (Asiedu and Nandwa, 2007; Dreher, Nunnenkamp and Thiele, 2008; Michaelowa and Weber, 2006), health (Walt et al., 1999; Williamson, 2008), and agriculture (Kherallah et al., 1994; Norton et al., 1992) sectors. Studies on the energy sector often focus on the effects of foreign direct investment (FDI) on energy consumption (Hubler and Keller, 2010; Meinik and Goldemberg, 2002; Perkins and Neumayer, 2009), rather than on the effects of foreign aid. Recently, a few studies have looked at foreign aid in the energy sector; however, they mainly focused on specific technologies (Tigabu, Berkhout & van Beukering, 2017; Nejj et al., 2017), a specific region (Dornan and Shah, 2016), or a specific sector (Kretschmer et al., 2013). Rogner (2013) evaluated the effectiveness of foreign aid on sustainable energy by reviewing literature on aid projects. However, these studies do not pay central attention to the recipient's capacity via knowledge transfer. In this paper, I pay further attention to the technical

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<sup>1</sup> For evidence of the low impact from FDI on environmentally friendly technology diffusion, see Perkins and Neumayer, 2009.

cooperation of aid—a foreign aid mechanism that transfers tacit knowledge—and its effect on technological capacity for clean energy. The mode of knowledge transfer, delivering embodied or disembodied knowledge, becomes a key attribute of foreign aid in this paper. Technology transfer literature has emphasized tacit knowledge but not quantitatively investigated it with an econometric approach. To my knowledge, this is the first study examining technology cooperation in foreign aid within the energy sector with econometric analysis. Filling this gap in the literature, this study has policy implications for both clean energy and aid communities, in terms of sustainable energy transitions in developing countries. Also, this study contributes to the literature on the renewable energy sector of foreign aid by testing whether foreign aid increases recipients' ability to invest in renewable energy. Although practitioners have paid attention to the renewable energy sector, analyses on the renewable energy sector of foreign aid within the academic literature have been fragmented. Lastly, this study revisits capacity building in foreign aid, with a specific focus on the renewable energy sector. Aid literature on capacity development has been limited to theoretical or framework studies (An et al., 2017). Empirical studies on aid effectiveness often focus on the end result of economic development, rather than the recipients' ability to support themselves within the sector. This study provides the international community with quantitative evidence of foreign aid's effectiveness in capacity development.

The rest of the paper is organized as follows. The next section describes the theoretical framework that motivates this study. The third section describes the data and methodology used in the analysis. The fourth section presents the results from the empirical analysis. Finally, the fifth section concludes this paper with discussions and policy implications.

## 2. Technological capacity and knowledge transfer in foreign aid

In this study, foreign aid is seen as a channel by which to transfer knowledge. Two streams of literature are relevant to the recipient's capacity. Literature on the economics of knowledge transfer has heavily investigated recipients' absorptive capacity at the firm level, specifically which factors determine the success of knowledge transfer.<sup>2</sup> At the firm level, human resources (Adler, 1965; Guillaumont and Chauvet, 2001, as cited in Chenery and Strout, 1966, recited from Lensink and White, 2001; Rosenstein-Rodan, 1961) are the major attribute of absorptive capacity. Meanwhile, the literature on capacity development (CD) in foreign aid focuses on the recipient's capacity after an aid transfer (Manning, 2008; An et al., 2017; for technological capacity, see Chen and He, 2013; Watkins and Ehst, 2008). Capacity development is a process in which different entities within a society (including individuals, organizations, institutions, and society) reach the goal (such as to solve problems, perform functions, or manage affairs) and maintain that ability (UNDP, 1997; Godfrey et al., 2002; Manning, 2008; An et al., 2017). The emergence of capacity development in the practitioner community has led the academic community to discuss the concept behind the evaluation of aid for capacity development. Most of the studies are theoretical and involve developing frameworks to evaluate CD in aid projects (and Wehn, 2016).<sup>3</sup> Although some studies apply CD frameworks in several sectors with country-specific case studies (e.g. Sanz et al., 2013 for water sector; van Loon et al., 2010 for environmental impact assessment), there are hardly any studies investigating the energy sector.<sup>4</sup> Moreover, past discussions on CD have focused mainly on the aid recipients' institutional capacity, which has

<sup>2</sup> For foreign aid, see and Radelet, 2003; for general technology transfer, see Keller, 1996, 2004.

<sup>3</sup> For more comprehensive analysis of these studies, see An et al. (2017).

<sup>4</sup> Sovacool and Drupady, 2012 studied cases of small-scale renewable energy projects in selected developing countries. Although based on extensive fieldwork, the cases in their research presented mixed results on the success of projects. Plus, technological capacity was not a central theme of the analysis.

been emphasized in aid effectiveness literature highlighting domestic policy and governance (Collier and Dollar, 2002; Clemens et al., 2004; Dalgaard et al., 2004; Durbarry et al., 1998; Hadjimichael, Ghura, Mühleisen, Nord, & Ucer, 1995; Hansen and Tarp, 2000, 2001) as determinants of successful aid projects.

Focusing on CD makes the recipient's capacity an endogenous variable influenced by incoming foreign aid. In a successful setting, external knowledge through aid transfer increases the absorptive capacity for future transfers. The end result of increased capacity includes increased absorptive capacity as well as enhanced latent factors that influence the internalization of external knowledge. At the firm level, absorptive capacity is not a mere sum of an individual member's capacity but also includes inter- and intra-organizational communications (Cohen and Levinthal, 1990). Analogously, a country's absorptive capacity is then the sum of absorptive capacity at the firm level and communications traveling internationally or through intra-national networks. In low-income developing countries, with low capacity among private firms to absorb foreign knowledge, the role of government becomes important, especially in spreading the transferred knowledge to the private sector. This role of government is an example of latent factors included with the country-level capacity. In this study, we specifically focus on technological capacity that promotes the spread of transferred knowledge attached to technology.

Having the capacity to use the knowledge entails the ability to combine local and external knowledge. New knowledge is acquired through foreign aid projects, in which the recipient countries actively absorb the inflow of transferred technology.<sup>5</sup> The transferred knowledge increases the recipient's technological capacity to use the knowledge. This lets the recipient further apply the transferred knowledge to other projects and reproduce similar projects on its own. For example, a wind turbine is transferred and needs to be connected to the local electricity grid for the electricity generated from the turbine to be used. Such knowledge first comes from external sources. If the knowledge transfer has been successful, then the recipients will be capable of combining local and external knowledge after the closure of an aid project. This will lead to the reproduction of similar wind turbine installations that the recipient can connect to its grid system on its own.

The transferred knowledge may also enhance recipients' technological capacity to design and improve the technology. This will increase the domestic manufacturing of the equipment with improved features—for example, more efficient wind blades for wind turbines. China and India have been successful in enhancing their technological capacity through knowledge transfer (Lewis, 2007). However, foreign direct investment provided the channel for knowledge transfer in these cases, rather than aid. This type of capacity may lead to the export of improved products. However, most of the recipient countries have low levels of absorptive capacity, which limits the extent of knowledge that foreign aid transfers.

As their capacity is enhanced, countries experience four stages of knowledge accumulation: *pre-catching-up*, *catching-up*, *pre-frontier-sharing*, and *frontier-sharing* (Criscuolo and Narula, 2008). Most foreign aid recipients are at the pre-catching-up stage. For low-income developing countries, the immediate goal is not catching up with the frontier group but sustaining themselves in the pre-catching-up stage. Within the pre-catching-up stage, however, a threshold effect of capacity exists for a host country to benefit from the external knowledge.<sup>6</sup> Before reaching the threshold, countries do not have the capacity to acquire or use existing knowledge. Once they pass the threshold, countries can explore the technology options and acquire and use existing knowledge.

<sup>5</sup> Literature focuses on firms' behaviors in identifying useful new knowledge from external sources (Zahra and George, 2002). Examples of studies focusing on a country as their unit of analysis are: Keller (1996); and White, 1997; Mowery and Oxley (1995); Watkins and Ehst (2008).

<sup>6</sup> For more literature reviews on this, see Criscuolo and Narula (2008).

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