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Strategic structure matrix: A framework for explaining the impact of superstructure organizations on the diffusion of wind energy infrastructure

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HIGHLIGHTS

- A new framework—the Strategic Structure Matrix—is proposed.
- It characterizes strategic initiatives designed to promote innovation diffusion.
- The matrix was validated using case study data on wind power diffusion in India.
- The matrix can help shape government policies to improve RET diffusion.

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ABSTRACT

Increasing the use of renewables in the global energy mix has become a top priority for policy makers. In this paper, we use a diffusion theory based approach to analyze the impact of government initiatives on the development of wind energy infrastructure focusing on the specific case of wind energy diffusion in India. We propose a new framework—the strategic structure matrix—as a way to characterize the strategic focus and analyze the effectiveness of different initiatives to increase wind power diffusion. We apply the matrix to explain the different pace and paths of wind energy growth observed in five Indian states: Tamil Nadu, Gujarat, Maharashtra, Andhra Pradesh, and Karnataka. Our findings suggest the importance of a comprehensive approach that includes multiple strategies across initiatives, local regulatory measures, and supply-side incentives.

1. Introduction

Concerns over climate change and environmental pollution have placed a strong emphasis on increasing the share of renewable energy technologies (RETs) in the world's energy mix. In the past decade, great strides have been made to develop and use renewables for electricity production, heating and cooling, and transportation. In 2010, renewable sources generated 16.7% of total energy consumed worldwide, and wind capacity alone has increased from 6.1 GW in 1996 to 238 GW in 2011 (REN21, 2012). However, as demand for energy continues to increase, especially in developing countries where it has historically outpaced supply, there is an urgent need for greater inclusion of RETs.

The growth of renewable energy is aided by the policies and actions of various organizations, including local and national governments. However, some policy measures have led to greater development of renewable energy infrastructure than others, and the impact of the same initiative in different cities, states or nations are far from identical. It is important to understand why and under what conditions certain strategies have met with success, in order to better inform policy makers on designing initiatives to increase renewable energy use.

In this paper, we use a diffusion of innovation lens to analyze strategies used by organizations to promote diffusion. In the next section, we use past literature to develop a novel framework—the strategic structure matrix—to improve existing analysis of the impact of organizational initiatives on the pace of diffusion. The explanatory value of the matrix is tested by examining the initiatives used by

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government organizations in India to promote the development of wind energy infrastructure from 1992 to 2011. Section 3 presents the research setting and methodology, which begins with a country-wide overview and then narrows focus to five states: Tamil Nadu, Gujarat, Maharashtra, Karnataka and Andhra Pradesh. The results of our analysis of these five states are presented and discussed in Section 4. Section 5 contains the contributions and limitations of the paper, and offers suggestions for future research. Section 6 concludes the paper.

2. Organizations and diffusion

Using Rogers' (2003) definition, diffusion is "the process in which an innovation is communicated through certain channels over time among members of a social system" (Rogers, 2003, pg 5). Innovations are ideas, processes and technologies that are perceived as new by an adopter. Communication channels may include mass media and word of mouth through social networks. Lastly, the social system comprises of members who may be potential adopters. Much of diffusion research seeks to understand the factors that lead to adoption or non-adoption of an innovation, often with the ultimate goal of learning how to make it diffuse more quickly.

Research has shown that organizations, including governments, academic and research facilities, industry and trade associations, often play an important role in the diffusion of new technologies. For example, despite the prominence of Sony during the commercialization of the transistor radio in Japan, the Japanese Ministry of International Trade (MITI) and the government Electrotechnical Laboratories (ETL) helped establish a competitive market, diffused knowledge of the new technology, and demonstrated its technical capabilities before Sony entered the market (Lynn, 1998). These actions played a key role in successful diffusion. In another part of the world, a case study on the development and diffusion of biomass technologies in Austria identified fifteen organizations on the supply-side alone which shaped the spread of biomass boilers in the agricultural community, including the Chamber of Agriculture and the Regional Energy Association as two of the most influential (Rohracher, 2002). Their "intense promotional and networking efforts" were crucial in jump-starting diffusion during the initial phases. The next logical question is then, what is it about these organizations that make their actions so effective?

2.1. Innovation community framework

While many empirical studies examine organizations' involvement in diffusion, Lynn et al. (1996) found that there existed no analytical framework for identifying how relevant organizations affect the rate of diffusion or the path of such diffusion. Borrowing from the ideas of organizational ecology to find the boundaries of organizations involved in diffusion, they created the "innovation community" framework which allows classification of organizations into superstructure and substructure organizations. Substructure organizations are producers of the innovation or its technological components. They perform almost all economic research on the innovation. Superstructure organizations coordinate the flow of information and activities within the innovation community. They are usually non-market entities and include governments, research institutions, and professional or trade associations. Superstructure organizations are generally taken for granted in the literature on the diffusion process (Reddy and Rao, 1990) and therefore have not received much scholarly attention. In this paper, we will focus our attention on superstructure organizations and their role in diffusing renewable energy technologies.

Past research has shown that certain characteristics of a superstructure organization can determine its effectiveness in promoting innovation diffusion. Some characteristics include size, heterogeneity within the organization, basis of authority, level of centralization, and purpose (Howells, 2006; Lynn et al., 1996). Referring to the case studies mentioned earlier, the Chamber of Agriculture was able to take the role of a "system builder" in diffusing biomass technology in Austria because of its high basis of authority and its ability to influence other organizations (Rohracher, 2002). The success of Japan's ELT in aiding the commercialization of the transistor radio can be attributed to its purpose of advancing new technologies and leasing patents to various firms (Lynn, 1998). If the transistor had been developed by a single firm, it is unlikely that technical knowhow would have propagated as rapidly as it did.

While useful, analyzing a superstructure organization's characteristics does not singularly explain how it accelerates diffusion. A single organization may be involved in the diffusion of several innovations but with varied success, perhaps because of the different actions it chooses to take regarding each one. For example, India's Ministry of New and Renewable Energy recently had many initiatives to promote development of both wind and solar power. Despite findings that its initiatives contributed to early growth of wind energy (Rao and Kishore, 2009), analysis of the 2003 National Solar Mission found that it slowed growth of solar industries in certain areas and predicts that it will negatively impact future diffusion of decentralized solar applications (Harish and Raghavan, 2011; Raghavan et al., 2010). Additionally, superstructure organizations with similar traits may have different success with their initiatives. Therefore it is also important to look at the specific actions of superstructure organizations and the strategies they use in aiding innovation diffusion.

2.2. Increasing the focus on strategy

Few researchers have examined the strategic focus of initiatives employed by superstructure organizations and their role in innovation diffusion. After reviewing existing literature, the authors have identified five key categories of strategies: lowering a diffusion barrier, empowering an actor type, enabling an environment necessary for diffusion, targeting the technology or the support infrastructure, and affecting supply or demand. We now describe each of these categories in greater detail.

2.2.1. Lowering a diffusion barrier

Data collected during a 2012 interview with a researcher from the World Resources Institute classified the three major barriers to technological diffusion as technological, financial and regulatory. Technological barriers prevent a new technology and its support infrastructure from functioning properly or adapting to local conditions. Additionally, "technological lock-ins" can occur, in which the dominance of incumbent technologies prevent widespread use of innovative technologies (Foxon and Pearson, 2008). Funding for research and developing demonstration projects would be examples of initiatives aimed at overcoming technical hurdles. Financial barriers are ones in which the cost of or access to capital limit the commercialization of a technology for widespread use. Wind power in India is a more expensive technology for electricity production than many of its competitors, including fossil fuel-based generation methods, giving it a competitive disadvantage (Sargsyan et al., 2010). A United Kingdom case study also found evidence that the promotion of innovation is at odds with the economic efficiency of existing technology (Foxon and Pearson, 2008). Tax credits or access to low interest loans correct this disadvantage and reduce financial barriers for developers.