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Innovation core, innovation semi-periphery and technology transfer: The case of wind energy patents☆

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ABSTRACT

Some scholars have pointed to a rise of South-South technological transfer led by emerging economies such as China, India, Brazil and South Africa while other scholars highlight that emerging economies still need to catch up with developed countries. Drawing on world system's theory, we argue that an adapted innovation framework of 'core - semi-periphery - periphery' could be an important analytical framework that may help us understand the process of innovation catch up. This may help specifically to better understand how an emerging economy can at least in theory have sectors that could be defined as innovation core and source for technology transfer. We will look at wind energy as North American, European, Indian and Chinese firms dominate the market. This study used citation network analysis and patent analysis to analyse knowledge flows between wind firms and to identify and compare the positon and role of each firm in the knowledge network. We argue that there is still, despite catching up, a difference between innovation core countries (US, Germany, Denmark) and innovation semi-periphery (China, India) which will limit the opportunities of knowledge transfer within the sector of wind energy.

1. Introduction

The academic field of international technology transfer and co-operation has had more than three decades to mature as a subject (Bell, 1990; Able-Thomas, 1996). There has been a recent discussion around how the rise of China and India (Kaplinsky and Messner, 2008; Humphrey and Messner, 2006) will change the overall role of these countries as prospective drivers of innovation. Urban et al. (2015) argue that much of the literature and debates on low carbon technology transfer and cooperation is restricted to North–South technology transfer from high-income countries to low and middle income countries. The rise of emerging economies like China, India, South Africa and Brazil as new economic, political, social and technological powers however challenges the pre-conceptions about low carbon technology transfer and rebalances the focus towards South–South technology transfer and cooperation (Urban et al., 2015).

This article argues that we need to be more realistic of the nature of South-South low carbon technology transfer and analyse different energy sectors as it could be that a country could be a low carbon innovative core country in wind energy but far less developed in other renewable energy sectors such as hydropower and solar energy. The article will not make conclusions on the overall capacity of a country to produce and transfer knowledge but just discuss the narrow sector of a low carbon sector such as wind energy corporations.

There has been an expanding list of research that explores the distinction between how Asian and European wind firms have engaged in different ways of facilitating low carbon technology transfer and technology cooperation (Lewis, 2013; Gosens and Lu, 2013; Lema and Lema, 2012, 2013; Schmitz and Lema, 2014; Dai et al., 2014; Nordensvärd and Urban, 2015). There has been an ambiguous focus on North-South technology transfer as a blueprint and how this could be challenged by a South-South technological transfer framework heralded by emerging economies such as China, India, Brazil and South Africa.

Recent additions to the literature assert that Chinese, India and European wind energy firms are engaged in a complex set of technology cooperation (e.g. Schmitz and Lema, 2014; Lema and Lema, 2012; Urban, 2018). For at least three decades, China and India have been the recipients of transferred wind energy technology from the European Union (EU) countries (Lema and Lema, 2012; Mallett et al., 2009). This followed the classical North–South technology transfer model involving Foreign Direct Investment (FDI), Overseas Development Aid (ODA) or domestic investments for foreign-acquired technologies.

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The mainstream research in this area has repeatedly suggested that these emerging economies are in an innovation catch-up mode. The production capabilities have risen in these countries but this has not meant that low carbon innovation capabilities have matched this development. Often there has been a discussion on firms from China and India needing to catch up and act in a certain way, which differs from the firm strategies of advanced economy multinationals, including in the wind energy industry (Awate et al., 2012, 2014).

The main issue here is: how do we define the nature of an innovation catch up? Does this mean merely that developing countries have adapted and deployed innovation from the global North/developed countries or does it mean these countries have themselves become creators of innovation and a source for technology transfer to other countries? There is a need to create a framework to categorize the difference between "being there" and "catching up" as both signify a different status in innovation.

We argue that an adapted innovation framework of 'core – semi-periphery – periphery' could be an important analytical framework that may help us understand the process but also the nature of low carbon innovation catch up. This may help specifically to better understand how an emerging economy can have sectors that could be defined as innovation core and source for technology transfer or at least moving in this direction.

This relies on adapting Wallerstein's conceptualization of periphery and semi-periphery (Wallerstein, 1974), drawing on world system's theory, which argued that some countries could find themselves in between center and periphery which could be seen as an intermediate position – a semi periphery. We argue that this could fit very well to describe innovation where catching up would imply an innovation semi-peripheral position. This article focuses less on innovation periphery and there is a need to research the difficulties for innovation to reach least developed countries and they are often completely disconnected from the innovation process. This article will therefore focus on the differences between core and semi-periphery.

We will look at the wind energy sector in North American, European, Indian and Chinese corporations as these corporations dominates the market. We have also chosen these countries as North America and Europe are seen as developed countries and India and China are still seen as developing countries. We have chosen wind power as a case as corporations in both China and India have become among the top 10. If there has been a technological catch-up it should be visible in this sample.

China is the world's largest wind energy market and three of its biggest wind energy firms, Goldwind, Guodian United Power and Mingyang, are part of the global top 10. India is the world's fourth largest wind energy market and its leading wind energy firm, Suzlon, is part of the global top 10. At the same time, European wind energy markets and European technology have become internationalised due to the entry of big wind energy firms from emerging economies that have licensed technology, set up joint ventures, acquired and merged with European wind energy firms. We have added also corporations from other countries inside and outside Europe to get a relation on the overall position of Chinese and Indian corporations on the innovation maps.

A way to discuss how innovation cores differ from innovation semi peripheries is by analysing patents, and how widely these are used. This study used citation network based on enterprises patents to presents knowledge flows between wind firms. Using mapping fits very well with the concepts of core and semi-periphery as we create and analyse actual maps of innovation nodes where we can find both center and periphery.

We searched more than 6500 basic patent applications which belong to 16 leading wind firms (General Electric (GE), Vestas, Siemens, REpower/Senvion, Gamesa, Guodian United Power, Aerodyn, Mingyang, Sinovel, Goldwind, Suzlon, Enercon, Envision, Fuhrlaender, REgen, Vensys) between 2000 and 2015. We used network-based methodologies to analyse patent citations, which can identify and compare the positon and role of each firm in the global knowledge network. Patent analysis based on patent map and patent citation network is applied in this study to analyse the key technology trajectory and comparison of international technology distribution. We used ThemeScape in the Thomson Innovation (TI) patent information platform to analysis the technology clusters, which was generated based on word frequency from patent information.

The study concludes that by looking at patents there is a considerable difference between wind firms from Countries such as Germany, Denmark, US and wind firms from China and India on the other side. More specifically, the paper finds that wind energy firms in the global North, such as Vestas, Siemens, Gamesa, Aerodyn, Enercon, General Electric are based at the core of innovation systems, hence they have more patents than their Chinese and Indian counter-parts, as well as having more citations and therefore being stronger represented in global knowledge networks. Chinese and Indian firms, such as Suzlon, Guodian United Power, Mingyang and Goldwind are emerging, more after 2007/8 than before, but are still located at the semi-periphery compared to their competitors in Europe and the US. There are still difference between platform technologies where there is less difference between some corporations from developed countries on one side and emerging economies on the other side. In the mapping of emerging offshore technologies and complementary technologies we can still see a more dominant position of Western/European corporations as innovation cores. The core are also more of knowledge producers that focuses on research and development on core patents whereas the latter focuses more on introduction, adaption and absorption of knowledge but with a lower knowledge transfer.

2. Background and literature review

2.1. Innovation and technology transfer

The paper aims to combine the theories of international technology transfer and cooperation for low carbon innovation and World System Theory to create a better categorisation of innovation in different technological sectors and how this can help us understand the challenges of technological transfers for emerging economies. Transfer of low carbon technology has been fundamental in providing access to wind energy innovation in emerging economies such as China and India whereas most developing global south countries have received little.

First, the paper discusses what is meant with innovation and then technology transfer and cooperation is being discussed. Innovation is here defined as creating something new, developing a new product, service or idea (Rogers, 2003). Innovation is more than just an invention or R&D but could be seen as a set of processes within a larger system (Carlsson and Stankiewicz, 1991). Technology is very much interlinked with the social system which means to consider different actors, networks, and institutions (Rogers, 2003). The scope of innovation system contain the full spectrum of energy systems such as supply and demand, all stages of the technology development cycle and also all innovation processes, feedbacks, actors, institutions, and networks (Gallagher et al., 2012).

Wind energy innovation systems relate to wind power generation (e.g. core technology and components for wind turbines), transmission and distribution (e.g. grid systems), as well as systems that relate to the deployment of wind energy (e.g. offshore/onshore). Innovation systems also include broader issues beyond the hardware, such as skills, expertise and knowledge (Urban et al., 2012). Changes in innovation paths can depend on various factors like firm strategies, market strategies, competition, previous innovation (Porter, 1990).

The broad and inclusive term "transfer" encompasses diffusion of technologies and technology cooperation across and within countries. It comprises the process of learning to understand, utilise and replicate the technology, including the capacity to choose it and adapt it to local