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Open innovation in the power & energy sector: Bringing together government policies, companies' interests, and academic essence

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ABSTRACT

The Power and Energy (P & E) sector needs to respond to several challenges fostering investments in research and development. According to the Open Innovation (OI) paradigm, key stakeholders like utilities, vendors, laboratories, universities etc. should take advantage of external knowledge to improve their innovation performance. Several studies have demonstrated that firms adopting the OI paradigm are more likely to innovate. Despite the interest of P & E firms in enhancing their innovation capabilities, surprisingly few articles (usually case studies) described the implementation of the OI paradigm in P & E firms. This article fills the gap by identifying the key drivers that encourage a firm in the P & E sector to embrace the OI paradigm. The authors adopt a hybrid research approach collecting evidence from the literature and through a multiple case-study analysis involving seven British firms and universities operating in the P & E industry. As the drivers of OI have mutual influence, this article describes them with a fuzzy cognitive map. Finally, the authors identify appropriated policies to enhance the OI adoption and, consequently, the sustainability of innovation in the P & E sector. A salient research agenda closes the paper.

1. Introduction

In the last decades, technological breakthroughs (such as Google's search engine, voice over IP telephony, Apple's iPod, music streaming, etc.) have overturned their respective industries (Bers et al., 2012). Such technological breakthroughs can be considered both inventions and innovations. Indeed, while inventions can be defined as the creation and establishment of something new, innovations are inventions that become economically successful and earn profits (Erwin and Krakauer, 2004; Schumpeter, 1934). Radical inventions such as the cited ones may disrupt established firms' business models or even entire industries, paving the ground for new, and even more radical inventions. The innovativeness of a firm may be associated with the development of inventions (Chang, 2003; Mention, 2011; Revilla et al., 2013; Trigo and Vence, 2012; Vega-jurado et al., 2009), with their patentability (Belussi et al., 2010; Connelly et al., 2009; Connelly and Sekhar, 2012; Hussler and Rondé, 2009; van de Vrande et al., 2011) or with their market success (Czarnitzki and Thorwarth, 2012; Faems et al., 2010; Kuittinen et al., 2013; Leiponen, 2012).

Traditionally, the technological innovation in Power and Energy (P & E) firms is mainly ascribed to internal Research and Development (R & D) (Noailly and Ryfisch, 2015). Typical P & E firms had (and still

have) laboratories and research centers where their personnel is engaged in R & D activities. External sources of ideas, knowledge, and innovation - such as universities and research institutions - are limited to a supplemental role aimed to fill the perceived gaps. Nevertheless, one of the core characteristics of modern radical innovations is their interconnectedness across organizations, disciplines, industries, and national boundaries, which makes them emerging not from a single source but from complex interactions among different players (Bers et al., 2012). Furthermore, promoting a purposive collaboration among firms and other players in the innovation ecosystem is likely to improve the R & D productivity (Ili et al., 2010). This may have a huge effect on energy policies considering that the annual R & D investment for the P & E sector in OECD countries is about 20 billion USD (International Energy Agency, 2013).

The idea, initially developed by Henry Chesbrough that "firms can and should use external ideas as well as internal ideas, and internal and external paths to market, as the firms look to advance their technology" (Chesbrough, 2003, p. xxiv) has spread and evolved, laying the foundations for a new epistemic community that has formed around the concept of Open Innovation (OI) (West et al., 2014). According to this community, firms are becoming increasingly aware of the abundant underlying knowledge landscape. Firms need to integrate

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ENERGY POLICY

Table 1

Closed vs Open innovation paradigm. Elaborated from: (Chesbrough, 2006).

Closed innovation	Open innovation
External knowledge has a supplementary role with respect to intra-firm knowledge Hiring and funding world-class talents will lead to the innovations needed by the firm Spillovers are potentially harmful and leak of knowledge must be avoided Internal R & D can provide the competitive advantage without the need of interacting with the external innovation ecosystem	External knowledge is as important as the intra-firm knowledge Business models need to be developed in order to convert R & D efforts into value creation Firms need to purposively manage outbound flows of knowledge and technology Most of the knowledge developed in almost any discipline fall outside a firm's boundaries
Intellectual property management is meant as a defensive tool	Intellectual property management can have a proactive and nuanced role

their internal R & D efforts and to purposely manage their outbound flows of knowledge and technology (Henry W. Chesbrough, 2006). Table 1 summarizes the main novel characteristics of the OI paradigm with respect to the closed innovation paradigm.

Firms can find fertile grounds for OI in their customers, suppliers and competitors, universities, private or public R & D laboratories, etc. (Sofka and Grimpe, 2010). To take full advantage of the OI paradigm, firms must enhance their networking capabilities and their absorptive capacity, i.e. the ability to exploit external knowledge (Cohen and Levinthal, 1990). The striking success of the OI paradigm in literature is probably related to the vast amount of research linking OI with improved innovation performance (Greco et al., 2015b). Empirical studies exploring the effect of OI on innovativeness are fairly distributed among small, medium and large firms. Many of them analysed different industries (Czarnitzki and Thorwarth, 2012; Ebersberger et al., 2012; Greco et al., 2016; Laursen and Salter, 2006), while others focused on high-tech or R & D intensive ones (Belussi et al., 2008; Caputo et al., 2016; Henttonen et al., 2011; Hurmelinna-Laukkanen et al., 2012).

In this growing body of literature, somewhat surprisingly, very few studies explored OI in the P & E sector. Most of the existing studies (reviewed in Section 2.2) qualitatively describe cases about successful implementations of the OI paradigm in P & E companies. Nevertheless, there is no reference to a systemic view of the OI adoption in the P & E sector. This article fills this gap by identifying the drivers of the OI adoption in P & E, describing them synoptically with a fuzzy cognitive map (FCM) and validating the theoretical construct with a cross-case study analysis of the UK *Knowledge Transfer Partnerships* (KTP).

This article is organized as follows. Section 2 describes the methods used to perform the literature review, the multiple case study analysis, and the FCM. Section 3 shows the results, including the main gaps identified in the literature, the benefits associated with the implementation of the OI paradigm in KTP and the FCM. Finally, Section 4 discusses the results, identifies the main contributions of the article, its policy implications and opportunities for future research.

2. Method

2.1. Research approach

As the application of the OI paradigm to the P & E sector is still in its early stages the research approach must be exploratory, focused on the theory building (Easterby-Smith et al., 2012). As usual in exploratory research, the authors rely on secondary data, mostly qualitative (Brookes and Locatelli, 2015; Tranfield et al., 2003). As explained in (Eisenhardt and Graebner, 2007, pp. 26–27) "theory-building research using cases typically answers research questions that address "how" and "why" in unexplored research areas particularly. By contrast, the research strategy is ill-equipped to address the questions "how often," and "how many," and questions about the relative empirical importance of constructs". In particular, we followed the research protocol presented in Fig. 1, which has been iterative and cyclic. Firstly, we performed a systematic literature review of OI in the P & E sector, which is described in the sub-section 2.2. This allowed the development of a draft FCM. Secondly, taking the lead from the literature review, we analyzed a series of case studies about OI, describing KTP partnerships between UK companies and UK universities. The analysis corroborated existing links and identified additional ones. The new links have been assessed against the generic (i.e. outside the boundaries of P & E firms) OI literature and, if supported, included in the FCM. The FCM was considered final when, looking at the case studies and the literature, the authors reached the theoretical saturation, i.e. *"the point at which incremental learning is minimal because the researchers are observing phenomena seen before"* (Eisenhardt, 1989, p. 545). Actually, every single link and node in the FCM can be targeted as an independent research topic. So, as common for exploratory research, this paper lays the initial background (in the form of the FCM) for future research.

2.2. Secondary data analysis

The bibliographic analysis covered the entire population of documents indexed in two relevant literature databases: Elsevier Scopus and Google Scholar. The research queries aimed to identify articles explicitly citing the OI paradigm in either Power or Energy contexts. Firstly, the results of the query on Scopus¹ returned 99 articles. We downloaded and read each of them in order to verify the relevance for the purpose of this study, identifying 22 relevant articles. Subsequently, we extended our research to Google Scholar. The query² allowed identifying 20 additional papers not indexed in Elsevier Scopus, 5 of which relevant for the purpose of this study. Fig. 2 shows the characteristics of the resulting 27 articles. Remarkably, the majority of the papers described single case studies, whereas only two of them were theoretical in nature. The 27 articles have been clustered according to their level of analysis in the following sections.

2.2.1. Theoretical studies

Both the two theoretical studies (González et al., 2012; Srikanth, 2011) focus on the wind power industry, achieving similar conclusions. Firms are encouraged to embrace the OI paradigm, especially in the early stages of development of new technologies, such as the development of new materials (Srikanth, 2011) or a new design for wind turbines blades (González et al., 2012). According to González et al., the OI reduces the time to market, expands a firm's market, knowledge, and technological capabilities, improve its efficiency and reduce R & D costs (2012).

2.2.2. Qualitative studies

Qualitative studies include single or multiple case studies, as well as

¹ Scopus query: (TITLE-ABS-KEY ("Open Innovation") AND TITLE-ABS-KEY (power) OR TITLE-ABS-KEY (energy)).

with at least one of the words: Energy, Power.

where my words occur: in the title of the article.

² Google Scholar query: Find articles.

with the exact phrase: Open Innovation.

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