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Linking forms of inbound open innovation to a driver-based typology of environmental innovation: Evidence from French manufacturing firms

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ABSTRACT

Environmental innovation research has not yet clarified how different forms of inbound innovation might exert effects. The current article proposes four driver-based EI types according to two main dimensions: compliance versus voluntary and own value capture versus customer value capture. With a problem-solving perspective, we develop links from different forms of inbound innovation to various types of EI and test the related hypotheses with two waves of the French Community Innovation Survey. On a short-term basis, R & D cooperation and technology acquisition correlate positively with all four types of EI, but over time, persistent R & D cooperation and technology acquisition are associated with EI only at the production stage, according to voluntary/strategic or compliance drivers. Inbound innovation enables quick responses to market demands for EI in the final use stage.

1. Introduction

Environmental innovations (EI), defined as the production, assimilation or exploitation of a product, production process, or methods that is novel to an organization and results in a reduction of environmental risk, pollution, and other negative impacts of resources use (including energy use), compared to relevant alternatives (Kemp and Pearson, 2008, p. 7), has captured increasing attention from researchers due to its importance to firm performance and for the sustainable environment at large (Ambec et al., 2013; Gilli et al., 2014; Marin and Lotti, 2017). Although firms are developing and adopting more EI, empirical studies generally either do not distinguish different types of EI (e.g., De Marchi, 2012; Jaffe and Palmer, 1997; Kammerer, 2009), or simply classify EI according to their technical outcomes (e.g., reduced material uses, CO_2 emission, energy consumption, water, soil, noise) (e.g., Ghisetti et al., 2015; Horbach et al., 2012; Wagner, 2008). Findings obtained with these approaches can be useful to some extent, but they overlook firms' *motivations* to engage in EI, which have a different *locus of value capture*.

First, when firms perceive a problem or challenge, they are motivated to innovate (Cyert and March, 1963; Felin and Zenger, 2014). These perceived problems might entail economic underperformance, demanding customer requirements, or new regulatory requirements (Horbach, 2008; Porter and van der Linde, 1995). That is, in addition to market pull and technology push trends that motivate firms to introduce EI voluntarily, regulatory forces likely drive EI as well (De Marchi, 2012; Horbach et al., 2012; Kammerer, 2009; Porter and van der Linde, 1995). We thus need to distinguish EI with respect to voluntary versus compliance motivations, as called for in prior literature (Bossle et al., 2016; Hojnik and Ruzzier, 2016).

Second, in addition to their economic and environmental externalities, similar to any innovation (De Marchi, 2012), EI are supposed to create value that various agents can capture (Lepak et al., 2007). Prior literature draws a rather subtle line between EI that are developed and adopted by the focal firm and those that emerge as product or process innovations by a distinct firm that introduces them to the market, to be adopted by other firms (Arora et al., 2014; Bossle et al., 2016; Hojnik and Ruzzier, 2016). The former usually have clear cost or pollution reduction benefits for the focal firm; the latter create new value propositions for customers (Kammerer, 2009). The distinct locus of value capture then may provide different drivers for firms to innovate (Bowman and Ambrosini, 2000).

Our focus on EI, in terms of product and process innovations, in turn suggests that open approaches to innovation might have varying implications for different types of EI that require firms to engage in external knowledge sourcing and collaboration (Chesbrough, 2003; West and Bogers, 2014). For example, with an inbound approach, firms access external technology sources for their innovation (Dahlander and Gann, 2010; Enkel et al., 2009), which can be particularly beneficial for

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EI (Ghisetti et al., 2015; Horbach et al., 2012). A firm's access to external technologies often takes different forms, such as an ad hoc acquisition of external knowledge through licensing, external R & D, or formalized R & D cooperation agreements. These forms each require different levels of control and coordination (Gulati and Singh, 1998; van de Vrande et al., 2006), though to our knowledge, little research has considered the effect of different forms of inbound innovation on firms' EI (Dahlander and Gann, 2010; West and Bogers, 2014).

To define which inbound innovation strategies firms deploy for different types of EI, we consider the two key dimensions: motivations (*compliance* versus *voluntary*) and locus of value capture/adoption (*own value capture* versus *customer value capture*). Accordingly, we formulate a four-way, driver-based typology of EI that constitutes an original contribution to the extant literature. We investigate the influence of different forms of inbound open innovation on the introduction of different types of EI. Data from two waves of the French Community Innovation Survey (CIS) during 2004–2008 provide the empirical evidence.

In the next section, we review the state-of-the-art literature pertaining to the drivers of EI and open innovation. Using our new two-dimensional, driver-based typology for EI, we identify four profiles of firms engaged in EI. Next, we develop hypotheses about the implications of inbound innovation for the different EI profiles. After we present the data and methods, we discuss the results. Finally, we highlight our contributions, pinpoint some limitations, and suggest future research directions.

2. Theoretical background and hypothesis development

2.1. Drivers of environmental innovation

Researchers have paid substantial attention to what leads firms to develop and adopt EI, using rubrics such as motivations, drivers, and stimuli (see Bossle et al., 2016; Hojnik and Ruzzier, 2016; Triguero et al., 2013). Similar to any other technological innovations, EI may be developed and adopted by firms in response to technology pushes (Geffen and Rothenberg, 2000) and market pulls (De Marchi, 2012; Horbach et al., 2012). The new technologies must find applications with clear value propositions for the target market. However, EI are also reinforced by regulatory forces (Horbach et al., 2012; Kammerer, 2009). According to the Porter hypothesis (Porter and van der Linde, 1995), increasingly stringent environmental regulations give firms an incentive to develop and adopt new technologies and processes, with positive economic and environmental externalities (Ambec et al., 2013; Jaffe and Palmer, 1997). Both current and anticipated regulations can drive firms to engage in EI and ultimately create competitive advantages (Kemp and Pontoglio, 2011). In their review of factors that trigger EI, Hojnik and Ruzzier (2016) find that regulations are among the most frequently reported drivers.

Well-designed and executed regulations may trigger the introduction of EI, which can enhance firms' business performance in the long run, but the cost of compliance can be high in the short term by reducing firms' productivity and performance (Ambec et al., 2013; Marin and Lotti, 2017). In this sense, some firms adopt EI to comply with regulations and are compelled to create new solutions to reduce negative environmental impacts, but others voluntarily explore the boundaries of new technologies and methods as part of their proactive environmental strategies to stay ahead of regulations (Buysse and Verbeke, 2003; Kemp and Pearson, 2008). These two categories of firms would exhibit different propensities to introduce EI (Bocquet et al., 2013). Firms that embrace voluntary activities (e.g., environmental management systems) likely achieve sustainable competitive advantages ahead of their competitors (Frondel et al., 2008; Wagner, 2008), while also mitigating the pressures from environmental regulations (Eiadat et al., 2008). Therefore, we conceptually distinguish *compliance* and *voluntary* drivers of EI. This distinction also appears in a previous empirical study of the link between EI and firm profitability (Rexhäuser and Rammer, 2014).

Regardless of whether they are compliance or voluntarily driven, EI are supposed to create various benefits, such as reducing pollution, resource consumption, and energy use, all of which, in turn, may lead to cost savings and improved business performance (Bossle et al., 2016; Kemp and Pearson, 2008). However, there is also a distinction—which has not been highlighted explicitly in prior literature—between EI with environmental and economic benefits created for and captured by an innovating firm's customers and EI that are developed and adopted by the focal innovating firm itself. From an innovation adoption perspective (Cooper, 1998), both cases contribute to the diffusion of EI, but the former is adopted by the market (customers as users), whereas the latter is adopted by the focal firm itself (users as innovators).

Arora et al. (2014) illustrate an interesting case of the promotion of manufactured nanotechnology products (MNPs) that increased the resource and energy efficiency of construction materials in the US. Various industrial firms and research institutes held key technologies underlying these MNPs, for which many patents were filed. The EI based on these MNPs were adopted widely in the building construction industry, which consists of a large network of architects, engineering firms, general contractors, property owners, and lead users. In most cases, firms that own the key technologies developed and introduced relevant EI for the entire building construction industry, as an application market. In this case, customers must be convinced that the EI provide advantages, in terms of cost or energy savings, improved quality, better disposal solutions, or reduced health impacts (Kammerer, 2009). That is, firms create value by introducing EI, whose environmental and economic value is captured by customers. In other cases, technology holders (innovators) may find MNPs useful for their own production processes, because they create environmental and economic benefits for the firms themselves. Self-adoption of EI makes perfect sense if the benefits of EI are obvious in the short run, because the innovating firm needs to offset its upfront development costs. These firms invest and introduce EI primarily to gain benefits for themselves, especially if the use value is high but the exchange value on the market is relatively low, whether due to competition or ineffective appropriation regimes (Lepak et al., 2007). These EI generally feature technologies that apply to the firm's own production, logistics, and disposal processes, which can be optimized and upgraded to improve its efficiency. From a resource-based view, such self-adopted EI can create a competitive advantage over competitors, due to its effective deployment of resources and related capabilities (Barney, 1991; Teece, 2007, 2014). Prior studies also show that firm profitability improves when its own resource efficiency increases, due to EI (Eiadat et al., 2008). Applying the Porter hypothesis, Rexhäuser and Rammer (2014) even suggest that it may be necessary to increase an innovating firm's own resource efficiency first, regardless of its motives for EI. Therefore, in line with the recent development in the literature (Hojnik and Ruzzier, 2016), we distinguish these two different mechanisms of innovation adoption and value capture, which we label *market innovators* and *production innovators*, respectively.

By combining the compliance versus voluntary motivations with the distinction between market and production innovators, we propose a driver-based typology that specifies four nuanced profiles of driver-based EI. First, market innovators are obviously motivated by market pull factors, because market acceptance is key for their EI to be adopted (Kesidou and Demirel, 2012). Firms are generally motivated by customer demands to voluntarily develop innovative products and processes for the market to earn economic rents. Meanwhile, stringent regulations also push firms to introduce EI to the market, by providing information, setting standards, and reducing market uncertainty (Jaffe and Palmer, 1997; Porter and van der Linde, 1995). Second, production innovators are subject to both voluntary and regulation forces, such that they are motivated to capture the related benefits for themselves. Therefore, we can delineate four nuanced profiles of EI (see Fig. 1):