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Innovating for a greener future: the direct and indirect effects of firms' environmental objectives on the innovation process

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ABSTRACT

This paper examines how firms' "environmental mode" affects the innovation process. Extending the literature on determinants to innovation, we postulate that engaging in an "environmental mode" (measured by the adoption of environmental objectives by firms) will influence the innovation process both directly and indirectly. Based on a theoretical mapping of the determinants of innovation, and a large scale survey among firms we argue that firms engage in an "environmental innovation mode" and that this mode will be intertwined with firms' product and process modes. To have an environmental impact, environmental objectives need to be implemented in the form of either a new product or a new process. Hence, environmental innovation can be conceptualized as an additional mode of innovation that interacts with other modes and innovation processes within firms. Theoretical implications of our empirical results are discussed.

1. Introduction

The human understanding of the natural world and its ability to support or constrain economic development has progressed over the late decades. Climate change and peak-oil are examples of concepts that have entered the public debate and exemplify that the natural world continues to shape societal and economic evolution and development. High on the policy agenda and public debate is the transition away from economic activity based on high-carbon energy sources to sustainable economic activities based on environmentally friendly technologies and consumption patterns (Foxon, 2011; Stern, 2007). Although such structural change is deemed necessary, it has also proven to be difficult (Hall and Kerr, 2003; Foxon et al., 2005). A key issue facing our societies is how to make this happen?

Innovation, defined by the Oslo Manual as the *"implementation of a new or significantly improved product (good or service), or a process, a new marketing method, or a new organizational method in business practices, workplace organization or external relations"* (OECD/Eurostat p. 46), is one of the most important mechanisms facilitating structural change (Schumpeter, 1934). Firms occupy a key role in the structural change towards increased sustainability as it is within their capacity to develop, implement and adopt environmental innovations (EI). It is therefore important to understand the environmental innovation process to be able to formulate effective policies and guide society's effort to help foster the economic transition towards increased sustainability through innovation. Reflecting this, it is debated among the scholarly community to what extent there is need for specific theorizing about environmental innovation. Scholars have argued that while there may be similarities between "environmental" and "non-environmental" innovation processes, research and theorizing about innovation in general does not cover the whole complexity of environmental innovations (see discussion in Rennings, 2000; De Marchi, 2012).

The main differences between environmental and non-environmental innovations uncovered by previous studies are the "double externality problem" (Rennings, 2000), the role of regulations (Jaffe and Palmer, 1997; del Rio et al., 2011) and that environmental knowledge will often differ from the traditional knowledge base of the firm (De Marchi, 2012; De Marchi and Grandinetti, 2013; Wagner and Llerena, 2011). The "double externality problem" refers to the situation where environmental innovations produce both positive spillovers for the firm based on basic R&D, and at the same time produce positive externalities by improving environmental quality (Rennings, 2000; Jaffe et al., 2005). This means that environmental innovators improve the

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quality of the environment, but while the firm bear the costs of the innovation it is the society that reap the benefits of less pollution (Beise and Rennings, 2005). This "double externality problem" can reduce the incentives for firms to undertake environmental innovation and the role of regulations is therefore important in motivating environmental innovations. This is referred to as the "regulatory push/pull effect" and aims to correct market failures due to the "double externality problem", as well as to provide incentives for innovation and adoption of better abatement technologies (Heyes and Kapur, 2011). In addition to regulations, previous studies have discussed the determinants of EI in relation to technology push (Horbach et al., 2012; Horbach, 2008; Cainelli et al., 2015; De Marchi and Grandinetti, 2013; Popp, 2005), market pull (Popp, 2001; Wagner, 2008; Kesidou and Demirel, 2012) and the importance of external knowledge sources (Cainelli et al., 2015; Ghisetti et al., 2015a; De Marchi, 2012). Although these determinants are quite established in the EI literature, there is still a gap in our holistic understanding of the total environmental innovation process. Our approach to address this gap is to take a "step back" compared to previous studies on the environmental innovation process (Horbach et al., 2013, 2012; Horbach, 2008; Brunnermeier and Cohen, 2003; Cleff and Rennings, 1999), starting with the objectives (as this is found to be the starting point of the innovation process (OECD, 2005; Paulraj, 2009)) and explore the relationship between environmental objectives and different innovation determinants. We also explore if there is an indirect relationship between environmental objectives and different determinants for EI, mediated through other innovation objectives. The following research question is asked: *"To what extent is the innovation process different within firms with environmental goals?"*

To answer our research question we first review the literature that has attempted to map the determinants of EI. This is done to outline the most important determinants of EI on which firms with higher environmental goals may "score" differently. Using a large-scale survey, we subsequently examine to what extent firms with high environmental goals score differently on the determinants of EI.

Our study contributes to the literature in several ways. An important first contribution is the introduction of a "modes of innovation" framework that can be used as a starting point to explore and examine how green innovation objectives is intertwined with other innovation objectives and innovation processes within firms. Based on the innovation literature we argue that firms can pursue different approaches (e.g. modes) to innovation (Tether and Tajar, 2008), such as "product" and "process" modes. Adding to this literature, we argue that firms can engage in an "environmental innovation mode" (to different degrees) and that an environmental mode of innovation may be intertwined with other modes of innovation and innovation processes within firms. Our framework, which stems from evolutionary economic theory and the idea that firms both differ and can pursue several approaches to innovation (Nelson and Winter, 2009; Nelson, 1991) is used as a theoretical starting point for the development of a simple mediation model over how environmental objectives (i.e. environmental innovation mode) may be related to processes of innovation within firms. While our model acknowledges that there may exists an important direct relationship between environmental goals and innovation (Horbach, 2008; De Marchi, 2012), we also argue that the "adoption of environmental objectives" can have important indirect relationships with how innovation processes happen within firms. In particular, we test and find empirical support for, the argument that the adoption of "environmental objectives" by firms will influence the firms' objectives and ambitions (their process and product innovation modes) when it comes to the development and implementation of new products and process and that this indirect influence matter to how environmental innovation processes occur in firms. After all, it is not sufficient in itself to have the ambition to "be environmental". To really have influence on the firms' innovation process, and for society's transition towards increased sustainability, "environmental goals" should also be closely integrated with the firms' innovation processes, such as their objectives and goals concerning the development of new products and processes. Related to this we argue that firms engage in an "environmental innovation mode" and that this mode will be intertwined with firms' product and process modes. To have an environmental impact, environmental objectives need to be implemented in the form of either a new product or a new process. Hence, environmental innovation can be conceptualized as an additional mode of innovation that interacts with other modes and innovation processes within firms. We find considerable empirical support for our argument that a key distinguishing feature of environmental innovation processes is that the adoption of environmental objectives influence the innovation process both directly and indirectly through firms' product and process objectives.

A related contribution is that our research keys directly into the debate in the literature about the extent to which environmental innovation requires specific theorizing (Rennings, 2000; De Marchi, 2012) with the added insight that environmental ambitions not only may have a direct effect on the innovation process, but also indirect effects on how innovation happen within firms. Thus, we offer an enriched and more nuanced view of environmental innovation processes as they happen within firms with implications for theorizing about environmental innovation processes. Such an increased understanding of the environmental innovation process will not only provide a better ground for theorizing, it may also help with the formulation and implementation of policies aiming to foster the transition towards increased sustainability.

A third contribution is that our research is based on empirical analysis of environmental innovation and the innovation process using a large scale firm database. There is currently limited knowledge about factors influencing the successful management and actual market commercialization of environmental innovations and to what extent this is different compared to other innovations, especially knowledge based on representative large-scale quantitative studies seen from the perspective of the firm (Balachandra et al., 2010).

2. Literature review

2.1. Environmental innovation

When researching a phenomenon, such as environmental innovation, it is important to be clear about how it can be defined, empirically measured and resembles similar concepts in the literature (Arundel et al., 2006). Environmental innovation has several definitions, where the definition by Kemp and Pearson has been most commonly used in recent years. This definition incorporates several aspects of the innovation process and views environmental innovation as *"the production, assimilation or exploitation of a product, production process, service or management or business method that is novel to the organization (developing or adopting it) and which results, throughout its life cycle, in a reduction of environmental risk, pollution and other negative impacts of resources use (including energy use) compared to relevant alternatives"* (Kemp and Pearson, 2007, p.7). It should be noted that several terms have been used to describe environmental innovation in the literature: green innovation, eco-innovation and environmental innovation (e.g. Boons and Lüdeke-Freund, 2013; Carrillo-Hermosilla et al., 2010; Hall, 2000). Although these terms to some extent share the same content (Schiederig et al., 2012), we choose to use the term