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Does innovation respond to climate change? Empirical evidence from patents and greenhouse gas emissions

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ABSTRACT

Mitigating the increasing effects of climate change requires extreme policy measures such as reducing global carbon dioxide emissions, expensive abatement policies and the immense costs associated with developing green technologies. While literature on environmental-innovation has been focusing on how innovation contributes to alleviating climate-change impacts by examining existing mitigation technologies and programs, this paper does so via a reverse approach. It examines how innovation responds to climate change. By employing various econometric methods on a panel dataset of 70 countries, patent count as a proxy for innovation, and carbon dioxide and other greenhouse gas emissions as proxies for climate change, this study finds that the number of climate-change-related-innovations is responding positively to increasing levels of carbon dioxide emissions from gas and liquid fuels – mainly from natural gases and petroleum respectively; and negatively to increases in carbon dioxide emissions from solid fuel consumptions (mainly from coal) and other greenhouse gas emissions. It also finds that government investment does not always influence decisions to develop and patent climate-technologies. Empirical findings from this study contribute to the environmental-innovation literature by providing extended knowledge on how innovation reacts to changes in major climate change factors. Based on this, certain policy implications can be drawn such as diverting public funds to areas where innovative activities contribute the most to combating climate change.

1. Introduction

In an effort to mitigate the increasing effects of climate change, the Conference of Parties (COP) of the United Nations Framework Convention for Climate Change (UNFCCC) has agreed in 2015 to limit the increase of global temperature to 2 °C above pre-industrial levels by 2020 (UNFCCC, 2015). While most member countries agreed on 2 °C, the convention emphasized that efforts to reduce the increase further to 1.5 °C is vital (McSweeney and Pidcock, 2015). This can be achieved mainly through moderating global annual emissions of Greenhouse gases (GHG) which are believed by most scientists to be the main causes of climate change (Oreskes, 2004). In particular, carbon dioxide (CO_2) emissions which are by far the highest global GHG gases emitted (EPA, 2016). This objective requires serious commitments by countries in putting priority to reducing CO_2 emissions. Developing and deploying environmental friendly technologies are among the numerous actions needed by countries to achieve this goal.

Since 1976, there has been a remarkably increasing trend in the number of climate-change-related technologies developed, represented here by the number of Y02 patents in Fig. 1. Y02 is an EPO classification in the PATSTAT database for climate-change-related patents. It has several categories of which four are plotted in the graph below. First is the Y02B group which covers climate change mitigation technologies related to buildings; Y02C includes technologies related to capturing, storing, sequestrating or disposing GHG gases; Y02E represents technologies associated with the reduction of GHG emission, related to energy generation and transmission or distribution; and Y02T covers climate change mitigation technologies related to transport (Espacenet, 2016). The fifth, highlighted in blue, is the total of these four. Clearly, there has been a tremendous rise in number of the Y02 technologies since 1976 – especially the E and T groups. Note, 2014 only covered January to June (not the entire year).

Understanding the role of innovation in minimizing the impacts of climate change is a not a new concept. In fact, there has been quite a number of studies examining the progress and success of Government programs established to facilitate the development and diffusion of climate mitigation technologies (de Jong et al., 2016; Dhar and Marpaung, 2015; Haselip et al., 2015; Mowery et al., 2010; Watson

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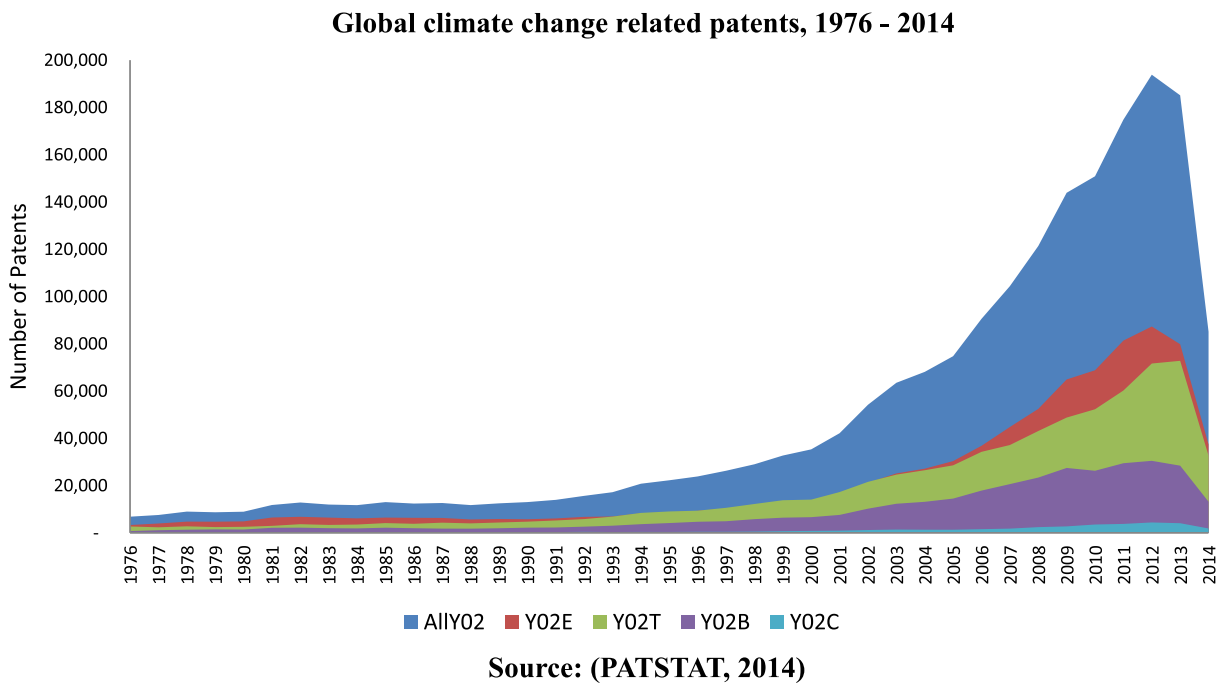

Fig. 1. Global counts of Y02 patents, 1976–2014.source: (PATSTAT, 2014).

et al., 2015). Others linked the environmental issues to economic growth and productivity (Dong et al., 2014; Grossman and Krueger, 1995; Jaffe and Palmer, 1997; Kozluk and Zipperer, 2015; Porter and van der Linde, 1995; Tucker, 1995) as well as climate impact predictions under different scenarios (Moss et al., 2010). However, the bulk of literature has been in the area of analyzing the relationship between eco-friendly technologies and GHG emissions from the perspective of how the former affects the latter. Then the question arises of whether there exists a reverse effect of GHG emissions on the developments of eco-technology innovations. That is, how the trends in developing climate-related technologies have shifted in response to the changes in amounts of GHG emissions. To address such question, this paper aims to offer for the first time a unique approach to test the presence of this reverse relationship, and in doing so, evaluates the important role of technological innovation in a fight against climate change.

While it is clearly logical to conclude that the higher the number of climate-related technologies the better for combating climate change, there is no existing empirical-based evidence to support this. This is the gap that the study is aiming to bridge. Bringing empirical insights to understanding how climate change indicators influence the development of clean innovations is essential to demonstrate this purpose. Furthermore, the use of patents count as a proxy for innovation made this possible. With its discreteness property, patents count is appropriately suitable for such kind of analysis.

In summary, this paper aims to provide a novel backward-step approach to understanding the role of innovation in reducing the effects of climate change through the use of carbon dioxide emissions and the number of climate-change-related patents, and several econometric techniques. This is done through investigating how innovation responds to climate change indicators. The techniques employed include a fixed effect logistic regression, panel fixed effect and random effect negative binomial regressions and ARDL dynamic panel data estimation based on the generalized method of moments (GMM). To do this, four key objectives are established for investigation as listed below. Note they are designed in way so that they can provide guides to understanding this approach.

Study objectives:

1.1.
To investigate how does different groups of climate-change-related patents respond to increasing levels of climate change indicators such as carbon dioxide and other green-house gas emissions.

1.2.
To examine if different sources of carbon dioxide emissions affect the number of climate-related patents differently

1.3.
To analyze whether different levels of carbon dioxide and GHG emissions trigger different levels of mitigation responses in the form of the number of climate-technology inventions or patents

1.4.
To investigate and compare the impacts of several public-private joint investments on the number of climate-related patents

Finally, climate change has been widely known to be human-induced and that it should be addressed by researchers from multiple disciplines (Goodall, 2008). This paper is therefore intended to contribute to solving this climate change problem by providing extended novel knowledge, backed with empirical evidence, on how technological innovation responds to the changes in major climate change indicators. This is specifically in areas where the existing literature has not touched such as those identified and listed in the above objectives. Note, even though the study utilizes a panel dataset of 70 different countries, it is designed mainly to explore the relationships in an aggregate manner rather than a per-country basis or cross-country comparisons.

The rest of the paper is organized as follows. The next section provides a brief review of the literature on the role of innovation in sustainable economic growth, policy instruments toward environmental-innovation and evaluating climate change programs. Section 3 presents the data and the empirical models utilized in this study as well as some methodological issues. Section 4 presents the results and findings. The last section concludes with a brief discussion and summary of the results, limitations of the study and some policy implications.