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Unveiling scientific communities about sustainability and innovation. A bibliometric journey around sustainable terms

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ABSTRACT

Literature about the relationship between innovation and sustainability has skyrocketed in the last two decades and new terms have appeared. However, only very few bibliometric analyses have reviewed some of these terms (*eco-innovation*, *environmental innovation*, *green innovation*, and *sustainable innovation*), and they concluded that such terms are mostly interchangeable. These findings surprise in light of the different positions shown in the innovation for sustainability debate. Our bibliometric analysis tracks meanings and communities associated with these four terms and indicates some overlaps, especially between *eco-innovation* and *environmental innovation*. However, we found relevant differences of meanings and communities that reflect the different positions in the innovation for sustainability debate.

1. Introduction

The relationship between technology, innovation, and environment is an example of a widely contested topic because technological change has been considered both the source and the solution for many environmental issues related to anthropogenic activities (Hekkert et al., 2007). The root of academic discovery in this field began in the 1970s, when several authors discussed the feasibility of endless economic growth on a finite planet (Beckerman, 1974; Cole et al., 1973; Georgescu-Roegen, 1971; Meadows et al., 1972; Solow, 1973). The well-known idea of sustainable development (SD) was a milestone in this debate. Linking economic growth to the actual state of technology gave innovation a central role – as the way to stretch the limits of economic growth within the availability of finite resources. One consequence of the SD debate was to settle the scientific agenda. This resulted in more scholars analyzing innovation through the lens of sustainability (Freeman, 1996). The approach also finds important applications in policy contexts, as in recent reports and manuals written by regional, national, and international organizations (Dutz and Sharma, 2012; O'Hare et al., 2014; OECD, 2009, 2010, 2013a, 2013b; UNEP, 2014; World Bank, 2012), and even within co-funding calls,[1] regulations and other policy instruments (EU Commission, 2011a, 2011b, 2009).

When contested positions exist, terms and languages may have a powerful role because they can be used to shape meanings and identify belongings to the different communities (Nicolini, 2012). Therefore, the comparison between concepts is crucial to define and explore the intellectual structure of a given scientific field, to access the influence and scientific impact of different journals, authors and geographic locations to each concept, to suggest future paths for the development. For this reason, we were surprised to find only few bibliometric analyses Dias Angelo et al., 2012; Karakaya et al., 2014; Schiederig et al., 2012) that addressed the language dimension of the relationship between innovation and sustainability without finding relevant differences in the usage and meanings of different terms. More specifically, Dias Angelo et al. (2012) reviewed papers – over the last three years and only in the journals tied to organizational environmental management – which contain the terms *environmental innovation*, *green innovation* and *eco-innovation* in titles or abstracts indexed in the ISI Web of Science (WoS) and Scopus. They found a predominance of environmental innovation, but not any difference in meanings. Karakaya et al. (2014) studied

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[1] See http://ec.europa.eu/environment/eco-innovation/apply-funds/selection-criteria/index_en.htm.

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the diffusion of eco-innovation looking at *eco-innovation*, *ecological innovation*, *green innovation*, *sustainable innovation* and *environmental innovation* terms in Google Scholar. While the focus of Karakaya et al. is to identify the core disciplines and research streams of literature, they did not highlight any differences between these terms. Schiederig et al. (2012) identified and analyzed four main sustainable innovation terms (*eco-innovation*, *environmental innovation*, *green innovation*, and *sustainable innovation*) and concluded that the terms "*can be used largely interchangeably*" (p. 182), even though "*sustainable innovation includes a social dimension as well as ecological dimension*" (p. 188).

Such non-conflictual view seems to stand in contrast with the richness of the positions in the sustainability debate. For instance, Rennings (2000) uses the terms eco-innovation and environmental innovations as synonymous, while Ekins (2010) makes a clear distinction between them. In addition, these three bibliometric reviews seem not to define a clear methodology to identify meanings and communities, leaving room for more advanced and detailed bibliometric analyses.

We performed an alternative bibliometric analysis that explicitly aimed to (i) disentangle the meanings and (ii) identify associated scholarly communities and discussions behind these same four terms. We utilized bibliographic data from WoS and a methodology that combined keywords analyses – as a way to track meanings – with community detection based on shared references.

Differently from the cited reviews, our results indicate that these four terms focus on different topics and partially identify different scientific communities. For example, *sustainable innovation* is preferred by communities dealing with complex system-oriented approach, especially the transition school of UK and The Netherlands. *Green innovation* is used by the management community, and it is very popular outside Europe. *Eco-innovation* has an important focus on eco-design and it has important overlaps with *environmental innovation* especially within specific communities – as for example – those studying evolutionary economics. We also found a correspondence between journals and communities, and – very interesting – the use of the Journal of Cleaner Production as common platform of the different communities.

In conclusion, we confirm that terms and language are important concepts to understand different positions and meanings within different scientific sub-communities. The different importance and popularity of the scientific sub-communities can influence future policies for sustainability. For example, the growing popularity of the *eco-innovation* term may result in policies which focus on eco-design and eco-labels, whilst the sustainable innovation perspective may focus on policies which purse wider societal changes (Franceschini and Pansera, 2015).

The paper is organized as follows: Section 2 briefly introduces the concepts of Kuhnian scientific communities and the discourse analysis approach to sustainability. Section 3 presents the data and methodology used for our bibliometric analysis. Section 4 presents the main results and discussions, and Section 5 outlines our main conclusions and potential future developments for this approach.

2. The discourse analysis about innovation and sustainability in a Kuhnian world

Before Kuhn, theorists of epistemology and science understood scientists as individual agents free from any social boundaries (Jacobs, 2006). Polanyi (1951), Royce (1968), and Fleck (1979) touched upon the notion of the scientific community, but it was Kuhn's seminal work *The Structure of Scientific Revolutions* (1962) that popularized this topic (Jacobs, 2002). In Kuhn's view, a scientific community consists of scientists who agree on specific paradigms about reality. Paradigms are ways in which scientists look at the world, and each paradigm consists of specific theoretical frameworks, puzzles to be solved, methodological processes, and potential solutions. These paradigms are the "theoretical hard core" of scientists who shape research programs (Lakatos and Musgrave, 1970).

Different scientific communities seek to gain popularity and reproduce themselves as they attract new members through specific processes of education, initiation, and selection in which students have been similarly educated and are thought to use the same language (Jacobs, 2006). Consequently, paradigms evolve and compete at any time, representing the progress of scientific knowledge. Paradigms and scientific communities are found in all research topics in which different ideologies, approaches, and interests exist. The existence of different scientific communities is crucial to solve complex problems through the continuous exposition and confrontation of parallel theories (Kornfeld and Hewitt, 1981) and, therefore, the advance of scientific research is intrinsically dependent on diversity (Popper, 1963).

The use of a common language defines the existence of –and draws the boundaries between– different paradigms and scientific communities. The use of language is a specific subject of study, called *discourse analysis*, which has become popular to address the relationship between science, technology, and society (Hajer and Versteeg, 2005). As Nicolini argued, discourse is "*first and foremost a form of action*" (2012, p. 189) through which each community tries to attach meaning to topics and influence other communities. Consequently, any discourse is a way to sustain specific social groups and cultures (Gee, 2010). Therefore, discourse analysis can be applied to study the dominant ideologies and values in the scientific world.

The comparison between concepts is important to define and explore the intellectual structure of a given scientific field (Dobers et al., 2000; Hill and Carley, 1999; Ramos-Rodríguez and Ruíz-Navarro, 2004), to access the influence and scientific impact of different journals, authors and geographic locations to each concept (Baumgartner and Pieters, 2003; Ingwersen, 2000), and to suggest future paths for the development of the many different branches within a field. It has been used largely to define concept-based scientific communities in many fields such as Strategic and operational management (Charvet et al., 2008; Ramos-Rodríguez and Ruíz-Navarro, 2004; Vokurka, 1996), corporate social responsibility (De Bakker, 2005), logistics and transportation (Kumar and Kwon, 2004), service innovation (Sakata et al., 2013), National Innovation systems (Teixeira, 2013) and even Innovation itself (Fagerberg et al., 2012).

Under the lens of discourse analysis, nature, innovation and sustainability are socially constructed and historically dependent concepts. As any social concepts, they are widely debated within scientific communities that carry different theoretical lenses, terms, and ideological values (Castro, 2004; Franceschini and Pansera, 2015; Garud and Gehman, 2012; Hopwood et al., 2005; Markard et al., 2012; Pansera, 2012; Rennings, 2000; Scoones, 2007).

The relationship between technological change and environment has been discussed at least since the early 1970s, when the first general discussions on the environmental impacts were conducted (Ehrlich and Holdren, 1972; Meadows et al., 1972). As the research field has evolved in the last decades, the scope of the innovation literature has widened in the last decades to include not only technical innovations (Freeman and Soete, 1997) but also organizational, marketing, institutional, and normative aspects (Fagerberg and Verspagen, 2009).

Such discussion was also incorporated in early evolutionary works (Freeman, 1984) and in the so-called Berlin school of environmental policy research, which came up with the related concept of ecological modernization (Christoff, 1996), focusing on a sociological, policy-oriented perspective. With the idea of sustainable