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The Strategic Environment Assessment bibliographic network: A quantitative literature review analysis

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ABSTRACT

Academic literature has been continuously growing at such a pace that it can be difficult to follow the progression of scientific achievements; hence, the need to dispose of quantitative knowledge support systems to analyze the literature of a subject. In this article we utilize network analysis tools to build a literature review of scientific documents published in the multidisciplinary field of Strategic Environment Assessment (SEA). The proposed approach helps researchers to build unbiased and comprehensive literature reviews. We collect information on 7662 SEA publications and build the SEA Bibliographic Network (SEABN) employing the basic idea that two publications are interconnected if one cites the other. We apply network analysis at macroscopic (network architecture), mesoscopic (sub graph) and microscopic levels (node) in order to i) verify what network structure characterizes the SEA literature, ii) identify the authors, disciplines and journals that are contributing to the international discussion on SEA, and iii) scrutinize the most cited and important publications in the field. Results show that the SEA is a multidisciplinary subject; the SEABN belongs to the class of real small world networks with a dominance of publications in Environmental studies over a total of 12 scientific sectors. Christopher Wood, Olivia Bina, Matthew Cashmore, and Andrew Jordan are found to be the leading authors while Environmental Impact Assessment Review is by far the scientific journal with the highest number of publications in SEA studies.

1. Introduction

Strategic Environment Assessment (SEA) is a systematic process that takes into account and evaluates the effects of policies, plans, and programs on the environment. Since the introduction of the European Directive 2001/42/CE on SEA, a number of scholars and practitioners have discussed the theoretical cornerstones and applications of this administrative procedure. The interest in SEA development has regarded several fields such as agriculture, forestry, fisheries, energy, industry, transport, waste management, water management, telecommunications, tourism, town and country planning. Thus, the SEA literature embraces different contexts and fields of research, ranging from land-use planning to energy management and from public policy to environmental change. A number of authors have scrutinized the effectiveness of SEA (De Montis, 2013; Fischer and Gazzola, 2006; Zhang et al., 2013), the critical issues and unresolved problems in the application of SEA (Noble, 2009; Weiland, 2010), and the adopted solutions in various contexts (Rauschmayer and Risse, 2005; Stoeglehner, 2010). If one searches for the keywords 'Strategic Environmental Assessment', Google search engine provides about 17,900,000 different results.[1] The number and extent of contributions and applications on this subject are so vast that it is inconceivable to produce a comprehensive state of the art without employing a knowledge support system. Understanding the most frequent topics and the most cited publications (scientific articles and books) is helpful to produce a quantitative analysis of the state of the art of a very complex topic. We aim to identify the topics with the highest impact and assess the extent to which SEA encompasses different implementation contexts. Given the amount of publications that increasingly expand the SEA bibliographic database, we propose a methodology based on network analysis in order to reconstruct the SEA state of the art.

The use of knowledge support systems in bibliographic reviews was first introduced by the pioneering work of Eugene Garfield (Garfield et al., 1964), which accompanies the systematic analysis of scientific documents relating to DNA studies (Batagelj, 2003; Börner et al., 2003). Traditionally, bibliographic networks use citations between articles or co-authorship relations in order to understand how scholars and their works influence with each other (Brughmans, 2014; Jin et al., 2011). In fact, scholars differ both in terms of scientific productivity and influence of their work (Eom and Fortunato, 2011; Seglen, 1992). With respect to average time of existence of publications in citation networks, scientific documents may be classified into two large families: key papers that have a high number of citations and are almost considered as permanent within the scientific landscape, and those

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transients, where the permanence within citation networks quickly becomes marginal (Price, 1965).

Specific studies have reported on a direct correlation between the average article's citation lifetime and the growth rate of the corresponding research field (Abt, 1998). Chen (2005) has analyzed the level of importance of documents within citation networks and found that the importance of a publication is attributable to both endogenous and exogenous factors within a research field. Among the endogenous factors, new findings produce radical changes in the network (for example, bosons in astronomy or DNA in genetics). Exogenous factors are not directly related to a research field, but may significantly influence it by providing incentives for knowledge development (Chen, 2005).

Network analysis has been used to reconstruct and understand scientific literature by means of a systemic framework (Almind and Ingwersen, 1997; Calero-Medina and Noyons, 2008; Coulon, 2005; Ding, 2011). Network analysis tools can identify bibliographic interchanges and clusters of research topics, which are the basic elements of modern scientific literature (Marshakova-Shaikevich, 2005; van de Wijngaert, 2012). Network techniques are useful in the case of vast research areas that are highly interconnected with other disciplines (Fortunato, 2010) and subject to rapid changes (Abt, 1998). An important advantage of quantitative analysis consists in limiting the adoption of subjective criteria in the classification process. However, Garfield et al. (1964) believe that the co-action of human operator is crucial and more effective than any classification algorithm alone.

Against this background, we aim to explore the following research questions (RQ):

- RQ1: Can network analysis help scholars to analyze the state of the art of complex research areas such as SEA?
- RQ2: What fields are mainly contributing to the international discussion on SEA?
- RQ3: What are the most important publications?
- RQ4: What are the most used keywords?
- RQ5: What international scientific media do scholars and practitioners use to divulgate their work on SEA?
- RQ6: Which scholars and practitioners are mainly contributing and impacting on the discussion on SEA theoretical and practical applications?

In this paper we investigate the state of the art on SEA building and scrutinizing the SEA Bibliographic Network (SEABN).

The remainder of the paper is organized as follows. In the next section, we present the cornerstones of our research methodology applied to SEA literature. The third section explores the implications of three levels of network analysis for bibliographic studies. The forth section describes the SEABN while the fifth section presents the results of network analysis for the SEABN according to the schema presented in the third section. The last section summarizes the main findings of this study and presents future research plans.

2. Network analysis as bibliographic analytical tool

Research studies and academic literature have been growing at various rates depending on the historical period and field of research (Larsen and von Ins, 2010). In the past years this effect has been multiplied by new publishing media such as online journal, conference proceedings, and scientific blogs. For example PLOS ONE, one of the most famous on-line open access journals, has published 23,468 articles in 2012 (Hoff, 2013) and 31,500 in 2013 (Graham, 2014). The variety of sources and number of contributions generate difficulty in maintaining a consistent and comprehensive state of the art of a specific subject. There is an increasing request to have quantitative knowledge support systems to catalog the vast amount of available scientific information (van de Wijngaert et al., 2012). A few attempts have proposed quantitative approaches to study the literature of subject. Meta-analysis (Light and Pillemer, 1984; Maas et al., 2004a,b) uses common features among articles to relate blocks of scientific knowledge. In this sense meta-analysis can be considered as the cornerstone of quantitative bibliographic reviews based on network analysis as articles are interrelated through shared characteristics. Network analysis '*combines the strengths of meta-analysis (objective, systematic) with the visual-analytics*' (van de Wijngaert et al., 2012) and allows for a systemic analysis of the bibliographic properties of a research area. A number of scholars have focused on similarities between documents and have used quantitative procedures in order scrutinize their relationships (Ahlgren et al., 2003; Boyack et al., 2005; Klavans et al., 2006; van Eck and Waltman, 2009; White, 2003). Kessler (1963) proposes the concept of "bibliographic coupling" as a measure of similarity between "*two documents based on the number of common references*" (Marshakova-Shaikevich, 2005, p. 1535). Small (1973) and Marshakova-Shaikevich (1973) use the number of documents that cite two publications as a combining parameter. Less attention has been dedicated to visual representations (Börner et al., 2003; Garfield, 2009; Skupin, 2004). van Eck and Waltman (2010) distinguish two types of representation: (1) maps where the Cartesian distance between objects (papers) on a surface is indicative of their similarity, and (2) maps based on graphs, where distance between nodes (papers) is irrelevant and relationships are identified by links (Newman, 2001a, 2001b; Wasserman et al., 1994). In this work, we use representations based on category (2).

Network analysis and network theory have a long research tradition rooted in the seminal works of Euler,[2] Solomonov and Rapoport (1951), and Erdős and Rényi (1959, 1960). Through new theorems and mathematical advances these scholars applied the network paradigm to study many real world phenomena not fully understood until then (Newman and Girvan, 2004). New advances in graph theory were also proposed by a seminal work published in Watts and Strogatz (1998). They introduce a network class named small world that is characterized by clusters of densely interconnected nodes (i.e. with a relatively high clustering coefficient C) and by a characteristically small topological distance (i.e. shortest path l) between each pair of nodes in the network. In contrast to small world networks, regular networks have a high C and a high l, while random networks have a low C and a low l. One year after Watts and Strogatz's contribution, Barabasi and Albert (1999) introduced a new revolution in the network paradigm. They proposed a model for the growth of networks based on the economic catch phrase "The rich get richer." In this formulation, nodes' connectivity evolves according to power laws. These networks are called scale free and have been observed in various realms such as the Internet, the WWW, airline networks, movie collaborations, cross-collaboration in science, and protein–protein interactions (Albert and Barabasi, 2002; Boccaletti et al., 2006; Newman, 2003a). The diameter marks the maximum topological distance (shortest path) between nodes in a graph. This measure is indicative of graph dispersion, i.e. the greater the diameter (lower the cohesion), the sparser the relationships between nodes. The presence of denser micro-structures generates nested sub-networks which enclose information on groups of nodes that share common properties, i.e. in social networks, the sub-networks of kinship reasons, friendship, and business opportunity (Fortunato, 2010). Elements strongly connected with each other typically identify clusters characterized by common interests, where these relationships are built (Lazar and Preece, 2009; Wellman and Gulia, 1999); these elements often represent subgroups within a more extensive relational system (Jin et al., 2011). The networks of collaboration between authors, and citation networks, are typical social networks (Newman, 2001a, 2001b).

[2] One of the greatest mathematicians ever: applying graph theory for the first time in his Solutio problematis ad geometriam situs pertinentis (1736) he demonstrated that it was impossible to complete a leisurely walk of the city of Königsberg by crossing its seven bridges only once.