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# Open Science now: A systematic literature review for an integrated definition

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## ABSTRACT

Open Science is a disruptive phenomenon that is emerging around the world and especially in Europe. Open Science brings about socio-cultural and technological change, based on openness and connectivity, on how research is designed, performed, captured, and assessed. Several studies show that there is a lack of awareness about what Open Science is, mainly due to the fact that there is no formal definition of Open Science. The purpose of this paper is to build a rigorous, integrated, and up-to-date definition of the Open Science phenomenon through a systematic literature review. The resulting definition “Open Science is transparent and accessible knowledge that is shared and developed through collaborative networks” helps the scientific community, the business world, political actors, and citizens to have a common and clear understanding about what Open Science is, and stimulates an open debate about the social, economic, and human added value of this phenomenon.

## 1. Introduction

Open Science is a disruptive phenomenon that is emerging around the world and especially in Europe. Open Science brings about socio-cultural and technological change, based on openness and connectivity, on how research is designed, performed, captured, and assessed. Open data tools, open access platforms, open peer review methods, or public engagement activities are irreversible trends, that are impacting all scientific actors and have the potential to accelerate the research cycle.

Intergovernmental organisations across the world such as the European Commission, the European Parliament, the European Council, the Organisation for Economic Cooperation and Development (OECD), the United Nations, and the World Bank recognize the importance of Open Science to address the big societal challenges that humanity faces in the 21st century, such as climate change, public health emergencies, sustainable food production, efficient energy, or smart transport, among others.

But does the scientific community, the business world, political actors, and citizens have a common and clear understanding about what Open Science is? Several studies show that there is a lack of awareness among these stakeholders (European Commission, 2015b, 2015c), mainly due to the fact that “there is no formal definition of Open Science” (Arabito & Pitrelli, 2015; European Commission, 2015b; Kraker, Leony, Reinhardt, & Beham, 2011; OECD, 2015).

The purpose of this paper is to build a rigorous, integrated, and up-

to-date definition of the Open Science phenomenon. Through a systematic literature review, the concept of Open Science is identified, conceptualised, and defined.

The article is structured hereinafter as follows. The theoretical framework is presented in Section 2. The methodology of the study is described in Section 3. The obtained results of the research carried out, the discussion of the findings and their implications, are presented in Section 4. Section 5 presents the conclusions, limitations, and future research horizons.

## 2. Theoretical framework

Open Science is an emerging field of research. Accordingly, a clear and comprehensive theoretical framework does not exist yet in academia.

The theoretical framework of this article is obtained, therefore, from the filtering process of studies carried out during the systematic literature review. Based on the analysis of a final database of 75 studies, 67 articles from reference journals of ISI Web of Science – Core Collection and Scopus, and 8 official publications from Intergovernmental organisations' databases (called henceforward International databases), all of which were published from 1985 (first detected study) to 2016 (last detected study). The research team concludes that Open Science is conceptualised as:

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**Open Science as knowledge:** Bisol, Anagnostou, Capocasa, et al. (2014); Bond-Lamberty, Smith, and Bailey (2016); Brown (2009); Caulfield, Harmon, and Joly (2012); Cho and Choi (2013); Cook-Deegan (2007); Czarnitzki, Grimpe, and Pellens (2015); Czarnitzki, Grimpe, and Toole (2015); David (1998, 2004a); Davis, Larsen, and Lotz (2011); Deng (2011); De Roure, Goble, Aleksejevs, et al. (2010); European Commission (2014, 2015b, 2016); European Council (2016); Friesike, Widenmayer, Gassmann, and Schildhauer (2015); Fry, Schroeder, and den Besten (2009); Gorgolewski and Poldrack (2016); Grand, Wilkinson, Bultitude, and Winfield (2016); Grand (2015); Hampton, Anderson, Bagby, et al. (2015); Jamali, Nicholas, and Herman (2016); Jong and Slavova (2014); Langlois and Garzarelli (2008); Lasthiotakis, Kretz, and Sá (2015); Leonelli, Spichtinger, and Prainsack (2015); MacLean, Aleksic, Alexa, et al. (2015); McKiernan, Bourne, Brown, et al. (2016); Morzy (2015); Mukherjee and Stern (2009); Nelson (2003); OECD (2014, 2015); Peters (2010a, 2010b); Powell (2016); Rinaldi (2014); Robertson, Ylioja, Williamson, et al. (2014); Schmidt et al. (2016); Shibayama (2015); Stodden (2010); Szkuta and Osimo (2016); Thanos (2014); West (2008); Wolkovich, Regetz, and O'Connor (2012).

**Open Science as transparent knowledge:** European Commission (2015b); European Council (2016); Hampton et al. (2015); Kraker et al. (2011); Leonelli et al. (2015); Lyon (2016); Rentier (2016); Ramjoué (2015); Scheliga and Friesike (2014).

**Open Science as accessible knowledge:** Bisol et al. (2014); Czarnitzki, Grimpe, and Toole (2015); David (2004a); Merton (1973); Dasgupta and David (1994); De Roure et al. (2010); Ding (2011); European Commission (2014, 2015b, 2016); Grand et al. (2016); Grand (2015); Gittelman and Kogut (2003); Hampton et al. (2015); Jong and Slavova (2014); Lyon (2016); MacLean et al. (2015); Morzy (2015); Mukherjee and Stern (2009); Nelson (2003); OECD (2014, 2015); Rentier (2016); Rhoten and Powell (2007); Schmidt et al. (2016).

**Open Science as shared knowledge:** Bisol et al. (2014); David (1998); European Commission (2016); Grand (2015); Grand et al. (2016); Grubb and Easterbrook (2011); Labastida (2015); Lyon (2016); McKiernan et al. (2016); Robertson et al. (2014); Schmidt et al. (2016); Schroeder (2007); Wolkovich et al. (2012).

**Open Science as collaborative-develop knowledge:** Azmi and Alavi (2013); David (1998); Deng (2011); European Commission (2015b, 2016); Grand et al. (2016); Friesike et al. (2015); Fry et al. (2009); Hormia-Poutanen and Forsström (2016); Wolkovich et al. (2012).

### 3. Methodology

With the aim to build a rigorous, integrated, and up-to-date definition of Open Science, the research team designs a systematic literature review based on Booth, Papaioannou, and Sutton (2012) approach. The team undertakes four sequential steps following the Search, Appraisal, Synthesis, and Analysis (SALSA) Framework (Grant & Booth, 2009).

In order to manage efficiently the systematic literature review and to minimise the potential biases on the part of the researchers, the team adopts a review protocol based on Cochrane Collaboration's approach (Higgins & Green, 2011). The review protocol ensures that the team follows accurately the established methods.

Hence, the four sequential steps of the systematic literature review, established in the review protocol, are:

#### 3.1. Step 1. Search - strategy for identification of studies

##### 3.1.1. Search techniques

The team searches the term Open Science, when it appears either in the title, abstract, or keyword of the studies.

The team selects ISI Web of Science – Core Collection (Thomson

Reuters) and Scopus (Elsevier) databases, due to the trans-disciplinary nature of Open Science and the impact factor of these databases. The aim is to carry out a comprehensive bibliography identification. Taking into account that evidence exists about the Open Science phenomenon outside the scientific community, the team searches studies in International databases such as the databases of: the European Union, the United Nations, the OECD and the World Bank.

##### 3.1.2. Study selection criteria

For ISI Web of Science – Core Collection (Thomson Reuters) and Scopus (Elsevier) databases, the team includes articles, published in international peer-reviewed journals, written in English, and published between 2006 and 2016. The year of 2006 is chosen as a starting point because this is the year in which Chesbrough, Vanhaverbeke, and West (2006) published “Open Innovation. Researching at New Paradigm”. From this year on, Open Innovation begins to gain force and spur “open” and “cooperative” ideas in other fields of knowledge, science among them.

For International databases, the team includes official publications, which are outputs of research carried out by its departments/research institutes, or are publications that express a political commitment to the Open Science.

The team excludes proceeding papers, book chapters, books reviews, meeting abstracts, theses, interviews, editorial material, and articles that are not in English.

At the end of this step, each author runs a pilot test in order to contrast the adequacy of the search strategy.

#### 3.2. Step 2. Appraisal - strategy for quality assessment of studies

For this step, the team uses Refworks for managing the identified references of the database.

In order to obtain a valid, reliable, and applicable database, first, the team verifies how many articles overlap among ISI Web of Science – Core Collection (Thomson Reuters) and Scopus (Elsevier). Second, the team conducts an abstract sift; those articles that mention the term Open Science once or twice without any relation with the area of research are excluded. Third, the team adds to the database the official publications found from the International databases. Finally, the team conducts a full-text sift, at the same time that the data is extracted. Those articles and official publications that do not meet inclusive criteria, do not provide a relevant definition of Open Science, or do not display data to support interpretations of Open Science definition (Dixon-Woods et al., 2006) are excluded.

#### 3.3. Step 3. Synthesis - strategy for data extraction

Based on the research goals, the team designs a coding template in Google Sheet as a method of documentation, with the following coding variables: author, title, inclusion/exclusion, definition, key elements/dimensions, values/principles, results/opportunities, and results/challenges. In order to achieve an optimum level of reliability for the proposed coding template, the review team runs a pilot test with 10 random articles. After that, the team compares their coding experiences and adopts the final coding template. The final collection of articles is divided among the team in groups of 5 chronologically to be analysed and synthesised.

The qualitative approach to synthesise the data extracted is narrative (Rumrill & Fitzgerald, 2001), due to the fact that it helps to identify, explore, and interpret the data, as well as helps to present new perspectives, all of which contributes to the development in the next systematic step, of a definition of Open Science.

#### 3.4. Step 4. Analysis - strategy for data analysis

The team decides to build a rigorous, integrated, and up-to-date

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