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Atlas of scientific institutions in food science (Scopus, 2003–2013)

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ABSTRACT

Bibliometric indicators are used to characterize the research activity of institutions worldwide with production in the period 2003–2013 in journals that are indexed in Scopus's Food Science thematic category. Basic, normalized indicators were used to compare the institutions' performances, together with highly cited papers (top-10% and top-1%). An interactive map was generated, displaying the 645 institutions with at least 100 documents produced during this period. The greatest numbers of those institutions are in the United States, South Korea, Spain, and China. National collaboration networks were detected on the East and West Coasts of the United States, and in Canada, Ireland, France, Spain, Holland, Denmark, China, South Korea, Malaysia, Brazil, India, Argentina, and Nigeria. There was no significant research activity in many developing and food exporting countries located in sub-Saharan Africa, North and East Africa, the Middle East, Latin America, the Caribbean, Eastern Europe, Central Asia, and South East Asia. The need to take into account other criteria based on qualitative attributes and the inherent limitations in the bibliometric indicators are discussed.

1. Introduction

The world's population has now surpassed seven billion people. Current projections estimate that by 2030 there will be 8.5 billion, and that by 2050 there will be 9.7 billion (United Nations, 2015). This demographic development goes together with dietary changes, increased demand for food, improvements in crop and livestock farming, and the consequent increase in food production, although there will persist problems of malnutrition, food safety, and threats to biodiversity.

Food Science (FS) is a multidisciplinary field of research intertwining chemistry, biochemistry, nutrition, microbiology, and engineering. According to the classification scheme of scientific fields used in the AgriMapping project, FS comprises eleven broad thematic areas in the first level of aggregation, and forty-one that are more specific in the second level (Borsi & Schubert, 2011). This applied science character, aimed at solving complex, transdisciplinary, inter-institutional, cross-border problems, oriented towards quality control, and with a high level of social responsibility, means that its research practices fall under the so-called Mode 2 production of knowledge (Nowotny, Scott, & Gibbons, 2003).

The present study applies one of the possibilities offered by bibliometric methods (Guerrero-Bote & Moya-Anegón, 2015) to analyse the scientific production worldwide in FS at an institutional level. A characteristic of Mode 2 production of knowledge is that the resolution of the problems it deals with requires collaborative work of teams made up of people with different skills and experiences.

Institutionally, this means that there are many more potential places where such knowledge can be created (Hoekman, Frenken, & Tijssen, 2010). As well as universities, Mode 2 knowledge production will typically involve the interaction of research centres and institutes, governmental organizations, industry laboratories, and business firms, and from different regions within a given country or from different countries. With the bibliometric indicators calculated in the present work, the aim is to offer a comprehensive global overview of the scientific results obtained by the most productive institutions that carry out FS research. To this end, we use the basic bibliometric indicators that have been available for decades, relative or normalized indicators that correct some previous biases, and advanced network analysis indicators which express influence or prestige (Moed & Plume, 2011).

Another aspect of the present study is that it takes advantage of

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today's graphical visualization techniques to represent spatially certain aspects of the worldwide system of FS production. We consider the links of cooperation between the producing centres, detecting those links through the counts of co-authored papers and adding the impact values of those works. We then analyse different dimensions that those links express: (i) the network's structure as indicated by the sizes of the nodes; (ii) the national dimension of the network as represented by the relationships of interconnection between centres of the same country; and (iii) the international dimension as determined from the co-authorship relationships. Finally, we shall colour-code the links according to their impact values to facilitate the exploration of the resulting topology and the identification of paths in the network. To this end, we shall overlay the inter-institutional network on a Google map of the world. Studies taking a similar methodological approach have been carried out on, for example, the thematic category of Library and Information Sciences worldwide (Leydesdorff & Persson, 2010), on the highly cited papers produced in European cities on Neuroscience, Social Sciences, Astronomy, and Physics (Bornmann, Leydesdorff, Walch-Solimena, & Ettl, 2011), and on international collaboration between countries worldwide (Leydesdorff, Wagner, Park, & Adams, 2013).

2. Material and methods

The empirical material used in this study is based on original data of the Scopus multidisciplinary index (http://www.elsevier.com/solutions/scopus) compiled for the SCImago Institution Ranking (SIR) database (http://www.scimagoir.com). Scopus is the abstract and citation database of peer-reviewed literature with the broadest coverage. It is published by Elsevier. The SIR database includes bibliometric indicators of 4289 research centres worldwide (August 2015), including universities and research institutes, that published at least 100 documents during 2013. Together, these centres account for more than 80% of the world's scientific production indexed by the Scopus database.

SIR's thematic classification follows the Scopus conventions, classifying the journals into 27 major thematic categories (Subject Areas) and 313 minor, more restricted, thematic categories (Specific Subject Areas or Categories). The Subject Area of Agriculture and Biological Sciences comprises 11 Specific Subject Areas. One of these is Food Science, which, in 2013, included 234 journal titles.

For the purposes described above, we downloaded all the documents published in those journals in the period 2003–2013.

The bibliometric indicators calculated to characterize the scientific production in FS of each of those institutions were the following:

- *Ndoc*: Number of documents published in scientific journals included in the Scopus database.
- *%Ndoc*: Percentage of the documents concerning an area or category (here Food Science) with respect to the total production of the institution in question.
- *% International Collaboration*: Percentage of the documents in whose byline there appear authors of various countries. The "whole counting" method was used, following the procedures by which Scopus obtained and assigned the personal addresses contained in the publications in its database. If there were two different institutions signing the publications, the two institution names were used to subsequently add to them the geographic coordinates of latitude and longitude.
- *RG*: Number of documents published in scientific journals indexed in Scopus in which an author of the corresponding institution acted as Research Guarantor (corresponding author) (Moya-Anegón, Guerrero-Bote, Bornmann, & Moed, 2013). This indicator is also expressed as a percentage (%RG).
- *Normalized Impact (NI)*: Average normalized citation received by each document. This is understood as being the ratio between the citation received by the document and the average citation of documents of the same type, year, and category (Rehn & Kronman, 2008).
- *Excellence10*: Number of documents that are among the 10% most cited of the same year, type, and category (Bornmann, Moya-Anegón, & Leydesdorff, 2012). The indicator is also expressed as a percentage (%Excellence10).
- *Excellence10 as RG*: Number of documents that are among the 10% most cited of the same year, type, and category in which an author of the corresponding institution acted as Research Guarantor (corresponding author). The indicator is also expressed as a percentage (%Excellence10 as RG).
- *Excellence1*: Number of documents that are among the 1% most cited of the same year, type, and category. The indicator is also expressed as a percentage (%Excellence1).

We analysed the distribution of the indicators *%Excellence10 as RG* and *%Excellence1* of the institutions classified into 42 classes: a "total" class, with the values of all the institutions included in the study; four classes of institutions classified by activity sector; eight classes by continent; and twenty-nine classes by country. For these two indicators of excellence, we calculated the 25th, 50th, and 75th percentiles for each class of institution. Outliers were determined using the interquartile range method. The results are presented as box-and-whisker plots. This approach, based on percentile ranges, is interpreted as providing quality values because it takes into consideration the underlying form of the distribution of the citations within the thematic category. The advantage of using rankings based on percentiles is that it allows one to compare the citation distributions of uneven sets of documents, as is the case with institutional productions in FS (Leydesdorff, Bornmann, Mutz, & Opthof, 2011). To assist in better understanding the performance of the institutions, Table A1 in Appendix A presents other results of interest of the great amount of data used.

Geolocation using the place or institution names listed in the addresses of research papers, as in the present case, allows the places where this knowledge has been created, and whence it is being disseminated, to be located (Frenken, Hardeman, & Hoekman, 2009). The names and locations of the institutions that appear in the byline of the document's address field were extracted after normalization with manual and semi-automatic procedures. To generate the map, we used the GPS Visualizer online utility, accessible gratis at http://www.gpsvisualizer.com/. Besides giving this utility the institution's coordinates (latitude and longitude), we also input to it a series of bibliometric data for representation and consultation. The provider of the geographic coordinates was Google.

3. Results and discussion

The downloaded data were 201 220 documents of all types. Of these, 90% were articles, 5% reviews, 2% conference papers, 1% editorials, and the remaining 2% other documents. In order to discard the participating institutions which just have an occasional production on FS, we kept only those that produced 100 or more works in the period studied. This left a total of 645 different institutions worldwide. Of these, 84% were higher education institutions, 13% public research institutes, 2% health institutions, and 1% private entities.

The plots of Figs. 1 and 2 show the rankings of the 645 institutions using different indicators: production-size dependent