

Research Trends in Relation to the Orientation of the University Research Centers: Perspectives from the Bibliometric Analysis

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Abstract

The universities are centers of great capitals of knowledge and of investigative capacities; being protagonists agents in the dynamization of the information society starting from the groups and centers of investigation. This dynamic is not widespread in emerging economies where there is still a process of consolidation of these processes of technology transfer starting at the University Research Centers. According to the above, the objective of the research is to identify the investigative tendencies facing the orientation of the University Research Centers from a systemic literature review. The methodology consisted of a bibliometric analysis of 91 academic research records reported in the SCOPUS database. This information was systematized and organized to calculate the quantity, quality and structure indicators. Among the results obtained it is observed that the research on structuring the research center in the university context, has been oriented towards the search and development of mechanisms to connect universities with the needs of the specific social context. In addition, university research centers have attempted to structure their connection with enterprise from the technology transfer units, with projects aimed at strengthening areas related to productivity engineering, telecommunications and technology management

Keywords: bibliometrics, research centers, trends, universities.

1. Introduction

Scientific knowledge creation is currently fundamental for the further development of societies and countries. According with Cubillo (2017) and Bermudez et. al. (2014) the universities prove to be its great fosterers and also distributors they contribute to educational processes and have even become key actors in the development of regional innovation systems regarding investigative management from their groups and centers.

According to the UNESCO International Institute for Higher Education in Latin America and the Caribbean, although there has been scientific collaboration in the region for more than forty years, several structures are still needed to transform the strength of collective thinking and negotiations, developing academic centers and/or workshops to discuss common ideas that require interest and investment and to encourage technology transfer (IEASALC-UNESCO, 2008).

Scientific inquiries and academic publishing generated from research centers have had positive changes in the last three decades due to improvements in postgraduate studies, and the needs of the productive sector as well as for educational reforms —although the tendencies of these inquiries are unclear due to the diversity of sectors and the particular interests of each research center, which at the same time answer to the interests of the institution to which they belong (Barranquero & Ángel Botero, 2015).

According to (Boardman & Corley, 2008), all research centers have collaborative studies in common, but few have validated features which could expedite it, and thus benefit themselves from abilities, infrastructures and know-hows regarding the methodology implemented. It could also allow to broaden knowledge in particular areas and to offer assistance to the different actors for overcoming the challenges of the sciences (Boardman & Ponomariov, 2014)

Recognizing tendencies and areas worked on in university research is important to identify the international background in regard to scientific investigation. This study proposes the implementation of mathematical methods for tracking and evaluating the impact of scientific literature. It is a tool that has been used increasingly for the past years on account of the consolidation of bibliometric studies (Lee, Yoon, & Park, 2009). These measure the results of scientific development and knowledge in relation to their relevance, and disciplines like informetrics and scientometrics (Ajaújo Ruiz & Arencibia, 2002).

In order to validate the evolution and tendencies of university research, a bibliometric analysis was carried out in two stages: collecting data from the SCOPUS database and generating bibliometric indicators about quantity, quality and structure of the reported academic researches.

2. Methodology

The source of information used for the bibliometric study was the SCOPUS database. It is trustable, frequently used in literature, and has flexible engines for searches, accessibility, citation indexes, and lapses of time (Hall, 2011).

From the literature consulted, the following terms were identified as related to the topic: university research center, investigation, productivity and development investigation (with possible variations). The following was the search equation used for the present study, which offered a total of 60 registers:

TITLE ((research* W/4 center W/4 university) OR (scienti* W/4 investigat* W/4 producti*) OR (research* W/4 university W/4 performance) OR (investigat* W/4 center W/4 university) OR (scienti* W/4 development W/4 investigat*) OR (research* W/4 scienti* W/4 producti*) OR (research* W/4 center W/4 university W/4 journey)) AND KEY ((research* W/6 center W/6 university) OR (research W/6 university W/6 performance) OR (investigat* W/6 center W/6 university) OR (scienti* W/6 development W/6 investigat*) OR (research* W/6 scienti* W/6 producti*) OR (research* W/6 center W/6 university W/6 journey) OR (scienti* W/6 investigat* W/6 producti*))

The search engine detected articles with titles or key words that included equivalent terms for “university research center” and “development investigation” (with a relative placement of until 6 words). The lapse of time was not restricted in order to obtain a full overview and to present the network dynamics. There were also no restrictions for areas or disciplines.

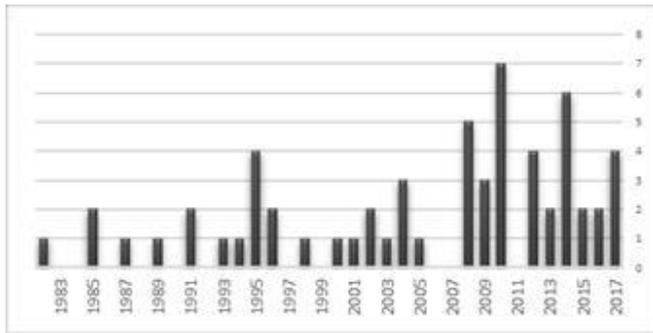
This information allows to put to together bibliometric indicators to value scientific activity and the impact of publications. The authors Durieux and Gevenois (2010) propose quantity indicators to correlate productivity levels, quality indicators to verify the impact or frequency of the publications in the academic field and, finally, structure indicators to identify connections and correlations between researchers.

3. Results

Based on the indicators proposed in the methodology, the results of the analysis are hereby presented:

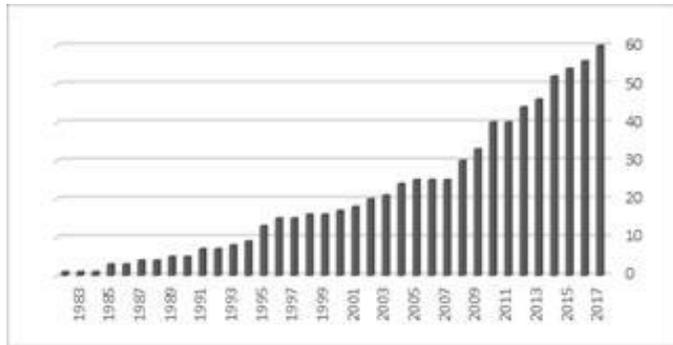
3.1 Quantity indicators

Section 1 presents the bibliometric quantity indicators for the term “research center” with the search equation proposed:



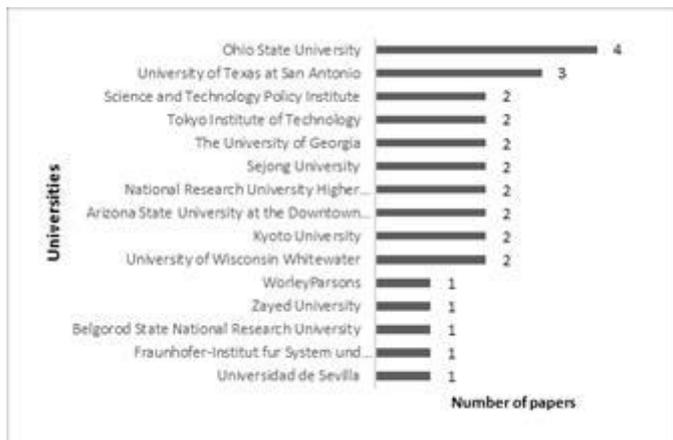
Graphic 1.1: Amount of publications per year

The indicators in Graphic 1.1 show the growth of interest for the term “research center”, first introduced in the database in 1981. Until 2008, its interest was low. 2010 and 2014 were the most productive years, as they had the larger amount of publications regarding research centers.



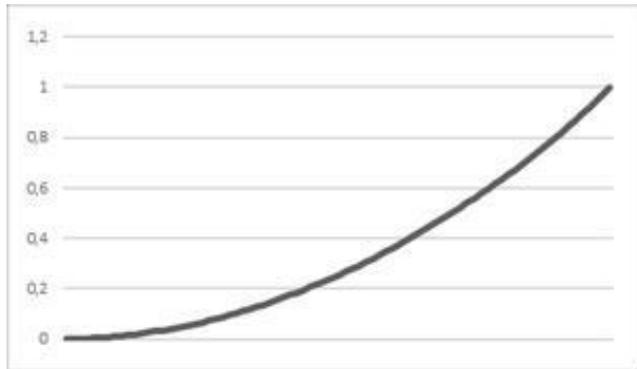
Graphic 1.2: Number of accumulated publications per year

Graphic 1.2 evidences how the amount of cumulative publications per year presents an exponential and thus significant growth, specially in the last decade.



Graphic 1.3: Number of publications per university

The bibliometric analysis also allows to identify the ten universities which publish the most about the topic. The Ohio State University has 9 publications, followed by the University of Texas at San Antonio with 6 publications and the Science and Technology Policy Institute with 4 (see Graphic 1.3). According to the results shown in Graphic 1.4, it is possible to conclude that the Pareto principle does not apply, for 74.29% of the journal publishes 80% of the articles. Thus, the percentage of journal was divided in quartiles: 5.71% of magazines published 25% of the articles, 35.71% of journals published 50% of the articles and, finally, 68.57% of journals published 75% of the articles. The data collected shows that, although the distribution of journals per journals is not even —for, as indicated by the first quartile, only 5.71% of journals published 25% of the articles— no journal prevails above others according to the records of the database.



Graphic 1.4: Cumulative percentage of publications by journal

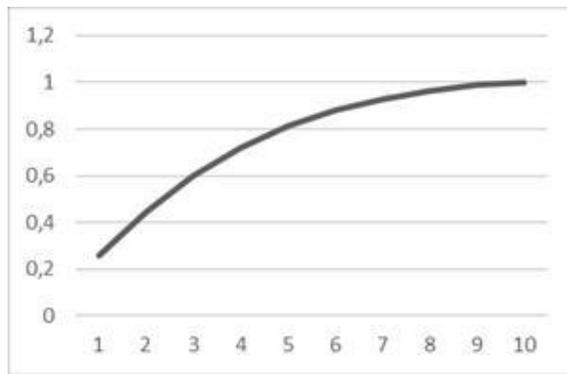
Regarding authors, Graphic 1.5 shows the ten most productive investigators. The list is headed by Boardman, P.C. (with 6 articles), Geisler, E. (with 3 articles), and Ponomariov, B. (with 3 articles) —the seven remaining authors have up to 2 publications.



Graphic 1.5: Number of publications in the top ten authors

The cumulative percentage of these publications (see Graphic 1.6) shows that the Pareto principle does not apply, for 77.97% of authors published 80% of the articles. Thus, the cumulative percentage of publications written by the ten most productive authors was divided: 16.30% of authors published 25% of articles, 44.05% of authors published 50% of articles

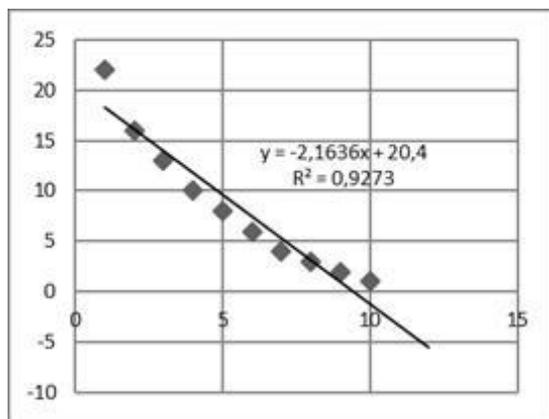
and, finally, 72.25% of authors published 75% of the articles. The data collected shows that the distribution of articles per investigator is evenly distributed, and hence no single author prevails above the others.



Graphic 1.6: Cumulative percentage of publications of the top ten authors

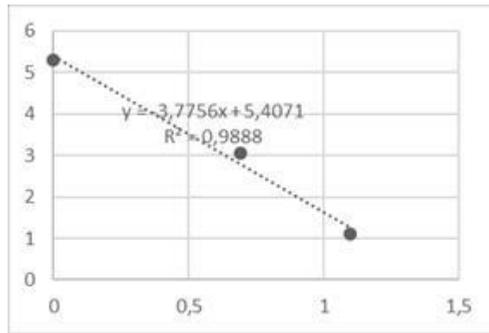
Besides the Pareto principle and the exponential law, the productivity law was also validated for magazines and authors. It was possible to review whether knowledge was fragmented or if there was a “science illness”, a term first introduced by Spiegel (1976) and quoted by Rueda (2007); explained as the accelerated obsolescence of scientific information, derived from the need to diffuse created knowledge. This way, a closer relationship can be fostered through the use of communication networks between scientists and users.

After applying the natural logarithm to each of the axes, the productivity law is obtained for the magazines (see Graphic 1.7) according to the number of publications per magazine. The r-squared coefficient of the cumulated amount of articles was whence obtained regarding the natural logarithm of the magazines. The coefficient of determination was 0.9273, close to 1. This allows to conclude that the model is explained by regression analysis, as stated by Lascourain (2006).



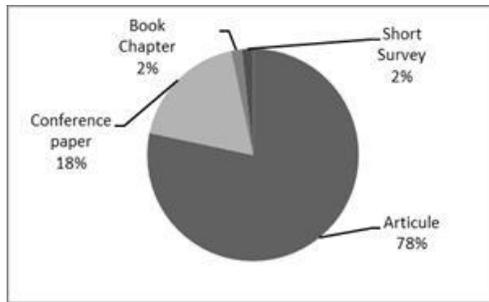
Graphic 1.7: Law of Journal Productivity

The same logic may be applied to validate the productivity law for the authors (see Graphic 1.8). The r-squared coefficient of the cumulated amount of articles regarding the natural logarithm of the authors is higher than 0.9. This indicates that it fits the model adequately.



Graphic 1.8: Law of Authors Productivity

To conclude the quantity indicators, 78% of the records obtained with the search equation correspond to articles, 18% correspond to conference papers, and the remaining 4% correspond to other types of documents (see Graphic 1.9). This could be an indicator of the current relevance of research centers and their continuous diffusion in conferences and events of the likes.

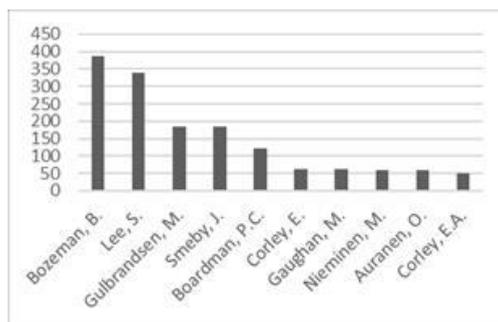


Graphic 1.9: Publications by type of document

3.2 Quality indicators

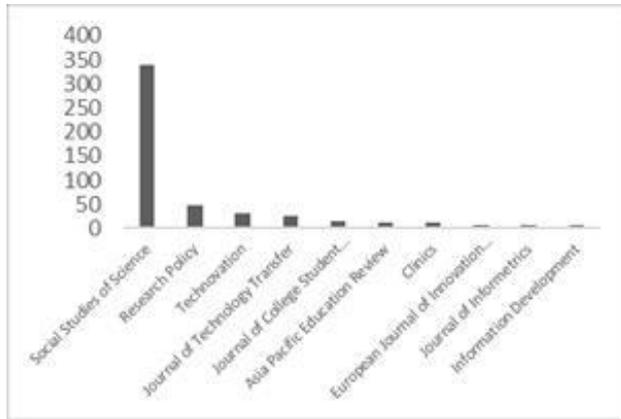
Section 2 presents the bibliometric quality indicators for the term “research center” with the search equation proposed.

It is possible to identify the ten authors with the most citations with quality indicators. Bozeman, B. has the most citations (386), followed by Lee, S. (338), Gulbrandsen, M. (186) and Smeby, J. (186), and Boardman, P.C. (see Graphic 1.2), who also appears on the list of authors with the most amount of publications (see Graphic 1.5).

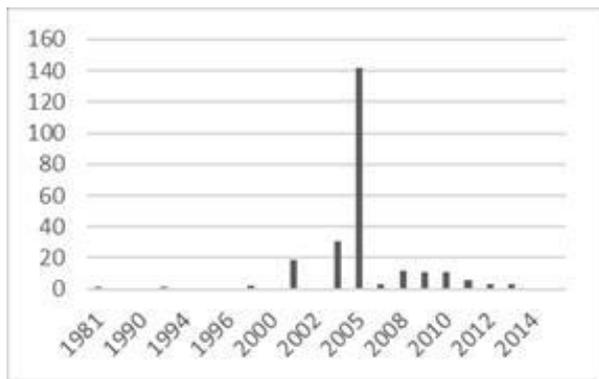


Graphic 2.1: Amount of citations per author

On the other hand, the indicator for the impact of citations per magazine (see Graphic 2.2) presents several similarities when facing the quantity indicator for publications per magazine (see Graphic 1.3): the four following magazines coincide in both indicators: Research Policy, Technovation, Journal of Technology Transfer, and Journal of Informetrics. The magazine with the most impact is Social Studies of Science with 338 citations. This asserts its contribution and importance for the diffusion of issues related to research centers. There is a significant difference with the other magazines in regard to amount of citation, for the magazine that follows is Research Policy, with 50 citations.



Graphic 2.2: Number of citations for journal



Graphic 2.3: Number of citations per year

The bibliometric analysis allows to conclude that the topic was not particularly studied except during the years of 2001 and 2004, during which there were 19 and 30 citations identified, respectively. The largest amount of citations was produced in 2005, with a total of 141, while it decreased significantly afterwards (see Graphic 2.3).

3.3 Structural indicators

Structural indicators measure the connections between publications, authors, and areas of knowledge. They tend to be associated with the construction and analysis of social networks, formed by nodes and links. For the bibliometric analysis, the nodes represent the authors while the links represent the co-authors (Pacheco-Mendoza & Alhuay-Quispe, 2017). This type of indicators are unidimensional. These highlight scientific production, the transmission of information, the collaborations between authors and institutions, and others (Price, 1978). Image 1 shows the network of researchers in the field. It allows to identify several of its characteristics by representing each researcher as a node and each connection between investigators in at least one project as a link.

Images 1 and 1.1 show topological maps of the author network throughout the periods of 1981 to 2008 and 1981 to 2017.

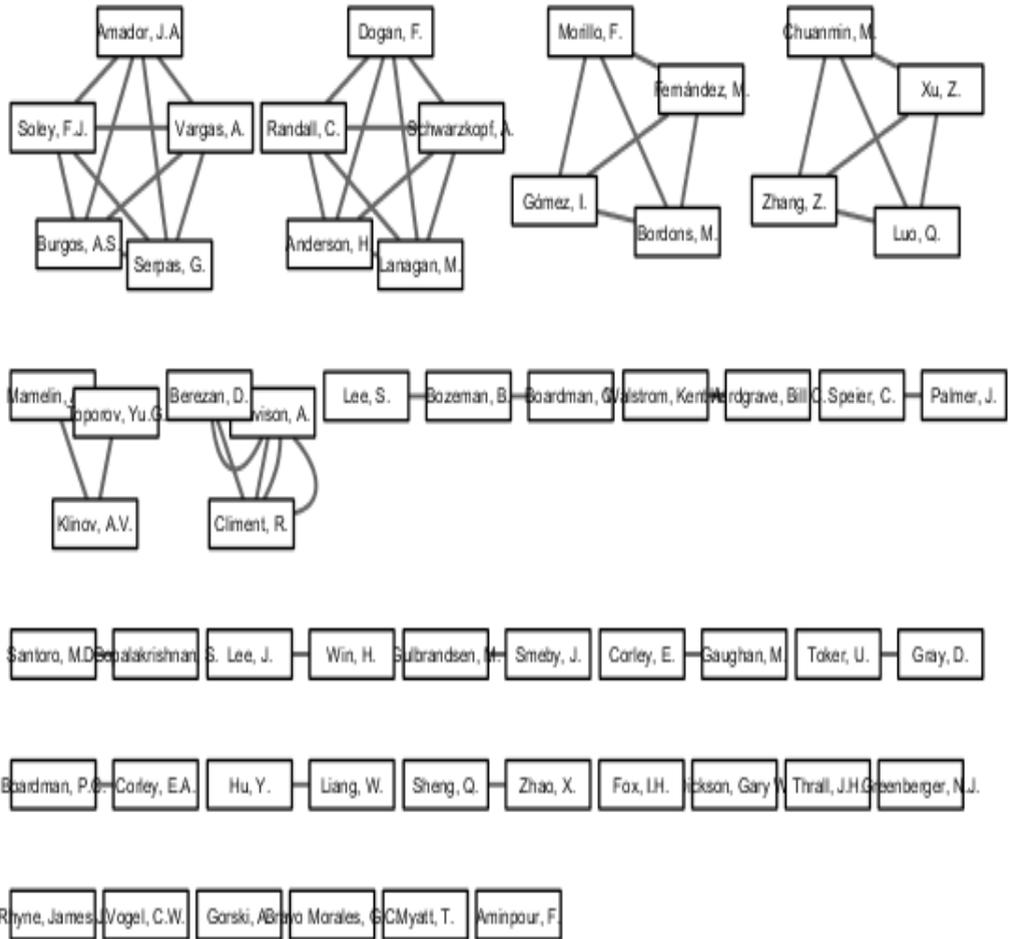


Image 1. Topological map of the author network since 1981 to 2008

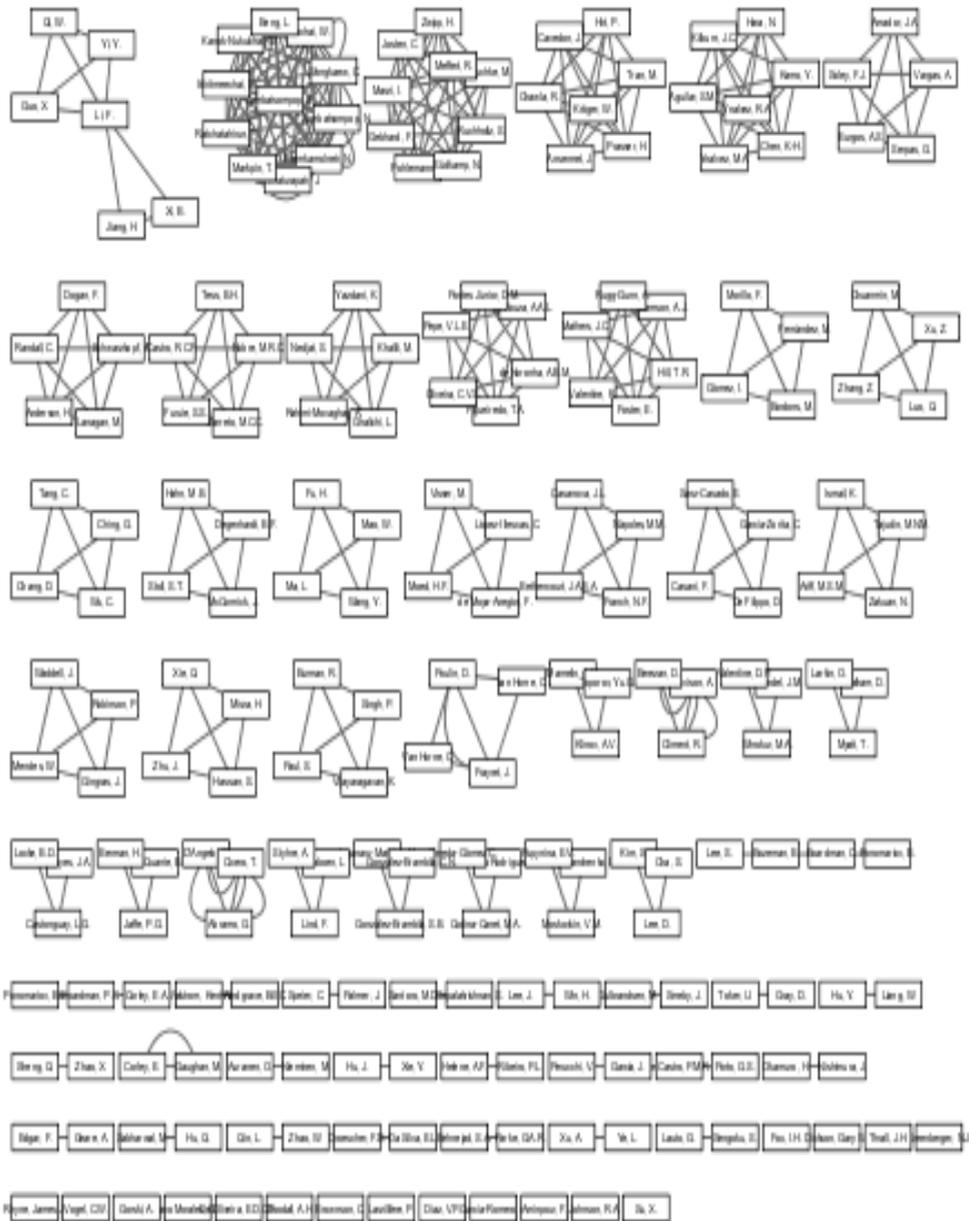


Image 1.1: Topological map of the author network since 1981-2017

As it can be observed in both images, the network of investigators shows certain relevant characteristics throughout the years. These can be seen in the results from the author network indicators presented in Table 1:

There are 228 authors in the field and, given that the size of a network is important for determining relationships (Gaete Fiscella & Vásquez, 2008), it can be considered that their network, which considers investigations related to research centers, is extensive. This proves that these investigators strive to participate with other experts from the network. On the

other hand, distance can also indicate the size of the network (1.033), for it shows how authors or nodes must be related to at least another node in order to be connected to the rest of the nodes from the network. Another indicator that measures the size of the network relates to the amount of “neighbours”: on average, each author has published along with other 3 authors (3.088), thus confirming the considerably large extension of the network.

The density of the network is close to zero (0.014), which evidences the scarce connectivity of the network and that its potential is not being exploited. Nevertheless, this scarce connectivity is not consistent throughout the network. As may be observed in Image 1.1, there are certain areas with high connectivity. This could indicate that the dispersion of production is significant, which could establish the centrality of certain nodes. On the contrary, there is null connection between others. Thus, there is much disparity in order to access or introduce information and knowledge in the network.

Additionally, the connection between nodes (authors) is significant in subnets, for they have a degree of connection of 0.696.

This type of centrality establishes the power certain nodes have inside a network to connect (or acts as the bridge for) particular node groups. In consequence, they are considered as hinges for the management of resources which may affect the network.

The network would thus evidence that researchers are very well connected—which may therefore influence other authors easily. Besides, they intervene or control the information from certain node groups with the rest of the network at a 33.77%.

Table 1. Indicators of Structure

Indicator	1981-2008	1981-2017
Number of nodes	57	228
Network Density	0,031	0,014
Network Diameter	2	3
Expected Characteristic Distance	1,020	1,033
Number of Connected Components	27	77
Average Number of Neighbors	1,754	3,088
Degree of Network Grouping (Clustering)	0,421	0,696
Network Centralization	0,042	0,031
Network Heterogeneity	0,779	0,788
Number of Isolated Nodes	10	17
Components Connected by Nodes	47,36%	33,77%
Components Isolated by Nodes	17,54%	7,45%

Table 1 presents structure indicators in two cumulative periods (1981-2008 and 1981-2015). This allows analysing the network’s evolution throughout time. An increase in the number of authors may be appreciated in the amount of nodes, as well as in the number of independent authors in the amount of isolated nodes. This evidences the existence of a considerably stable research group, probably composed of an academic elite. Nevertheless, the growth rate of nodes is larger than for isolated nodes and connected components. Hence, there is a decrease in the dispersion of the isolated subnets and the independent publications (variations of the components connected by nodes and the component isolated by nodes). It can be thus appreciated how subnets have increased in size and decreased in density, as is reflected by the evolution of the degree of connection and the network’s diameter. There is also a single link that connects the rest of the nodes from the network (1.033) and, at the same time, the maximum distance between any two nodes equals 3. This corresponds to a typology of knowledge management network, used to enhance the application of individual knowledge to the organization’s objectives. These networks evolve through the thematic mapping of the experience within the organization and of profitable environments to share knowledge [16].

4. Conclusion

The interest for university research centers as objects of investigations has grown since the beginning of the 80s and even more so throughout the last years. The years 1995, 2008, 2010, 2012 and 2014 have impacted the literature greatly, without the need to distinguish relevant authors, possibly because of the specificity of each center and its research topic.

Academic production is constrained to few countries and to the English language. Most authors reside in the United States while none reside in Latin America. The topic is currently relevant and lately has been asserted due to its diffusion in conferences and similar events held during the past three years. It is impossible to reduce the knowledge created to a single institution, author or magazine, for it has been widely spread due to its easy application in other areas of research knowledge.

The authors with more publications are not the most cited authors, thus evidencing the few correlation between amount and impact of publications. The authors which have been recently introduced in the field attach themselves to previously formed networks, instead of doing so as independent investigators. Nevertheless, the amount of relationships they establish with other authors are fewer with time, thus encumbering relationships between authors. There is a lack of patterns which indicate the presence of an author who leads the field, generating even more network disaggregation.

Because several challenges are generated, it is necessary to perform a wider analysis which includes “university research” as a search tool and “research center” as a key word, considering the objective of this study was to classify knowledge areas in order to obtain references and having more specific perspectives about the topic.

The present analysis did not include text mining, diffusion curves nor nodes quantitatively correlated, but they could be considered for future studies as useful elements to identify current topics of interest with a diachronic perspective and quantifying levels of interactivity, hence orienting new resources for the study of research centers.

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