DEPÓSITO LEGAL ZU2020000153
Esta publicación científica en formato digital
es continuidad de la revista impresa
ISSN 0041-8811
E-ISSN 2665-0428

Revista de la Universidad del Zulia

Fundada en 1947
por el Dr. Jesús Enrique Lossada

Ciencias Sociales y Arte

Año 11 N° 31
Septiembre - Diciembre 2020
Tercera Época
Maracaibo-Venezuela

DOI: http://dx.doi.org/10.46925//rdluz.31.02

Co-authorship network of national researchers of Social Sciences in Mexico

Fernando Lámbarry-Vilchis*
Juan Carlos Moreno-Jiménez**

ABSTRACT

In Mexico, the most outstanding researchers are distinguished by the National Council of Science and Technology. Although, in the international literature, researcher's co-authorship networks and their impact on efficacy have been studied, in Mexico this type of studies is showing a greater boom, so the objective of this paper is to analyze the structure of the network of co-authorships of the researchers in Social Sciences level 3 of the country. For this purpose, the research method was based on the theory of networks and specifically on topology metrics. One of the conclusions of the research is that the researchers under study publish in a similar proportion individually or collaboratively, configuring a fragmented co-authorship network with a main component with properties that are explained by both the small-world and the free-scale model.

KEYWORDS: Social Sciences co-authorship networks, national researchers in social sciences, social sciences centrality metrics.

*Investigador del Instituto Politécnico Nacional. Escuela Superior de Comercio y Administración Unidad Santo Tomás. Investigador Nacional Nivel 1, Conacyt, email: flambarry@ipn.mx

** Investigador independiente. Candidato a investigador en Ciencias del Instituto Politécnico Nacional, email: carlosm-10@hotmail.com

Recibido: 03/07/2020 Aceptado: 04/09/2020

DOI: http://dx.doi.org/10.46925//rdluz.31.02

Red de coautoría de investigadores nacionales en Ciencias Sociales en México

RESUMEN

En México los investigadores más destacados son distinguidos por el Consejo Nacional de Ciencia y Tecnología. Aunque en la literatura internacional se han estudiado las redes de coautoría de los investigadores y su impacto en la eficacia, en México este tipo de estudios están presentando mayor auge, por lo que el objetivo de este trabajo es analizar la estructura de la red de coautorías de los investigadores en Ciencias Sociales nivel 3 del país. Para ello, el método de investigación se fundamentó en la teoría de redes y específicamente en las métricas de topología. Una de las conclusiones de la investigación es que los investigadores bajo estudio, publican en similar proporción en forma individual o colaborativamente, configurando una red de coautoría fragmentada con un componente principal con propiedades que se explican tanto por el modelo de mundo pequeño, como de libre escala.

PALABRAS CLAVE: redes de coautoría en ciencias sociales, investigadores nacionales en ciencias sociales, métricas de centralidad en ciencias sociales.

Introduction

Co-authorship in scientific publications has been a topic of research interest since the 1960s, it was Newman (2001) the first to investigate the topological properties of large co-authorship networks with metrics based on the centrality theory (Freeman, 1979) that differentiates them from each other. These collaborative patterns are explained by two classic models of the network theory, *the small world* of Watts and Strogatz (1998), which is usually the most recurrent and, *the free-scale* of Barabási and Albert (1999, 2002). The models reveal collaboration patterns of the researchers in various fields of knowledge that characterizes and defines them between each other (Newman, 2004a, 2004b, 2001). For example, Newman (2001, 2004a) in the co-authorship networks of physics, mathematics and biology, concluded that they are structured with *small world* properties, but with different collaboration patterns and separation degrees, Moody (2004) in sociology found a growing structural cohesive core and, Goyal et al (2006) when analyzing the Economy network, found collaborative patterns explained by the *small world* model and in general, a greater co-authorship in the hard science researchers than in the social sciences (González-Brambila, 2014; Tan and Walsh, 2013; Liberman and Wolf, 2010), Rossoni (2014) in Brazil.

DOI: http://dx.doi.org/10.46925//rdluz.31.02

In Mexico, although the National Council of Science and Technology, which is the governing body for the development of scientific and technological research in the country, distinguishes national researchers for the quality and quantity of their publications and promotes the creation of inter and multidisciplinary research networks priority for the Science, Technology and Research sector of the country (Conacyt, 2014), the reality is that despite the importance of it, studies in Mexico to know the collaboration patterns from the perspective of co-authorship are scarce and even more so in the field of social sciences, therefore, this document extends the previous research of networks for the case of national researchers in Mexico. To achieve this, the research method was based on the topological analysis of the network formed by the co-authorship publications.

One of the conclusions of the research is that the co-authorship networks are fragmented, with characteristic *small world* and *free-scales* properties.

1. Theoretical basis

1.1. Scientific co-authorship networks

Many reasons to encourage co-authorship in research works have been cited in the literature, one of the most recurrent is that unlike publishing individually, the co-authorship has a greater impact on the research in terms of the number of publications and citation (Lee and Bozeman, 2005; Ponomariov and Boardman 2010). Which is why, over time, co-authorships in all disciplines have increased (Lopaciuk 2016; De Stefano et al., 2013; Kronegger *et al*., 2011; Acedo *et al*., 2006; Laband and Tollison, 2000), and the number of co-authors per publication has also increased (Goyal et al., 2006; Wuchty *et al*., 2007) although the degrees and types of collaboration differ from one country to another, and from discipline to discipline. For example, Newman (2001, 2004a) when analyzing three collaborative scientific networks: Physics, Mathematics and Biology, found that theoretical investigations have, on average, fewer authors (1.99-2.22) than those from experimental areas (2.66-3.75), high-energies physics averaged a larger number of co-authorships (8.96 authors per article) even an article with 1,681 coauthors. In all the networks, from five to six degrees of separation were found between the co-authors and high cohesion coefficients.

For their part, Liberman and Wolf (2010), concluded that anthropologists and mathematicians publish individually, unlike physicists and especially biotechnologists, who

DOI: http://dx.doi.org/10.46925//rdluz.31.02

usually include all participants of the laboratory group. Cheng, et al., (2013) found that the collaboration of researchers in Malaysia is more dominant in the hard disciplines than in the social sciences.

For the case of Mexican scientists, only the research of Gonzalez-Brambila (2014) is found, who analyzed the relationship between social capital and the creation of knowledge in different areas of knowledge from the Science and Social Sciences Quotation Indexes of the Institute of Scientific Information (ISI) and researchers of the National System of Researchers of Mexico from 1991 to 2002.

Among other things, he concluded that in the health sciences, exact sciences, biology and chemistry is where the most productive researchers are located and those that have more publications with researchers from abroad than those of engineering, agricultural sciences, biotechnology, social sciences and humanities. He also revealed that dense networks are associated with a lower performance of researchers in terms of scientific productivity, while the number of links improve productivity, suggesting that scientific policies should encourage scientific and interdisciplinary collaboration.

1.2. Topological properties of networks

For Barabási *et al.*, (2002) the importance of the study of co-authorship networks lies in the fact that they contribute to the understanding of the topological and dynamic laws that govern the complex networks.

The topological properties at the global level of the network help to understand the general structure of the network, its metrics reveal the concentration of authority, control and other resources. The metrics at the local level help to understand the influence and prestige of the individual actors in the network, when they are normalized values and according to the metric, the value of 0 indicates low centrality or connectivity and up to levels of 1, high centrality or connectivity.

The most recurrent topological properties of networks are described in the following paragraphs.

1.2.1. Topological metrics at a global level of the network

DOI: http://dx.doi.org/10.46925//rdluz.31.02

Models of small world and free scale: The patterns of collaboration are usually explained by two classical theoretical models*: the small world* of Watts and Strogatz (1998) and *the free-scale* of Barabási and Albert (2002, 1999). In the small world model networks have high nodal connectivity, low average trajectory length and a relatively high grouping coefficient, compared to those measured in random networks (Barabási and Albert, 2002, 1999; Watts and Strogatz, 1998). The most popular manifestation of the small world network is Stanley Milgram's concept of six degrees of separation (Milgram, 1967). While the model of free scale explains the patterns of large networks that exhibit preferential links with a distribution of degree that follows the Lotka´s power law (1926) $y = \frac{c}{x^n}$=P(k)~ $\frac{1}{k^\gamma}$ for 1<γ<3 or 1<n<3 , (Barabási and Albert, 2002), not exhibited characteristic in the Watts and Strogatz model. Where n its calculated by $n = \frac{N\sum XY - \sum X \sum Y}{N\sum X^2 - (X)^2}$ and $C = \frac{1}{\sum_{x=1}^{P-1}\frac{1}{x^n} + \frac{1}{(n-1)P^{n-1}} + \frac{1}{2P^n} + \frac{n}{24(P-1)^{n+1}}}$, where, x is the scientific production or number of articles produced, y the number of authors that produce x articles, n the exponent and C the constant of Lotka´s function, N is the number of observed pairs of data, X is the log *x* (base 10), Y is the log *y* (base 10), x is the number 1,2,3,...*n* contributions per author, P is the total number of observed data (Gobea, 2005).

In such a way that the probability of connecting to a particular node is determined by the degree of the node to be connected, that is, a tendency of certain nodes to interact with key nodes of the network structurally positioned to benefit more than others less central (Lopaciuk-Gonczaryk, 2016; Badar et al, 2016; Bordons et al, 2015; Badar et al, 2014; Gonzalez-Brambila, 2014; Li et al., 2013; Ye et al., 2013).

Component and diameter: It is the set of connected nodes in such a way that any random node in the set can reach another random node (Newman, 2004a, 2004b). When conducting comparative studies between several co-authoring networks Kretschmer (2004) concluded that, on average, the size of the largest component is above the 40% of the number of nodes in the network. While, the distance between two nodes indicates the closeness of one to another, while the geodesic indicates the shortest path between two nodes and the diameter, the longest distance between two nodes of the network.

Cohesion coefficient: The coefficient of cohesion or transitivity C or Γ of a network $\bar{C}$ (equation 2) represents the average of the grouping coefficients of all the nodes in the

DOI: http://dx.doi.org/10.46925//rdluz.31.02

network (Watts and Strogatz, 1998) and is calculated by $\bar{C} = \frac{1}{n}\sum_{i=1}^{n} C_i$, Where, a_i is the number of edges connected to the node i and k_i is the degree of the node i.

Density: The density d of a network g indicates the number of existing relationships r in relation to the maximum possible $\frac{n(n-1)}{2}$ (Barabási and Albert, 2002). A high level of collaboration makes the network denser, in contrast a lower collaboration results in a lower density (Otte and Rousseau, 2002). The density of a non-directed network is defined as: $d(g) = \frac{2r}{n(n-1)}$.

Centralization: While centrality refers to the position of nodes in the networks, centralization refers to the set of the structure of a network, so this metric is based on the differences between the centrality of the most central of the nodes and that of all others (Freeman, 1979), the network is compact to the extent that the distances between the pairs of nodes that comprise it are small. The index of the centralization of the network is determined from one of the three different measures of the centrality of a node: $C_x = \frac{\sum_{i=1}^{n}[C_x(p^*)-C_x(p_i)]}{max\sum_{i=1}^{n}[C_x(p^*)-C_x(p_i)]}$, where n is the number of nodes, $C_x\ (p_i)$ one of the measures of centrality of a node, $C_x\ (p^*)$ represents the maximum value that can take $C_x\ (p_i)$ for any node of the network, and $max\sum_{i=1}^{n}[C_x(p^*) - C_x(p_i)]$ is the maximum possible sum of the differences in the central node of the network.

1.2.2. Topological metrics at the local level of the network

Cohesion coefficient C o Γ: or transitivity coefficient of a node quantifies how much the node is grouped or interconnected with its neighbors (Albert and Barabasi, 2002; Watts and Strogatz, 1998), mathematically it is $C_i = \frac{a_i}{k_i(k_i-1)/2}$.

Centrality: for the centrality there are three classic metrics and commonly used: degree, proximity and intermediation, through it is identified the most important actors by their structural position (Borgatti, 2005; Otte and Rousseau, 2002; Freeman, 1979).

Degree centrality C_D: or simply the degree of a node is the number of edges that are attributed to it, without taking into account the intensity of the connection. In this way, it is the simplest and most intuitive measure of the potential communication activity of the node (Freeman, 1979). So, the degree of a node p_i it's simply the number of nodes p_j $(i \neq j)$

DOI: http://dx.doi.org/10.46925//rdluz.31.02

that are adjacent to it (Nieminen, 1974) and it is calculated as the degree or number of adjacencies for the node p_k: $C_D(p_k) = \sum_{i=1}^{n} a(p_i, p_k)$. While the distribution of degree is therefore the probability p_k that a randomly chosen node has the degree k.

Centrality of proximity C'_c: is based on the degree to which a node is close to the other nodes of the network, is the shortest average distance by which a given actor separates from all other nodes in a network (Lu and Feng, 2009). Here a node is considered central insofar as it can avoid the potential control of the others. The independence of a node is determined by its proximity to all other nodes in the network (Freeman, 1979). Actually, it is a measure of decentrality or inverse centrality, as it grows as the points separate, and the centrality in this context means proximity, that is, it is the average of the total reciprocal distance of that node away from each of the other nodes of the network (Lu and Feng, 2009). Mathematically it is: $C'_c(p_k) = \frac{n-1}{\sum_{i=1}^{n} d(p_i, p_k)}$, where $d(p_i, p_k)$ is the number of edges in the geodesic (shorter distance of two nodes) that joins p_i y p_k.

Intermediation centrality C_B: it is defined as the frequency with which a node is between other pairs of nodes in the geodesic that connect them (Freeman, 1979). It is a measure that indicates the potential of a node to control communication, so they often form bridges between the components of the network (Otte and Rousseau, 2002). It is calculated as: $C_B(p_k) = \sum_{i<}^{n} \sum_{j}^{n} b_{ij}(p_k)$.

2. Research method

The objective of this study was to analyze the topological properties of the co-authorship network of the researchers level 3 in Social Sciences of Mexico. Therefore the methodology was based on the used by Kumar and Mohd (2014) and implied three phases:

a) Data collection: it is area V, in which the National Council of Science and Technology concentrates the disciplines of the Social Sciences: only in seven of the ten, level 3 researchers were found, namely; Political Science and Public Administration, Demography, Law and Jurisprudence, Economic Sciences, Human Geography, Sociology and, Prospective. In total there were 303 active researchers of who by public consultation on January 2, 2019 to the National Institute of Transparency, Access to Information and Protection of Personal Data (INAI) their productivity was acquired of articles published from 2014 to 2018.

DOI: http://dx.doi.org/10.46925//rdluz.31.02

b) Preparation of the database: each of the articles was verified in the journals where they were published and validated in terms of the participating co-authors, with this a database with a total of 2,549 publications was created, of which 1,085 correspond to articles in co-authorship and 1,464 to unique authors (Annex table A1). A total of 2,732 authors were identified, of whom 303 are SNI and 2,429 are coauthors. In some of them, it implied correcting the disambiguation of their names as authors, that is, the records were checked to see the variations of the names of the authors as well as the incorrect characters of the Conacyt's own database. The disambiguation of the author's name, however, remains a limitation and an unresolved problem of bibliometric studies (Tang and Walsh, 2010), there is always the possibility that "JC Moreno" refers to "Juan Carlos Moreno" or "José Carlos Moreno", one of the ways to disambiguate was validating the institutional affiliation of the authors.

c) The statistical analysis was descriptive, while for the analysis of the network the topological metrics for the Social Sciences networks and the disciplinary ones were computed using Cytoscape.

3. Results and analysis

There were 303 national level 3 researchers in the Social Sciences, in seven different disciplinary fields, Economic Sciences, Legal and Law, Politics, Demography, Geography, Prospective and Sociology. Those that concentrate the greater number of them are Sociology with 36.3% and Economy with 25.74% while the discipline with the least number of them is Prospective that has 0.99% of the totality (Annex table A1). The productivity of researchers and the metrics of disciplinary networks are analyzed in the following paragraphs.

3.1. Productivity of the researchers

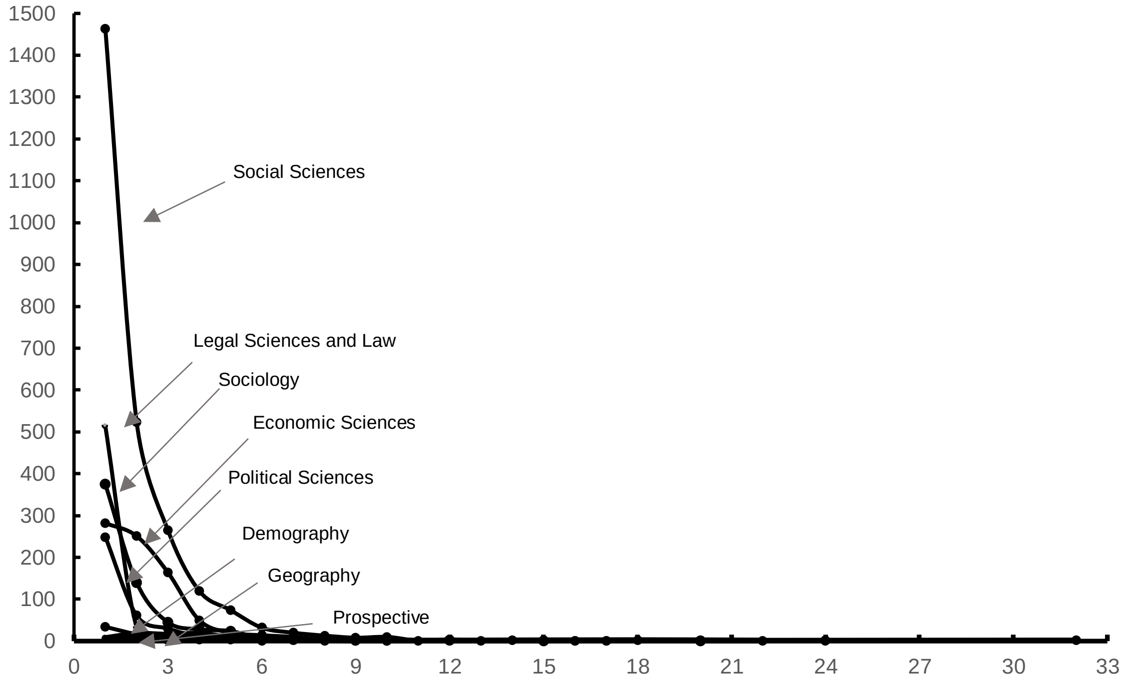
The publications of social researchers are in total 2,549, 57.43% were performed individually while 42.57% in co-authorship. However, there is no clear trend in the years studied as to whether the researchers prefer to publish individually or in collaboration with others, since it presents from one year to another increasing variations as decreasing in both forms of publication. Additionally, although the average number of authors per article is 12, relatively high, it is due to the fact that some disciplines such as "Prospective" have atypical values of up to 32 co-authors per publication, and that in four more disciplines researchers

DOI: http://dx.doi.org/10.46925//rdluz.31.02

have published with 20 or more co-authors (Sociology, Geography, Economics and Legal and Law) whereas, Demography is the one with the lowest average of authors per publication with 5 (figure 1).

It is also observed that Economic Sciences and Sociology, which are the areas that concentrate the largest number of national researchers with 62% of the total Social Sciences, have the largest number of co-authors who also represent 62% of the total; both disciplines contribute 56% of the publications of scientific articles in this field.

Figure 1. Number of publications and co-authors



Source: Own elaboration.

At the end of the day, there are four social disciplines that concentrate 93% of the publications; Economic Sciences with 798 (31%), Sociology with 633 (26%), Legal Sciences and Law with 566 (22%) and Political Science with 364 (14%), while the remaining three, do not reach the hundred, namely, they contribute only with a 7% altogether.

However, although that in the Social Sciences the articles published individually dominate slightly with 57.43% versus the 47.57% in co-authorship, in contrast, Economics, which is the discipline with the highest number of publications with 64.66%, does so in co-authorship (the second regarding national researchers), while Sociology, which is the second in this type of productivity but which with 110 researchers dominates in this area, maintains

DOI: http://dx.doi.org/10.46925//rdluz.31.02

values close to the general ones of the Social Sciences; 59.24% in single authorship vs 40.76% as individual author. While Legal Sciences and Law, which is the third discipline that concentrates the greatest number of researchers and publications, contrasts with the previous ones, presenting 90.81% of the work produced without co-authorship, while Geography and Prospective the two disciplines with the least amount of SNI's also present percentages above 90% of their publications but in a collaborative way (table 1).

On average, each researcher publishes 4 articles per year, although from a disciplinary perspective, Economics has the highest number of publications with 5, while researchers from the other disciplines publish 2 or fewer articles annually.

In this way, there is empirical evidence that researchers in Social Sciences publish in similar percentages, both to do collaborative and individually, however in three disciplines there is a strong dominance of up to 90% to do so either in co-authorship or as unique author.

3.2 Metrics and topological properties of the network

Table 1 summarizes the local and global metrics of both the network of national researchers of the Social Sciences as well as the disciplinary networks that compose it.

Component: The Social Sciences network has 2,282 nodes that form 260 connected components with 11,428 links, which indicates that beyond the 7 disciplines in which the network could be subdivided, there are 253 isolations. Its giant component groups 7.2% of the nodes in the network (figure 2). However, there are also a second and a third larger components that group respectively 7% and 6.5% of the nodes. While Sociology, divided into 99 components, is the most fragmented discipline, followed by Economic Sciences with 64 components.

Economy is the second network with the largest component; it groups 18% of its 821 nodes. While of all the disciplines, Prospective is the network that in the largest component groups the largest number of nodes, 63% of all of them, so it is the discipline with the least number of components (3).

Centralization. In general terms, the Social Sciences structure a moderately centralized network since it shows a coefficient of 0.446, it is Prospective that presents the coefficient with the highest value with 0.918, indicating that it is a centralized network that

DOI: http://dx.doi.org/10.46925//rdluz.31.02

concentrates power and resources, nevertheless it must be considered that it is the network with the lowest number of nodes.

As is common in the literature in co-authorship networks, the rest of the topological properties have been calculated only for the giant component.

Cohesion coefficient. The high cohesion coefficient of 0.929 of the Social Sciences network indicates a high average interconnection of all the nodes in the network, which means that, of three authors connected by a common author, there is a 93% probability that the second and third author co-authorize an article. In general, all the other networks of the social disciplines have coefficients of cohesion above 85%.

Density. The density of the economic sciences network is the one with the lowest value with 0.036 compared to the others, which makes it the most dispersed. The most collaborative networks due their high density coefficients are Law and Legal and Demography with 0.271 and 0.248 respectively, which compared with the 0.066 of the Social Sciences, are relatively high collaboration values. It is also to consider that Legal and Law is the third discipline with the highest number of researchers and productivity generated, which contrasts with the low density coefficients of Economics with 0.036 and Sociology 0.077, which are the two disciplines that precede it.

Degree Centrality: The average degree of authors in the giant component is located at 12, which shows that the authors in the social sciences network, in general, are well connected. However, Legal Sciences and Law is the discipline with the highest average degree level with 21. In contrast, Economic Sciences has the lowest average degree with 9, which is still a significantly high value. In this sense, those authors with the higher degrees become by their position the most influential.

Degree distribution and Lotka´s Law. The social science network shows a degree distribution that follows Lotka's power law with a coefficient of n = 2.52. Similarly, this is observed with coefficients with values between 1 and 3 in six of the seven social disciplines, the only exception being Prospective with a magnitude of 0.425.

DOI: http://dx.doi.org/10.46925//rdluz.31.02

Table 1. Characteristics and topological metrics of social sciences co-authorship networks

Metrics / Areas	CS	CE	CP	D	C J y D	G	Pr	S
Characteristics								
Total SNI	303 100%	78 25.74%	45 14.85%	13 4.29%	46 15.18%	8 2.64%	3 0.99%	110 36.30%
Number of articles	2,549	798	364	62	566	87	39	633
Number of authors	2,429	826	228	74	225	268	130	678
Unique author articles	1,464 57.43%	282 35.34%	249 68.41%	34 54.84%	514 90.81%	7 8.05%	3 7.69%	375 59.24%
Articles in co-authorship	1,085 42.57%	516 64.66%	115 31.59%	28 45.16%	52 9.19%	80 91.95%	36 92.31%	258 40.76%
Average of authors per article	12	7	8.361	4.8	8	8.42	8.2	7.8
** Average of articles per author*	3.79	4.5	1.67	0.747	1.4	0.67	0.53	2.37
Network								
Nodes	2,282	821	228	73	225	267	130	674
Relations	11,428	3757	1229	297	1629	1636	1569	2752
Components	260	64	41	13	45	7	3	99
Size of the giant component	165 7%	144 18%	100 44%	36 49%	65 29%	130 49%	82 63%	108 16%
Relations	1019	666	602	209	671	810	456	623
Global properties								
Lotka´s exponent	2.52	2.34	2.15	1.52	1.71	1.05	0.427	2.24
Cohesion coefficient	0.929	0.863	0.850	0.910	0.978	0.936	0.929	0.917
Diameter	6	11	7	2	2	4	2	5
Centralization	0.446	0.339	0.599	0.797	0.752	0.565	0.918	0.379
Density	0.066	0.036	0.069	0.248	0.271	0.087	0.104	0.077
Local properties								
Cohesion coefficient	0.929	0.862	0.850	0.909	0.978	0.936	0.929	0.916
Average degree	12.35	9.25	12.08	11.6	21.2	12.4	11.12	11.5
Average intermediation	0.012	0.025	0.019	0.022	0.011	0.012	0.011	0.016
Average proximity	0.339	0.221	0.352	0.577	0.584	0.389	0.531	0.377
Shortest trajectory average	3.024	4.68	2.957	1.752	1.729	2.61	1.896	2.704

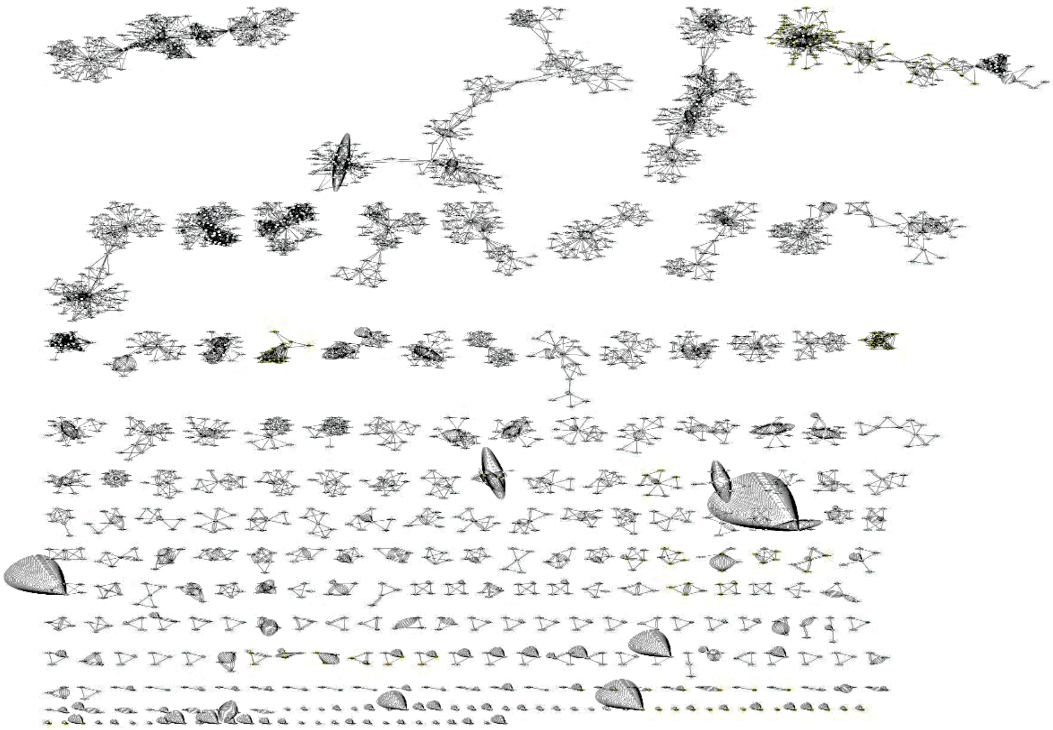
Source: Own elaboration

Note: CS: Social Sciences, CE: Economic Sciences, CP: Political Sciences and Public Administration, D: Demography, C J and D: Legal Sciences and Law, G: Human Geography, Pr: Prospective y S: Sociology.

*Anual average.

DOI: http://dx.doi.org/10.46925//rdluz.31.02

Figure 2. Social Sciences co-authorship Network



Source: own elaboration with Cytoscape.

Centrality of proximity and intermediation. The average centrality of proximity of the network is 0.339 with 3 average degrees of separation. It is Legal Sciences and Law with 0.584 the discipline with the highest coefficient of proximity so it has the shortest average geodesic of the network of 1.29, Demography and Prospective also have coefficients above 0.5. Meanwhile, the average intermediation centrality of the national researchers in the social sciences is 0.012, which indicates a low control of the flow of information (or other resources) with few nodes that act as bridges. Demography is the area with the highest coefficient of 0.022.

Conclusions

In this paper it has been analyzed the collaborative networks of the scientists of the national system of researchers, level 3 of Mexico, of the social sciences and its diverse disciplines of area V of the National Council of Science and Technology, through the co-authorship of works published during 2014 and 2018.

DOI: http://dx.doi.org/10.46925//rdluz.31.02

A first conclusion is that Sociology and Economics are the disciplines that concentrate, with 62%, the largest number of national researchers most recognized in the social area, which is reflected in that they are also who contribute with the largest number of published articles.

In general terms, scientists in this field tend to publish on average 4 articles per year, while 57.43% of them tend to publish it in an unique authorship, the rest of them do it collaborative way. However, in the two dominant disciplines an antagonistic pattern is revealed, while in Sociology 60% of the researchers publish individually, in Economics 66% do it in co-authorship. This can be explained from the perspective that in some disciplines the researcher seeks to gain individual recognition and economic incentives from the significant contributions made in the field, in spite of the fact that in the specialized literature it is evidenced, although incipiently, that the collaborations contribute to elevate the scientific productivity with more effective results and of greater impact than the individual ones.

A second conclusion is the high fragmentation of the co-authorship network that is made up of 260 components, since the main one of them groups only 7% of the total number of researchers. Demography, geography and prospective are the disciplines that have a main component that groups the 50% of its scientists, however, it is explained for being also the areas that have the least amount of national researchers, despite this, they are also fragmented networks. In addition to the above, the relatively low density values (below 0.3) make them not as prone to collaboration while their high centralization coefficients indicate the existence of concentrating or highly connected scientists (prolific authors) and less active authors who could eventually obstruct the flow of collaboration.

In general, it has been found that social science networks have a structure explained by the Watts and Strogatz model (high coefficients of cohesion, greater than 0.8 and short mean trajectories, with diameters less than 6) except for economics and political science that with diameters greater than six degrees of separation do not meet the *small world* configuration. However, regarding the distribution of degree of all networks (Lotka´s exponent) except prospective, Barabási and Albert "free-scale" collaboration patterns are evident; hence, the basic configurations of the models are not mutually exclusive but complementary.

DOI: http://dx.doi.org/10.46925//rdluz.31.02

The work reported in this document represents, inevitably, only a first approximation to the collaboration networks described and it is finally suggested to guide the national public policy of science and technology in Mexico to encourage scientific disciplinary and interdisciplinary collaboration, locally and internationally, of the national researchers in social sciences.

References

Acedo, F. J., Barroso, C., Casanueva, C., and Galán, J. L. (2006). Co-authorship in management and organizational studies: An empirical and network analysis. *Journal of Management Studies*, *43*(5), 957-983. DOI: doi.org/10.1111/j.1467-6486.2006.00625.x

Albert, R., and Barabási, A. L. (2002). Statistical mechanics of complex networks. *Reviews of modern physics*, *74*(1), 47. DOI: 10.1103/RevModPhys.74.47

Badar, K., Frantz, T.L. and Jabeen, M. (2016). Research performance and degree centrality in co-authorship networks. *Aslib Journal of Information Management*, *68* (6), 756 – 771, DOI: 10.1108/AJIM-07-2016-0103

Badar, K., Hite, J.M. and Badir, Y.F. (2014). The moderating roles of academic age and institutional sector on the relationship between co-authorship network centrality and academic research performance. *Aslib Journal of Information Management*, *66* (1), 38 – 53. DOI: 10.1108/AJIM-05-2013-0040

Barabási A.L., and Albert R. (1999). Emergence of Scaling in Random Networks, *Science 286 (5439)*, 509-512; DOI: 10.1126/science.286.5439.509.

Barabási, A. L., and Albert, R. (2002). Statistical mechanics of complex networks, *Reviews of Modern Physics, 74 (1)*, 47. DOI: 10.1103/RevModPhys.74.47

Barabási, A. L., Jeong, H., Néda, Z., Ravasz, E., Schubert, A., y Vicsek, T. (2002b). Evolution of the social network of scientific collaborations. *Physica A: Statistical mechanics and its applications*, *311*(3), 590-614. DOI: 10.1016/S0378-4371(02)00736-7

Bordons, M., Aparicio, J., González-Albo, B. and Díaz-Faes, A. (2015). The relationship between the research performance of scientists and their position in co-authorship networks in three fields, *Journal of Informetrics*, *9* (1), 135-144. DOI:10.1016/j.joi.2014.12.001

Borgatti, S.P., (2005). Centrality and network flow. *Social Networks*, *27* (1), 55–71. doi:10.1016/j.socnet.2004.11.008.

Cheng, M. Y., Hen, K. W., Tan, H. P., and Fok, K. F. (2013). Patterns of co-authorship and research collaboration in Malaysia. *Aslib Proceedings*, 65(6), 659–674. DOI: 10.1108/AP-12-2012-0094

DOI: http://dx.doi.org/10.46925//rdluz.31.02

Consejo Nacional de Ciencia y Tecnología (Conacyt) (2014). *Tecnología e Innovación 2014-2018.* CONACYT (Vol. 409778). DOF.

De Stefano, D., Fuccella, V., Prosperina, M. and Zaccarin, S. (2013). The use of different data sources in the analysis of co-authorship networks and scientific performance. *Social Networks, 35*, 370– 381. DOI: 10.1016/j.socnet.2013.04.004

Freeman, L.C. (1979). Centrality in social networks conceptual clarification. *Social Networks, 1(3), 215-239*, DOI: 10.1016/0378-8733(78)90021-7.

Gobea, S. (2005). *El Modelo Matemático de Lotka: su aplicación a la producción científica latinoamericana en ciencias bibliotecológica y de la información.* México: UNAM Centro Universitario de Investigaciones Bibliotecológicas.

Gonzalez-Brambila, C.N. (2014). Social capital in academia. *Scientometrics, 101* (3), 1609-1625. DOI: 10.1007/s11192-014-1424-2.

Goyal, S., Van der Leij, M.J. and Moraga-Gonzalez, J.L. (2006). Economics: an emerging small world. *Journal of Political Economy, 114,* 403–412. https://hdl.handle.net/11245/1.400360, DOI: 10.1086/500990

Kretschmer, H. (2004), "Author productivity and geodesic distance in bibliographic co-authorship networks, and visibility on the web", *Scientometrics, Vol. 60,* No. 3, pp. 409-420.

Kronegger, L., Ferligoj, A., and Doreian, P. (2011). On the dynamics of national scientific systems. *Quality & Quantity 45*, 989–1015. DOI: 10.1007/s11135-011-9484-3.

Kumar, S., and Mohd, J. (2014). "Relationship between authors' structural position in the collaboration network and research productivity: Case of Indian earth scientists", Program, Vol. 48 Issue: 4, pp.355-369, https://doi.org/10.1108/PROG-01-2013-0002

Laband, D. N., and Tollison, R. D. (2000). Intellectual collaboration. *Journal of Political economy*, *108*(3), 632-662. DOI: 10.1086/262132

Lee, S., and Bozeman, B. (2005). The impact of research collaboration on scientific productivity. *Social Studies of Science 35*, 673–702. http://www.jstor.org/stable/25046667, DOI:10.1177/0306312705052359

Li, E.Y., Liao, C.H. and Yen, R. (2013). Co-authorship networks and research impact: a social capital perspective. *Research Policy, 42* (9), 1515-1530. DOI: 10.1016/j.respol.2013.06.012

Liberman, S., and Wolf, K.B. (2010). Bonding number in scientific disciplines. *Social Networks 20*, 239–246. DOI: 10.1016/S0378-8733(98)00003-3.

Lopaciuk-Gonczaryk, B. (2016). Collaboration strategies for publishing articles in internationaljournals – A study of Polish scientists in economics. *Social Networks, 44* , 50-63. DOI 10.1016/j.socnet.2015.07.001

DOI: http://dx.doi.org/10.46925//rdluz.31.02

Lotka, A. (1926). The Frequency distribution of scientific productivity. *Journal of the Washington Academy of Sciences 16* (12): 317-323, 1926.

Lu, H., and Feng, Y., (2009). A measure of authors' centrality in co-authorship networksbased on the distribution of collaborative relationships. *Scientometrics, 81* (2), 499–511. ISSN: 0138-9130 (Print) 1588-2861 (Online)

Milgram, S. (1967). The Small-World Problem. *Psychology Today, 1* (1), May 1967, 61-67.

Moody, J. (2004). The structure of a social science collaboration network: disciplinary cohesion from 1963 to 1999. *American Sociological Review, 69 (2)*, 213–238. DOI: 10.1177/000312240406900204

Newman, M. (2004a). Coauthorship networks and patterns of scientific collaboration. *Proceedings of the National Academy of Sciences. 101 (1)*, 5200-5205. http://www.pnas.org/content/101/suppl_1/5200.full, DOI: 10.1073/pnas.0307545100

Newman, M. (2004b). Who is the best connected scientist? A study of scientific coauthorship networks. *Complex Networks, 650*, 337-370. DOI: 10.1103/PhysRevE.64.016132

Newman, M.E. (2001). The structure of scientific collaboration networks. *Proceedings of the National Academy of Sciences, 98 (2)*, 404-409. DOI: 10.1073/pnas.98.2.404

Nieminen, J. (1974). On centrality in a graph. *Scandinavian Journal of Psychology 15*:322-336. DOI: 10.1111/j.1467-9450.1974.tb00598.x

Otte, E., and Rousseau, R. (2002), "Social network analysis: a powerful strategy, also for the information sciences", *Journal of Information Science, Vol. 28,* No. 6, pp. 441-453.

Ponomariov, B. L., and Boardman, P. C. (2010). Influencing scientists' collaboration and productivity patterns through new institutions: University research centers and scientific and technical human capital. *Research Policy, 39*(5), 613-624. DOI: https://doi.org/10.1016/j.respol.2018.03.008

Rossoni L. (2014). Agency and small worlds networks: a multilevel analysis of academic productivity. RAM. *Revista de Administração Mackenzie, 15*(1), 200-235. DOI: 10.1590/S1678-69712014000100009

Tang, L., and Walsh, J.P. (2010), "Bibliometric fingerprints: name disambiguation based on approximate structure equivalence of cognitive maps", *Scientometrics, Vol. 84,* No. 3, pp. 763-784.

Watts, D., and Strogatz, S., (1998). The small world problema. Collective dynamics of small world networks. *Nature 393, 440–442.* DOI: 10.1038/30918

Wuchty, S., Jones, B.F., and Uzzi, B. (2007). The Increasing Dominance of Teams in Production of Knowledge. *Science, 316* (5827), 1036-1039. DOI: 10.1126/science.1136099

DOI: http://dx.doi.org/10.46925//rdluz.31.02

Ye, Q., Li, T., and Law, R. (2013). A co-authorship network analysis of tourism and hospitality research collaboration. *Journal of Hospitality & Tourism Research*, *37*, (1), 51-76. DOI: 10.1177/1096348011425500

Appendix

Table A1. Productivity of national researchers in the social sciences.

Productivity Discipline	Total SNI	SNI (%)	Unique author						Co-authorships					
			2014	2015	2016	2017	2018	Total	2014	2015	2016	2017	2018	total
Social Sciences	303	100%	409	458	420	176	1	1,464 57.43%	293	349	297	145	1	1,085 42.57%
Economic Sciences	78	25.74%	90	84	73	35	0	282 35.34%	130	157	157	71	1	516 64.66%
Legal Sciences and Law	45	14.85%	133	178	129	73	1	514 90.81%	16	13	12	11	0	52 9.19%
Political Sciences	13	4.29%	76	61	92	20	0	249 68.41%	41	37	29	8	0	115 31.59%
Demography	46	15.18%	7	11	13	3	0	34 54.84%	8	8	9	3	0	28 45.16%
Geography	8	2.64%	2	0	4	1	0	7 8.05%	24	29	19	8	0	80 91.95%
Prospective	3	0.99%	0	2	0	1	0	3 7.69%	12	11	5	8	0	36 92.31%
Sociology	110	36.30%	101	122	109	43	0	375 59.24%	62	94	66	36	0	258 40.76%

Source: own elaboration based on data from Conacyt.