Network centrality analysis in management and accounting sciences

Alexandre Dias,[a,*] Sidarta Ruthes,[b] Leonardo Lima,[b] Elisa Campra,[b] Maycon Silva,[b] Millena Bragança de Sousa[c] and Geciane Porto[d]

[a]*Faculdade de Ciências Econômicas, Universidade Federal de Minas Gerais, Belo Horizonte, Brazil*
[b]*Centro Universitário UniDomBosco, Curitiba, Brazil*
[c]*Instituto Federal de Educação, Ciência e Tecnologia de Minas Gerais, Ribeirão das Neves, Brazil and*
[d]*Faculdade de Economia, Administração e Contabilidade de Ribeirão Preto, Universidade de São Paulo, São Paulo, Brazil*

Received 8 February 2019
Accepted 20 September 2019

Abstract

Purpose – This study aims to analyze how gender, research experience and geography are related to the researchers' importance in the co-authorship network on management and accounting in Brazil.

Design/methodology/approach – A social network based on the co-authorship relationships in the papers published in leading Brazilian journals was examined using a logit model to estimate the probability of occupying prevailing positions.

Findings – The findings showed a network with a high level of fragmentation and a scarcity of authors serving as gatekeepers. Based on the number of directed links and collaboration with influential and well-connected authors, men were more likely to occupy central positions than women. Authors with higher academic degrees tended to establish more links but were more likely to distance from other authors. In terms of geography, authors from more- and less-favored regions may report similar propensity to occupy central positions.

Practical implications – Decision-makers should consider the importance of strengthening collaboration between different research groups and encourage female participation in broader

Alexandre Dias lead on conceptualization, formal analysis, investigation, methodology, validation, supervision, reviewing and editing the paper. Sidarta Ruthes supported on data curation, investigation, supervision and writing the original draft. Leonardo Lima, Elisa Campra, Maycon Silva and Millena Bragança de Sousa all supported with data curation and investigation. Geciane Porto supported with conceptualization, supervision, validation and reviewed and edited the paper.

RAUSP Manag. J.
Vol. 55 No. 2, 2020
pp. 207-226
Emerald Publishing Limited
2531-0488
DOI 10.1108/RAUSP-02-2019-0021

collaborative networks. Research evaluation bodies should strengthen incentives regarding interinstitutional partnerships.

Originality/value – Studies on collaborative networks in management and accounting sciences are less common and generally focus on describing the networks. This paper combines social network analysis and econometric procedures to analyze the relationship between demographic and geographical aspects, and distinct network centrality indexes.

Keywords Scientific collaboration, Social network analysis, Management, Accounting, Gender and science

Paper type Research paper

1. Introduction

Modern science is strongly supported by a production structure; teamwork, collaboration and interdisciplinarity are some of its main characteristics (Rey-Rocha, Martín-Sempere, & Garzón-García, 2002). These features have prompted a growing interest in academia in understanding the determinants of scientific production and the relationships upon which it relies.

The literature on scientific collaboration has been systematically studied since the 1960s (Glänzel & Schubert, 2004). Once the collaboration is strongly related to publications and citations, it has become a priority in research management around the world (Ceballos, Fangmeyer, Galeano, Juarez, & Cantu-Ortiz, 2017). Research involving the analysis of researchers' collaborative networks has sought to understand the dynamics of the social organization of scientific production through social network analysis (SNA). One of the most widely used approaches involves investigating how the position that scientists occupy in the co-authorship network impacts their scientific output (Bordons, Aparicio, González-Albo, & Díaz-Faes, 2015; Liu, 2015; Gonzalez-Brambila, Veloso, & Krackhardt, 2013). Literature highlights differences in the researchers' position in terms of gender (Abramo, D'Angelo, and Murgia, 2013; Badar, Hite, & Badir, 2014), geography (Koseoglu, 2016), and explores how seniority proxies as academic rank relate to scientists' collaboration patterns (Abramo, D'Angelo, & Murgia, 2014; Jeong, Choi, & Kim, 2011).

Disciplinary variations in collaboration patterns also exist, and social sciences scholars tend to collaborate less than science, technology, engineering and math scholars (Tsai, Corley, & Bozeman, 2016). Specifically, studies on scientific collaboration in the management and accounting sciences are unusual, and international literature generally emphasizes networks obtained through scientific production in which researchers from developing countries have low participation. Evidence demonstrated an increase in the network connectivity and the importance of actors who intermediated other actors, improving the knowledge flow (Acedo, Barroso, Casanueva, & Galán, 2006; Behara, Babbar, & Smart, 2014; Koseoglu, 2016). In Brazil, on the other hand, collaboration networks in such disciplines are highly fragmented (Cruz, Espejo, Costa, & Almeida, 2011; Rossoni, and Guarido Filho, 2009). Despite these findings, whose studies have focused mainly on describing the network characteristics, little is known about differences in the researchers' position in the applied social sciences networks as a whole.

This study adopts proxies to explain how gender, research experience and geography are related to the researchers' importance in the Brazilian co-authorship network in management and accounting sciences. This type of analysis is particularly relevant because different aspects of social networks may influence their members' ability to create knowledge (Nieves & Osorio, 2013), making this understanding an opportunity to provide insights into inequities in the structure of scientific collaboration in the disciplines

mentioned above. The main novelty of our paper is that it provides an empirical analysis of the collaboration patterns in so poorly studied disciplines and allows a better comprehension of the role of demographic and geographical aspects in the researchers' co-authorship network. A second contribution is that we included in our analysis inedited variables regarding the stages of academic degrees to express different levels of research experience during and after the process of research training. Finally, we adopt a higher level of methodological sophistication by combining SNA with econometric procedures, instead of only describing the network as we observed in most studies.

We represented a social network based on the co-authorship relationships identified in the articles published in leading Brazilian journals on management and accounting evaluated by the coordination for the improvement of higher education personnel (CAPES), which is an agency of the Brazilian federal government responsible for evaluating the journals in which Brazilian researchers publish. We then estimated the probability of authors occupying prominent positions in the network weighted by the degree, eigenvector and closeness centralities.

This paper is structured as follows. In Section 2, we explore the literature on the characteristics of the co-authorship networks and focus on the collaboration networks in management and accounting sciences. In Section 3, we present the methodological structure of the research. In Section 4, we carry out the analysis of the results and provide the discussion. Finally, we present the main conclusions in Section 5.

2. Literature background

2.1 Co-authorship networks and the role of gender and seniority on scientific collaboration

The collaborative production of knowledge has become a dominant manner to produce high-quality research results (Ahrweiler & Keane, 2013). Collaboration involves complex problems, rapidly changing technology, dynamic growth of knowledge, highly specialized areas of expertise and is considered a critical issue of "big science" (Hara, Solomon, Kim, & Sonnenwald, 2003). According to Glänzel & Schubert (2004), almost every aspect of scientific collaboration can be tracked by analyzing co-authorship networks using bibliometric methods, and the most recent efforts in this tradition are extensively based on graph theory and SNA techniques (Breschi & Catalini, 2010).

In a social network, people or groups are called "actors" or "nodes" and the connections that express the relations between them are called "links" (Abbasi & Hossain, 2011). Empirical evidence suggests that co-authorship networks tend to present a small world configuration, which means that the nodes are highly connected and at the same time, there is a small average distance between the network regions (Stefano, Fuccella, Vitale, and Zaccarin, 2013). The redundancy of the links within local cliques ensures the formation of a common language and communication codes to promote reciprocal trust and knowledge sharing among actors. The short cuts linking local cliques to different and weakly connected parts of the network are essential to promote the diffusion and recombination of new ideas, serving as new sources of knowledge (Cowan & Jonard, 2004).

Besides the general properties of co-authorship networks, it is useful to compare the nodes' importance in terms of their position. Thus, the idea of how central a node is can be essential. Jackson (2008) categorizes the measures of centrality into four groups:

(1) degree – how connected a node is;

(2) closeness – how easy a node can reach other nodes;

(3) betweenness – how important a node is in terms of connecting other nodes and serving as a gatekeeper; and

(4) neighbors' characteristics indexes – how important, central or influential a node's neighbors are.

Many studies relate demographic aspects of authors with their positions in the co-authorship network and gender has been widely adopted to explain differences in their positioning in the network. Compared to women, men were found to report higher degree and betweenness centralities (Koseoglu, King, & Rahimi, 2019) and closeness centrality (Karimi, Mayr & Momeni, 2019). Ozel, Kretschmer, & Kretscmer (2014) found that women were more likely to collaborate with other scientists irrespective of gender and to establish intergender (male-female) collaborations. Conversely, Araújo, Araújo, Moreira, Herrmann, and Andrade (2017) concluded that men collaborated more with other men than with women, across different fields and regardless of their number of collaborators. Such evidence sheds light on how men and women may adopt different collaboration strategies to produce knowledge, but they do not qualify the collaboration patterns and their impact on scientific outputs.

In this regard, Abramo et al. (2013) found that women, compared to men, collaborated more with researchers from the same university and with researchers from other national institutions, whereas men collaborated more with international researchers. Araújo, & Fontainha (2017) concluded that men were more likely to collaborate in interdisciplinary research than women. Dehdarirad and Nasini (2017) found that men and women had similar propensities to work collaboratively, but compared to those of men, papers signed by women tended to be cited less frequently. That is, even though men and women may share similar benefits in terms of their importance in the co-authorship network once both rely heavily on co-authorship ties to respond to publishing pressures (Badar et al., 2014), male authors seem to have an advantage over women when we qualify the types of collaboration established and the impact of the scientific production.

A critical perspective exposes several causes for gender asymmetry in science, highlighting that teaching jobs and administrative tasks available are not equally accessible to male and female PhD holders, male-dominated research fields occupy a better position in the global research market and are better paid, and female early career researchers face more struggles to obtain funding for their postdoctoral (Bozzon, Murgia, & Poggio, 2019). In sum, we draw attention to the fact that gender inequalities are partly the result of significant structural and systemic discriminatory practices (Aiston & Jung, 2015). To surpass barriers faced in male-dominated areas, Badar, Hite, and Badir (2013) suggest women strengthen their authorship ties, once they found a stronger positive relationship between their research performance and the degree and closeness centralities.

The concept of research seniority is also adopted to explain differences in the collaboration patterns. Seniority is related to the status that an individual has in the hierarchy of a social network (Stvilia et al., 2011), and it can be understood as an expression of the scientist's research experience. One can expect that over time, researchers will enjoy greater importance in the network because they had more time to develop and strengthen their collaborative links. Bordons, Morillo, Fernández, and Gómez (2003) found that scientific productivity increased as scientists' professional category improved and that research professors had more collaborators than their counterparts with lower academic ranks. Abramo et al. (2014) concluded that lower-ranking academics tended to construct their collaborations with colleagues at their home university, as at this stage they were less able to activate external collaborations with the same intensity as higher-ranking colleagues. Jeong et al. (2011) showed that researchers with superior academic records preferred collaboration to sole research and that the superior researchers strongly preferred inter-organizational collaboration. Pina, Barać, Buljan, Grimaldo, and Marusić (2019)

analyzed the role of grants in collaboration networks of junior and senior researchers and found that while grants were important to position the former within their scientific communities, they had a positive effect for the expansion of scientific communities of senior researchers. Despite the evidence produced, there is a lack of comprehension of how the research experience relates to distinct centrality measures.

2.2 Collaboration networks in management and accounting sciences

Although scarce, literature provides some evidence regarding the researchers' collaborative networks in management and accounting sciences and more broadly, in the applied social sciences. Nikzad, Jamali, and Hariri (2011) found that the average number of authors per article has increased in all disciplines in the social sciences. In the management field, the growing number of co-authors was attributed not only to the need for complementary skills but also to the expectation of increasing the chances of the manuscript's acceptance and of being reciprocated by the favor later (Liu, Olivola, & Kovács, 2017).

Evidence on gender inequalities is inconclusive. Pacheco, Pinedo, Ditta, Ruiz, and Varela (2018) found that female authors signed only 2 per cent of the papers in top journals in the fields of operations research and management sciences between 2008 and 2013, stressing that papers with at least one female author accounted for only 33 per cent of the sample. Conversely, Corley and Sabharwal (2010) concluded that top male scholars in public administration were more likely than their female counterparts to publish sole-authored articles and those female authors were more likely to publish in high-quality journals, which shows that they benefit from the degree centrality to produce impactful research. Nielsen (2017) showed that the women's share of authorship was considerably lower than men's, although differences in citation-rates appeared to be negligible for a sample of 65,436 authors in management research.

Acedo et al. (2006) found that the networks obtained from publications in leading American and European journals dedicated to organizational studies were relatively cohesive and that prominent positions were occupied by authors who played an essential role in connecting the network and disseminating information. Behara et al. (2014) concluded that while specific authors, institutions and countries ranked high in terms of direct connections, others played an important role as gatekeepers and bridge builders in the network. Authors with more publications and more considerable influence tended to be interconnected through multiple direct links. In the accounting sciences, Endenich, and Trapp (2016) found a significant negative relationship between a researcher's proportion of co-authored papers and his or her research output.

Koseoglu (2016) observed an increase in international collaborations in the Strategic Management Journal between 1980 and 2014. It was found an increase in density and connectivity and a decrease in fragmentation, indicating that the network was in the process of consolidation. The results also indicated that while few institutions presented low degree centrality, they had high betweenness scores. Institutions located in small and developing or undeveloped countries tended to build international collaborations with institutions located in developed countries to grow and join the network. In this sense, Ronda-Pupo, Díaz-Contreras, Ronda-Velázquez, and Ronda-Pupo (2015) concluded that articles published through international collaboration in Latin American and Caribbean research in management had 1.59 times more impact than those published through domestic collaboration.

In Brazil, Ferreira, Canela, Pinto and Falaster (2018) concluded that the increasing challenge in publishing in higher quality journals and the perception of pressure to publish had induced the scientific collaboration in the management field. Empirical evidence showed a growth in the percentage of co-authored papers (Espartel et al., 2013), a high level of

fragmentation in the network (Cruz et al., 2011) and a predominance of well-defined clusters interconnected through few intermediaries (Rossoni, & Guarido Filho, 2009). Moreover, most co-authors belonged to the same institution (Espartel et al., 2013), which is alarming, once heterogeneous networks were determinant in achieving better scientific production in business schools (Orozco & Villaveces, 2015).

Rossoni & Guarido Filho (2007) asserted that the location of Brazilian institutions was a significant factor in the determination of collaborative relationships. In terms of geography, the institutions in the south and southeast of the country stand out (Espartel et al., 2013; Sidone, Haddad, & Mena-Chalco, 2016; Wood, & Chueke, 2008). Thus, we emphasize the importance of considering geographical peculiarities in the analysis of collaboration networks in Brazil, as the Brazilian scientific production is not equally distributed.

3. Data and methodology

In this study, we analyzed the co-authorship network established among researchers who published in the top Brazilian journals in the management and accounting sciences in the between 2013 and 2016. Every four years, CAPES evaluates the journals in which Brazilian researchers publish in descending order of quality: A1, A2, B1, B2, B3, B4, B5 and C. In 2018, we mapped 14 national journals whose maximum evaluation obtained concept A2: *Brazilian Administration Review, Brazilian Business Review, Cadernos EBAPE.BR, Contabilidade Vista & Revista, Organizações & Sociedade, Revista de Administração Contemporânea, Revista de Administração de Empresas, Revista de Administração Pública, Revista de Administração da USP, Revista Brasileira de Gestão de Negócios, Revista Contabilidade & Finanças, Revista Contemporânea de Contabilidade, Revista de Contabilidade & Organizações and Pesquisa Operacional*. From them, we identified 1,852 articles published by 3,387 different authors in the quadrennium.

We built our database linking each article to the names of the respective authors, their genders, academic degrees and regions of their affiliation institutions. The authors' names were standardized using the OpenRefine software and through an exhaustive work of manual checking. Data on academic degrees and linking institutions were obtained predominantly in the articles and were cross-checked with those on the Lattes platform, an online platform in which the academic information of the Brazilian researchers is publicly available. Part of this information was not identified on behalf of foreign authors and those authors with a lower academic degree, who may not have a registration on the platform.

Table I presents a characterization of the authors' attributes that our database allowed us to analyze. We considered the highest academic degree and the region of the last institution for those who presented different information in different papers. Most authors were men (63.21 per cent). PhD (55.98 per cent) and holders of a master's degree (20.67 per cent) predominantly authored the papers. Authors were predominantly linked to institutions located in the south-eastern region (44.55 per cent), followed by the southern (20.70 per cent), north-eastern (10.48 per cent), midwestern (5.05 per cent) and northern (1.06 per cent) regions, in addition to a proportion of 12.93 per cent of them linked to foreign institutions. These statistics clearly show a predominance of authors linked to institutions located in the more developed regions of the country, which reflects a concentration of Brazilian researchers in these regions (CNPq, 2018). Data on academic degrees and linking institutions were not identified for 9.21 and 5.23 per cent of authors, respectively.

Similar to Breschi and Catalini (2010), we adopted a co-authorship link when two actors shared the authorship of an article. We adopted Gephi to represent the social network and to obtain the statistics used in our analysis. To examine the structural properties of the network, we adopted the following statistics:

Authors' attributes	*N*	(%)
Genders	3,387	100.00
Male	2,141	63.21
Female	1,246	36.79
Academic degrees	3,387	100.00
Undergraduate student	23	0.68
Graduate	87	2.57
Specialist	19	0.56
Master's student	86	2.54
Master's degree	700	20.67
PhD student	264	7.79
PhD	1,896	55.98
Not identified	312	9.21
Regions of linking institution	3,387	100.00
South	701	20.70
Southeast	1,509	44.55
Midwest	171	5.05
North	36	1.06
Northeast	355	10.48
Foreign	438	12.93
Not identified	177	5.23

Table I. Characterization of authors' attributes

- *Average degree*: It corresponds to the average number of connections that nodes establish in a network, defined by $2g/N$, where g is the number of relations in the network and N is the number of nodes that compose it.
- *Density*: Expressed by $2g/N\,(N-1)$, density refers to how much the nodes of a network relate to each other. The density varies from 0 to 1, where 0 means that there is no relation between the actors in the network and 1 indicates the maximum level of relation between them. When more nodes are connected to each other, the network density is higher, indicating a higher level of cohesion between actors (Abbasi & Hossain, 2011).
- *The number of connected components*: This statistic represents the number of subnetworks such that every pair of nodes in the subnetwork is connected by a sequence of links. The components of a network are the distinct maximally connected subgraphs of a network. Many networks are not fully connected and may consist of a number of separate components. The lower the number of connected components is, the more connected the network is Cherven (2015).
- *The largest connected component as a fraction of the total network nodes*: This statistic is represented by the subnetwork that contains the most significant fraction of the network nodes.
- *Modularity*: An approach to measure the amount of clustering in a network, modularity assesses the number of distinct groupings within a network. Highly connected nodes are likely to be incorporated into a common cluster (Cherven, 2015).

We computed different measures of centrality to analyze the authors' position in the co-authorship network. Exception for degree centrality, the indexes were standardized between 0 and 1. They are the following:

- *Degree centrality*: This index indicates the number of direct connections established by a node. Although this measure does not provide an interpretation of how well a

node is located within the network (Jackson, 2008), it expresses the ability to establish collaborative links.

- *Betweenness centrality*: This index expresses the control that a node exercises over information flow and other resources and is associated with the use of non-redundant resources (Li, Liao, & Yen, 2013). The following expression determines it:

$$Ce_i^B(g) = \sum_{k \neq j : i \notin \{k,j\}} \frac{P_i(kj)/P(kj)}{(N-1)(N-2)/2}, \quad (1)$$

wherein $P_i(k_j)$ represents the number of geodesics (shorter paths) that connect nodes k and j, which are separated by i, P (kj) refers to the total number of geodesics between k and j and N corresponds to the number of nodes.

- Eigenvector centrality: This measure is determined both by the number of adjacent connections and the proportion with which a node relates to well-connected nodes. A researcher can be more impactful by collaborating with other researchers who are themselves well connected (Cimenler, Reeves, & Skvoretz, 2014) than by collaborating with researchers who are directly connected to many students (Abassi, Altmann, & Hossain, 2011). It is expressed as follows:

$$\lambda Ci^e(g) = \sum_j g_{ij} Ci^e(g), \quad (2)$$

wherein the node centrality is proportional to the sum of the neighbors' centrality and λ is the proportionality factor, also called the eigenvalue. The network equation element (g), called the eigenvector, is represented by $Ci^e(g)$.

- Closeness centrality: This index expresses how close a node is to others and can be interpreted as a measure of access or efficiency or independence from the control exercised by other nodes (Brandes, Borgatti, & Freeman, 2016). The index is the inverse of the mean distance between i and any other node j: $(n-1)/\Sigma_{j \neq i}\, l(i,j)$, where $l(i,j)$ is the number of links in the shortest path between i and j. A node with strong closeness centrality has fewer steps between it and other nodes of the network, so a smaller index value indicates a higher centrality of the node (Cherven, 2015; Cimenler et al., 2014).

We adopted a logit model to estimate the association between the authors' genders, their academic degrees and the regions of their linking institutions with the importance they had in the co-authorship network. For node i, we specify:

$$y_i^* = x'_i \beta + u_i \quad (3)$$

In this formulation, y^* is an unobserved measure of the author's importance in the co-authorship network. The threshold was defined based on the distributions of the centrality indexes. The vector x is composed of dummy variables of gender (Gen), academic degrees and regions of the authors' institutions, and u is the random error representing the unobservable factors. We classified the academic degrees by level of postgraduate education, *stricto sensu*, as master's program in progress (Mast_st) and completed (Mast), and PhD program in progress (PhD_st) and completed (PhD). The Brazilian regions were the southern, south-eastern, midwestern, northern and north-eastern areas of the country. Men, PhD degree, and the south-eastern region were the reference groups. The dummy gender variable was adopted based on

its extensive investigation in the literature, and the academic degrees were adopted as inedited proxies of research experience to analyze the collaboration behavior among distinct research training stages compared to trained researchers. Brazilian regions were included in the model due to the geographical specificities of the scientific production reported in the literature.

By distinguishing the most central nodes from the least central ones, we estimated the probability of the variables being associated with a node with strong centrality according to the specification of Cameron and Trivedi (2009):

$$\begin{aligned} \Pr(y=1) &= \Pr\left(x'\beta + u > 0\right) \\ &= \Pr\left(-u < x'\beta\right) \\ &= F\left(x'\beta\right) \end{aligned} \tag{4}$$

wherein $F(\cdot)$is the cumulative distribution function of $-u$ logistically distributed.

We chose not to present the marginal effects, as our interest lies in understanding the relationship of the variables with the researchers' importance in the network.

4. Results and discussion

4.1 Characterization of network properties and authors' importance

The connectivity statistics of the co-authorship network are presented in Table II. The network consists of 3,387 nodes, which have an average number of connections of 2.65 and is formed by 731 connected components. The largest connected component consists of 22.91 per cent of nodes. Despite this grouping, the low connectivity of the network is demonstrated by the density of 0.001, indicating that only a small portion of the possible connections has been completed. Evidence gathered by Jackson (2008) showed that the fraction of nodes in the largest component represented 41 per cent in economics, which gives an impression of the small-world nature of the network analyzed. Broadly speaking, the statistics allow us to conclude that the network is sparsely connected with many small and disconnected components, in which the knowledge flow is not evenly distributed within it.

In Figure 1, we highlight the 10 largest communities reported by the modularity analysis. By increasing the analysis resolution, we obtained a minimum of 731 communities, that is, the network clustering produced a large number of clusters, which does not appear to characterize the small-world properties common to scientific collaboration networks (Fleming, King, & Juda, 2007). We also found that about four per cent of the authors published alone. They appear in the most peripheral regions of the network. Small groups of connected authors suggest that knowledge sharing is restricted mainly to isolated communities. In this sense, our findings expose the low connectivity of Brazilian research groups compared to the advances reported in international collaboration networks in the disciplines analyzed (Acedo et al., 2006; Koseoglu, 2016).

Structural properties	Statistics
Number of nodes	3,387
Average degree	2.65
Density	0.001
Connected components	731
Largest connected component (% nodes)	22.91%

Table II. Co-authorship network statistics

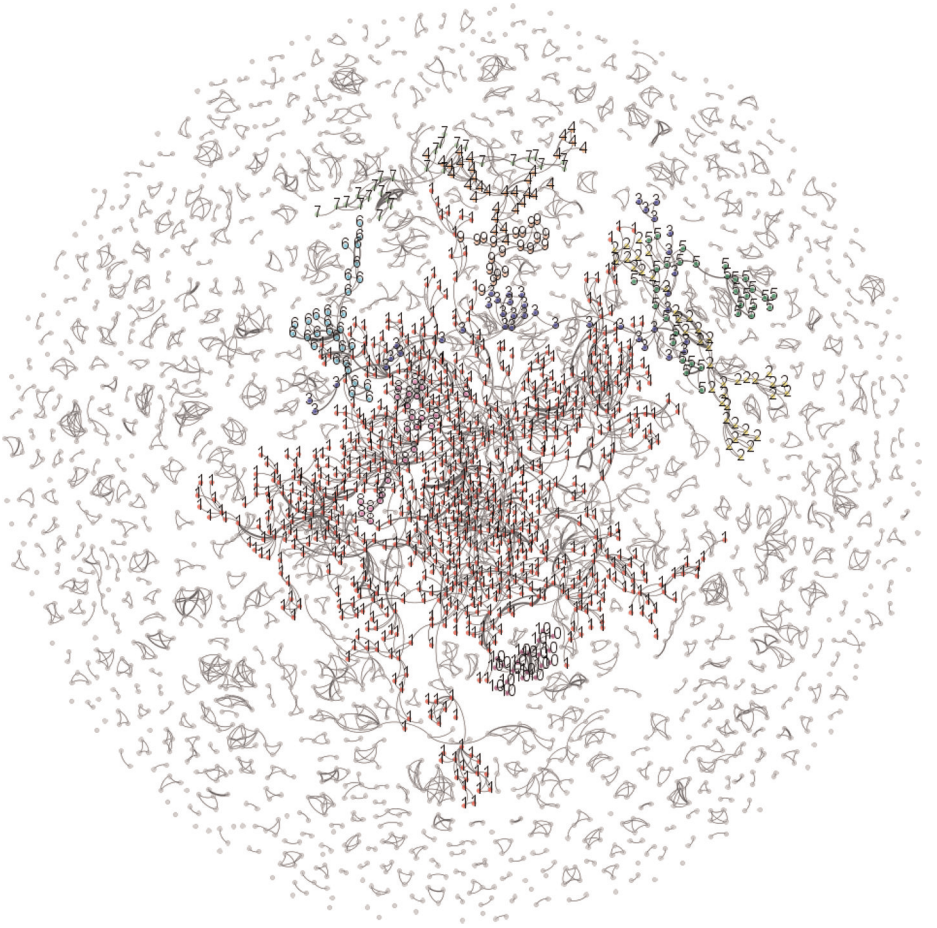
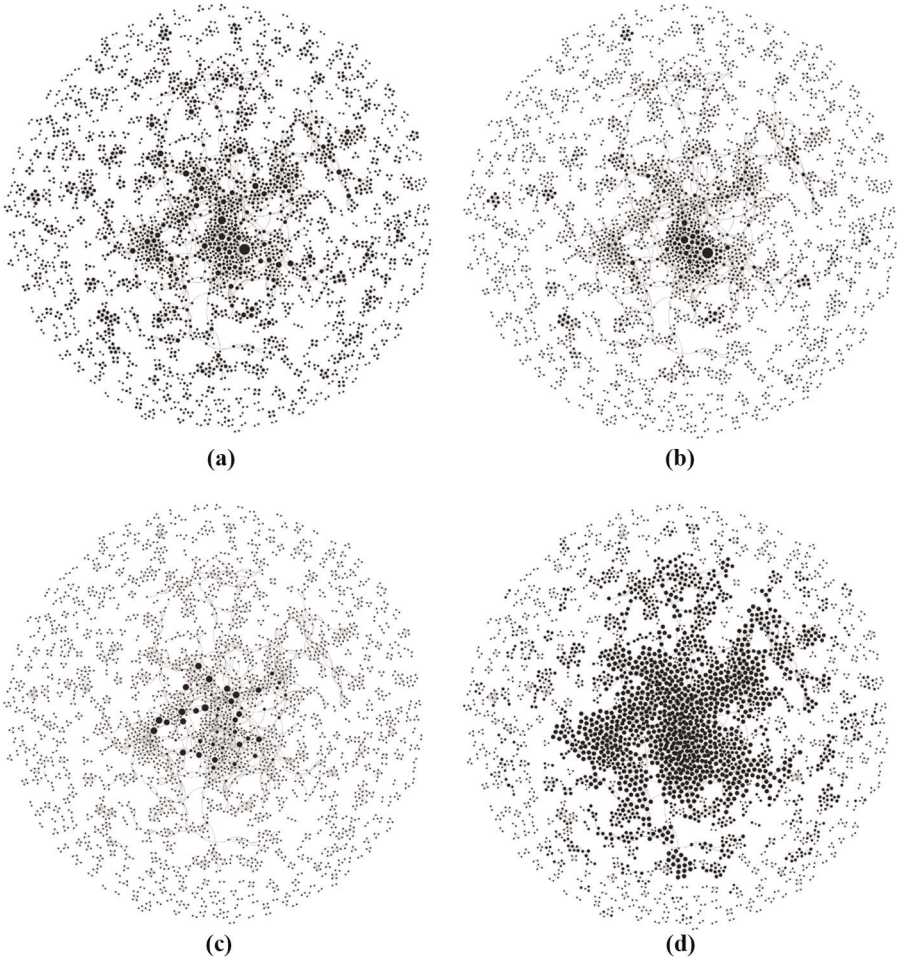


Figure 1.
Co-authorship network in the selected journals

Figure 2 presents the ranking of the node centralities for those authors with at least one connection. Degree, eigenvector and closeness centralities are the main indexes by which the authors' positions can be distinguished. We found a substantial overlap trend between the degree and eigenvector centralities. However, we emphasize the importance of the adjacent nodes, which is noticeable when weighting the nodes by the eigenvector centrality because of their connections with influent nodes linked to several actors.

When considering the betweenness centrality, we found only a small group of authors who exercised minimal control over the knowledge flow. The mean of this index is close to zero and even those authors who appear highlighted have low scores. The shortage of nodes that serve the function of gatekeeper can be considered a determining factor for the low connectivity of the network and contributes to narrow the knowledge into small communities. We also found that the most central nodes concerning the closeness centrality were predominantly located in larger communities.



Notes: (a) Degree centrality; (b) eigenvector centrality; (c) betweenness centrality; (d) closeness centrality

Figure 2.
Ranking of node centralities

4.2 Analysis of gender, research experience and geography in the co-authorship network

Table III presents the descriptive statistics of the centrality indexes according to the three dimensions of our analysis. We used a sample clipping composed of nodes with at least one connection, whose classification of academic degree was equal to or higher than the master's degree in progress and linked to Brazilian institutions, resulting in 2,470 nodes. The betweenness centrality was neglected for this stage because of its low capacity of nodes distinction. The unconditional means show that men have a higher degree score (2.96) than women (2.66), whereas the other centrality indexes do not indicate significant differences

Authors' attributes	*N*	Degree centrality Mean	Degree centrality SD	Eigenvector centrality Mean	Eigenvector centrality SD	Closeness centrality Mean	Closeness centrality SD
Genders	2,470						
Male	1,573	2.96	2.16	0.04	0.05	0.57	0.38
Female	897	2.66	1.93	0.04	0.06	0.58	0.37
Academic degrees	2,470						
Master's student	84	2.46	1.10	0.04	0.05	0.53	0.41
Master's degree	608	2.15	1.10	0.03	0.04	0.49	0.37
PhD student	241	2.41	1.25	0.04	0.04	0.51	0.36
PhD	1,537	3.22	2.41	0.04	0.06	0.61	0.37
Regions of linking institution	2,470						
South	649	2.73	1.85	0.04	0.06	0.62	0.35
Southeast	1,334	2.90	2.24	0.04	0.05	0.54	0.38
Midwest	143	2.85	2.06	0.04	0.05	0.52	0.41
North	30	2.23	2.23	0.01	0.01	0.85	0.28
Northeast	314	2.96	1.93	0.03	0.04	0.60	0.37

Table III.
Descriptive statistics of centrality indexes along with the authors' attributes

between both genders. In terms of academic degrees, PhDs report a higher number of connections (3.22) and closeness scores (0.61). Master's degree holders are systematically associated with the smallest means and report 2.15, 0.03 and 0.49 for the degree, eigenvector and closeness centralities, respectively. Concerning the geography, the degree statistics are higher for the north-eastern (2.96) and southern (2.90) regions, whereas the northern region reports the highest closeness score (0.85).

In our modeling, the binary dependent variables were defined based on the nodes' centrality scores. We defined the nodes with strong centrality based on the distributions of the indexes (Table IV). We considered the most central nodes to be those with degree and eigenvector scores from the 90th percentile, which corresponded to the mean of each index plus one standard deviation. For the closeness centrality, we found a cut-off from the 25th percentile, below which we defined the most central nodes. Figure 3 shows the distributional graphs, which corroborate our decision. For the degree and eigenvector centralities, we found a concentration of highest scores among the last portion of approximately 10 per cent of authors. In turn, about 25 per cent of them presented the lowest closeness scores.

Table V presents the econometric results, which show that male authors are related to a higher proclivity to possess a strong degree centrality at a 1 per cent significance level. Despite the low explanatory power of the variables in the regression in which de dependent

Percentiles	Centralities Degree	Strong	Eigenvector	Strong	Closeness	Strong
1	1	No	0.002	No	0.052	Yes
5	1	No	0.002	No	0.058	Yes
10	1	No	0.002	No	0.064	Yes
25	2	No	0.008	No	0.098	Yes
50	2	No	0.021	No	0.588	No
75	3	No	0.047	No	1	No
90	5	Yes	0.092	Yes	1	No
95	7	Yes	0.139	Yes	1	No
99	11	Yes	0.246	Yes	1	No

Table IV.
Distributions of degree, eigenvector and closeness centralities

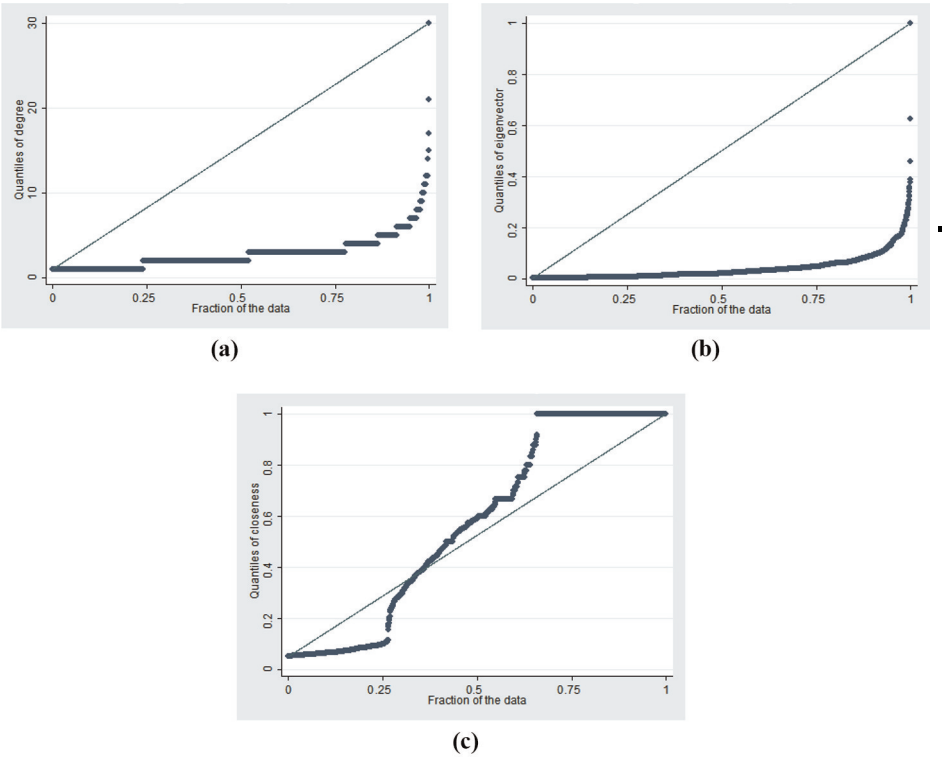


Figure 3.
Quantile plots

Notes: (a) Degree centrality; (b) eigenvector centrality; (c) closeness centrality

Variables	Degree	Eigenvector	Closeness
Gen	0.404*** (0.135)	0.277* (0.147)	0.0920 (0.101)
Mast_st	−1.840*** (0.600)	−0.0551 (0.367)	0.798*** (0.247)
Mast	−2.118*** (0.254)	−0.569*** (0.179)	0.714*** (0.110)
PhD_st	−1.534*** (0.302)	−0.314 (0.241)	0.495*** (0.157)
South	−0.192 (0.152)	0.381** (0.153)	−0.838*** (0.125)
Midwest	−0.109 (0.260)	0.325 (0.269)	0.265 (0.190)
Northeast	0.163 (0.182)	−0.193 (0.232)	−0.465*** (0.151)
North	−1.472 (1.018)	–	−1.870*** (0.718)
Constant	−1.641*** (0.131)	−2.320*** (0.154)	−1.189*** (0.102)
N	2,470	2,440	2,470
R^2	0.09	0.02	0.10

Notes: ***$p < 0.01$, **$p < 0.05$, *$p < 0.1$

Table V.
Results estimated by logit

variable refers to the eigenvector centrality, men are also associated with a higher likelihood of having prominent positions at a 10 per cent significance level. These findings are consistent with those of Koseoglu et al. (2019) and Nielsen (2017). Our evidence corresponds to say that men tend to establish more links and although marginally, they are more prone

to collaborate with well-connected and influential nodes compared to women. Apart from corroborating the female under-representation in science (Bordons et al., 2003), our evidence clearly shows an advantage in favor of male authors when it comes to their propensity in occupying central positions in the network. We cannot assert how much of this asymmetry is produced by a self-selection or social selection process (van den Besselar & Sandström, 2016). However, we should look deeper at the issue of gender inequality in management and accounting sciences, once it may be materialized through power dynamics by which women tend to be excluded from information and informal channels more often than their male peers (Bozzon et al., 2019).

We also found that lower academic degree holders, compared to PhDs, were less likely to occupy central positions in terms of the degree centrality. The master's degree holders had the highest differential in the probability compared to the reference group, whereas PhD students had the lowest. In other words, the link with the research institution, still as a student, seems to be associated with a more significant number of collaboration links. Our findings support the assumption that senior researchers tend to enjoy greater importance in the network, showing that in the management and accounting sciences such importance seems to be heavily based on the additional number of connections that PhDs can establish.

The positive relationship between the academic degrees and the nodes' importance was not sustained for the eigenvector and closeness centralities. Conversely, when weighting the nodes' importance by the closeness centrality, authors with lower academic degrees presented a higher proclivity to occupy central positions compared to PhDs at a 1 per cent significance level. That is, we found a negative relationship between the academic degrees and the closeness centrality, and this evidence can be interpreted as synonymous with dependence (Brandes et al., 2016), once students depend on senior researchers to generate research outputs. This dependency systematically increases as academic degrees decrease. Thus, if the research seniority seems to be associated with a large number of collaborative links as also evidenced by Bordons et al. (2003), it makes researchers less dependent, therefore, more distant from other actors. Unlike the experimental sciences, research resources in the social sciences are substantially less sophisticated (Stephan, 2010), which can make senior researchers less sensitive to adopting collaborative strategies based on proximity simply because access to research resources is not so necessary as they are in the experimental sciences.

In terms of geography, our findings did not allow us to establish a relationship between the nodes' importance and the development of Brazilian regions. We found that there was no difference in the probability of occupying central degree positions conditioned to the regions of authors' institutions, despite the concentration of authors in the south and southeast regions. In turn, we found that authors from the southern region were more likely to occupy prominent positions in terms of the eigenvector centrality. It is interesting to note that among the most central nodes, there are 3 postgraduate students for each PhD in the southern region, whereas this ratio is 8, 6 and 11 in the midwestern, north-eastern and south-eastern regions, respectively. Proportionally, the authors' collaboration network in the southern region consists of 31 per cent of PhD students, which is 8 times higher compared to the mean of the other regions. In this sense, our findings indicate that maintaining connections with researchers who hold higher academic degrees increases the likelihood of assuming a prominent position because of the benefits of their influence, which is consistent with the argument of Cimenler et al. (2014). An author can assume a relevant position in a network by favoring connections with other well-connected authors like those with higher academic degrees.

Except for the midwestern region, authors from other regions showed lower probabilities of occupying central closeness positions compared to those in the south-eastern region. We found that the proportion of master's holders for each PhD was higher in the midwestern and south-eastern regions (3.5 and 2.7, respectively). This result may be related to a higher concentration of authors with a lower academic degree in the co-authorship groups in such regions, implying in higher closeness scores due to a higher dependence on senior researchers as mentioned before.

5. Conclusion

This paper analyzed how gender, research experience and geography were related to the authors' importance in the management and accounting sciences co-authorship network in Brazil. Although the evidence produced by Mello, Crubellate, and Rossoni (2009) and Espartel et al. (2013) showed an increase in collaboration intensity in such disciplines, our results indicated a large number of small groups of authors connected into isolated communities. The collaborative relationships among Brazilian postgraduate programs in management indicate well-defined groupings (Rossoni & Guarido Filho, 2009), and we highlight that this characteristic is a result of the scarcity of researchers serving as gatekeepers, fundamental to build bridges in the network (Behara et al., 2014).

Men were more likely to occupy central positions in terms of the number of direct connections than women. Marginally, they were also more predisposed to occupy prominent positions concerning the eigenvector centrality, which corresponds to say that they tended to establish more links with well-connected and influential nodes compared to women. Such findings are striking evidence that at least in Brazilian top management and accounting journals, male authors dominate prevailing positions in the collaboration network.

In line with the career rank of scientists and other research seniority proxies, we showed that collaboration patterns could be distinguished according to the authors' academic degrees. In general terms, we found a positive relationship between the academic degrees and the propensity of reporting strong degree centrality, demonstrating the importance of the research experience for establishing collaboration links. Holders of a master's degree were less likely to occupy central positions even when compared to master's students. This finding illustrates that the interruption of the link with the postgraduate program before obtaining the PhD degree may dilapidate the author's importance in the co-authorship network. On the other hand, the results allowed us to conclude that the research experience may imply less dependence concerning the scientific production in the disciplines analyzed, once the higher the academic degree, the less likely authors are to be close to others.

We also found a predominance of authors linked to institutions in the more-favored regions, corroborating the conclusions of Wood, and Chueke (2008), Espartel et al. (2013) and Sidone et al. (2016). However, authors from more- and less-favored regions may report similar propensity to occupy central positions. In terms of geography, such propensity seems to be explained by the relationship between the number of PhDs and the other academic degrees of the co-authors, whose proportion is different among co-authors groups according to the Brazilian regions.

Our evidence shed light on relevant theoretical implications. First, additional research is needed to investigate whether gender imbalances in the disciplines analyzed reflect gender discrimination arising from managerial decisions (Abramo et al., 2013) or whether they may depict specific personal characteristics of women regarding the way they produce knowledge (Xie & Shauman, 2003). Furthermore, we showed that collaboration strategies seemed to vary according to the authors' research experience. In the management and accounting sciences, specifically, PhDs were found to adopt a collaboration strategy based

on the number of links, whereas authors with lower academic degrees seemed to adopt a strategy based on the proximity with other nodes. Empirical studies should explore this avenue deeply to analyze whether less resource-dependent fields as the applied social sciences systematically present this collaboration pattern or whether higher research seniority relates to less dependence regardless of the knowledge field.

In terms of the implications for research policy, we highlight the importance of promoting the knowledge flow between different research groups in such fields. Thus, we emphasize that the evaluation bodies should rethink the evaluation metrics of postgraduate programs to increase the weight of the interinstitutional research partnerships. Although such incentives exist in Brazil, they could be more valued, mainly to foment collaboration between programs from distinct regions. From a managerial perspective, decision-makers should think about fostering policies to encourage female insertion into broader collaborative networks. These policies can range from the uniform distribution of the academic supervisions between male and female researchers, according to Abramo et al. (2014), the stimulus to collaboration with colleagues in their own and other universities.

Finally, we point out as limitations of our research that the sample covered only a portion of the journals in the management and accounting sciences in Brazil. Moreover, we must bear in mind that the pressure to increase the volume and quality of scientific production can lead to co-authorship distortions, as evidenced by Liu et al. (2017). Thus, bibliometric data may not faithfully mirror the set of collaborative relationships that genuinely contributed to the production of the articles, although the scientometrics literature has traditionally adopted them.

References

Abbasi, A., & Hossain, L. (2011). Evolutionary dynamics of scientific collaboration networks: Multi-levels and cross-time analysis. *Scientometrics*, *89*, 687–710. https://doi.org/10.1007/s11192-011-0463-1

Abassi, A., Altmann, J., & Hossain, L. (2011). Identifying the effects of co-authorship networks on the performance of scholars: A correlation and regression analysis of performance measures and social network analysis measures. *Journal of Informetrics*, *5*, 594–607. https://doi.org/10.1016/j.joi.2011.05.007

Abramo, G., D'angelo, C. A., & Murgia, G. (2013). Gender diferences in research collaboration. *Journal of Informetrics*, *7*, 811–822. https://doi.org/10.1016/j.joi.2013.07.002

Abramo, G., D'angelo, C. A., & Murgia, G. (2014). Variation in research collaboration patterns across academic ranks. *Scientometrics*, *98*, 2275–2294. https://doi.org/10.1007/s11192-013-1185-3

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

Ahrweiler, P., & Keane, M. T. (2013). Innovation networks. *Mind and Society*, *12*, 73–90. https://doi.org/10.1007/s11299-013-0123-7

Aiston, S. J., & Jung, J. (2015). Women academics and research productivity: An international comparison. *Gender and Education*, *27*, 205–220. https://doi.org/10.1080/09540253.2015.1024617.

Araújo, E. B., Araújo, N. A. M., Moreira, A. A., Herrmann, H. J., & Andrade, J. S. Jr, (2017). Gender differences in scientific collaborations: Women are more egalitarian than men. *PloS One*, *12*, 1–10. https://doi.org/10.1371/journal.Pone.0176791.

Araújo, T., & Fontainha, E. (2017). The specific shapes of gender imbalanced in scientific authorships: A network approach. *Journal of Informetrics*, *11*, 88–102. https://doi.org/10.1016/j.joi.2016.11.002

Badar, K., Hite, J. M., & Badir, Y. F. (2013). Examining the relationship of co-authorship network centrality and gender on academic research performance: The case of chemistry researchers in Pakistan. *Scientometrics*, *94*, 755–775. https://doi.org/10.1007/s11192-012-0764-z

Badar, K., Hite, J. M., & 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*, 38–53. https://doi.org/10.1108/AJIM-05-2013-0040

Behara, R. S., Babbar, S., & Smart, P. A. (2014). Leadership in OM research: A social network analysis of European researchers. *International Journal of Operations and Production Management*, *34*, 1537–1563. https://doi.org/10.1108/IJOPM-08-2013-0390

Bordons, M., Morillo, F., Fernández, M. T., & Gómez, I. (2003). One step further in the production of bibliometric indicators at the micro level: Differences by gender and professional category of scientists. *Scientometrics*, *57*, 159–173. https://doi.org/10.1023/A:1024181400646

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

Bozzon, R., Murgia, A., & Poggio, B. (2019). Gender and precarious careers in academia and research: Macro, meso and micro perspectives. In A. Murgia, & B. Poggio, (Eds.), *Gender and precarious research careers: A comparative analysis* (pp. 15–49). London, United Kingdom: Routledge.

Brandes, U., Borgatti, S. P., & Freeman, L. C. (2016). Maitaining the duality of closeness and betweenness centrality. *Social Networks*, *44*, 153–159. https://doi.org/10.1016/j.socnet.2015.08.003

Breschi, S., & Catalini, C. (2010). Tracing the links between science and technology: An exploratory analysis of scientists' and inventors' networks. *Research Policy*, *39*, 14–26. https://doi.org/10.1016/j.respol.2009.11.004

Cameron, A. C., & Trivedi, P. K. (2009). *Microeconometrics using stata*. College Station, TX: Stata Press.

Ceballos, H. G., Fangmeyer, J., Jr, Galeano, N., Juarez, E., & Cantu-Ortiz, F. J. (2017). Impelling research productivity and impact through collaboration: A scientometric case study of knowledge management. *Knowledge Management Research and Practice*, *15*, 346–355. https://doi.org/10.1057/s41275-017-0064-8

Cherven, K. (2015). *Mastering gephi network visualization*. Birmingham, United Kingdom: Packt Publishing.

Cimenler, O., Reeves, K. A., & Skvoretz, J. (2014). A regression analysis of researcher' social network metrics on their citation performance in a college of engineering. *Journal of Informetrics*, *8*, 667–682. https://doi.org/10.1016/j.joi.2014.06.004

CNPq. (2018). *Directory of research groups in Brazil*. Retrieved from http://lattes.cnpq.br/web/dgp/por-titulacao-e-regiao

Corley, E. A., & Sabharwal, M. (2010). Scholarly collaboration and productivity patterns in public administration: Analysing recent trends. *Public Administration*, *88*, 627–648. https://doi.org/10.1111/j.1467-9299.2010.01830.x.

Cowan, R., & Jonard, N. (2004). Network structure and the diffusion of knowledge. *Journal of Economic Dynamics and Control*, *28*, 1557–1575. https://doi.org/10.1016/j.jedc.2003.04.002

Cruz, A. P. C., Espejo, M. M. S. B., Costa, F., & Almeida, L. B. (2011). Perfil das redes de cooperação científica: Congresso USP de Controladoria e Contabilidade – 2001 a 2009. *Revista Contabilidade and Finanças*, *22*, 64–87. http://dx.doi.org/10.1590/S1519-70772011000100005

Dehdarirad, T., & Nasini, S. (2017). Research impact in co-authorship networks: A two-mode analysis. *Journal of Informetrics*, *11*, 371–388. https://doi.org/10.1016/j.joi.2017.02.002

Endenich, C., & Trapp, R. (2016). Cooperation for publication? An analysis of co-authorship patterns in leading accounting journals. *European Accounting Review*, *25*, 613–633. https://doi.org/10.1080/09638180.2015.1085886

Espartel, L. B., Basso, K., Callegaro, A. R. C., Visentini, M. S., Tomazelli, J. B., & Henderson-Errandonea, V. M. (2013). Colaboração científica em administração: Análise das publicações em coautoria no Brasil no período 2000-2010 [Scientific collaboration in management: analysis of publications in co-authorship in Brazil among 2000-2010]. *Revista Gestão Organizacional*, *6*, 77–92.

Ferreira, M. P. V., Canela, R., Pinto, C. F., & Falaster, C. D. (2018). Coautoria em Administração no Brasil: pressões, complementaridades e produtividade [Co-authorship in management in Brazil: pressures, complementarities and productivity]. *BASE – Revista de Administração e Contabilidade da Unisinos*, *15*, 42–55. https://doi.org/10.4013/base.2018.151.04

Fleming, L., King, C., & Juda, A. I. (2007). Small worlds and regional innovation. *Organization Science*, *18*, 938–954. https://doi.org/10.1287/orsc.1070.0289

Glänzel, W., & Schubert, A. (2004). Analysing scientific networks through co-authorship. In F. M. Henk, & U. Schmoch, (Eds.), *Handbook of quantitative science and technology research: The use of publication and patent statistics in studies of S&T systems* (pp. 255–314). Dordrecht, The Netherland: Kluwer Academic Publishers.

Gonzalez-Brambila, C. N., Veloso, F. M., & Krackhardt, D. (2013). The impact of network embeddedness on research output. *Research Policy*, *42*, 1555–1567. https://doi.org/10.1016/j.respol.2013.07.008

Hara, N., Solomon, P., Kim, S. L., & Sonnenwald, D. H. (2003). An emerging view of scientific collaboration: Scientists' perspectives on collaboration and factors that impact collaboration. *Journal of the American Society for Information Science and Technology*, *54*, 952–965. https://doi.org/10.1002/asi.10291

Jackson, M. O. (2008). *Social and economic networks*. Princeton, NJ: Princeton University Press.

Jeong, S., Choi, J. Y., & Kim, J. (2011). The determinants of research collaboration modes: Exploring the effects of research and researcher characteristics on co-authorship. *Scientometrics*, *89*, 967–983. https://doi.org/10.1007/s11192-011-0474-y

Karimi, F., Mayr, P. & Momeni, F. (2019). Analyzing the network structure and gender differences among the members of the Networked Knowledge Organization Systems (NKOS) community. *International Journal on Digital Libraries*, *20*, 231–239. https://doi.org/10.1007/s00799-018-0243-0

Koseoglu, M. A. (2016). Mapping the institutional collaboration network of strategic management research: 1980–2014. *Scientometrics*, *109*, 203–226. https://doi.org/10.1007/s11192-016-1894-5

Koseoglu, M. A., King, B., & Rahimi, R. (2019). Gender disparities and positioning in collaborative hospitality and tourism research. *International Journal of Contemporary Hospitality Management*, *35*, 1–25. https://doi.org/10.1108/IJCHM-09-2018-0747.

Li, E. Y., Liao, C. H., & Yen, H. R. (2013). Co-authorship networks and research impact: A social capital perspective. *Research Policy*, *42*, 1515–1530. https://doi.org/10.1016/j.respol.2013.06.012

Liu, C. S. (2015). Network position and cooperation partners selection strategies for research productivity. *Management Decision*, *53*, 494–511. https://doi.org/10.1108/MD-02-2014-0076

Liu, C., Olivola, C. Y., & Kovács, B. (2017). Co-authorship trends in the field of management: Facts and perceptions. *Academy of Management Learning and Education*, *16*, 509–530. https://doi.org/10.5465/amle.2016.0080

Mello, C. M., Crubellate, J. M., & Rossoni, L. (2009). Redes de coautorias entre docentes de programas brasileiros de pós-graduação (stricto sensu) em administração: Aspectos estruturais e dinâmica de relacionamento [Networks of co-authorships among professors of Brazilian programs of post graduate (stricto sensu) in administration: structural aspects and dynamics of relationship]. *Ram. Revista de Administração Mackenzie*, *10*, 130–153. http://dx.doi.org/10.1590/S1678-69712009000500007

Nikzad, M., Jamali, H. R., & Hariri, N. (2011). Patterns of Iranian co-authorship networks in social sciences: A comparative study. *Library and Information Science Research*, *33*, 313–319. https://doi.org/10.1016/j.lisr.2011.01.005

Nielsen, M. W. (2017). Gender and citation impact in management research. *Journal of Informetrics*, *11*, 1213–1228. http://dx.doi.org/10.1016/j.joi.2017.09.005

Nieves, J., & Osorio, J. (2013). The role of social networks in knowledge creation. *Knowledge Management Research and Practice*, *11*, 62–77. https://doi.org/10.1057/kmrp.2012.28

Orozco, L. A., & Villaveces, J. L. (2015). Heterogeneous research networks in Latin American schools of business management. *Academia Revista Latinoamericana de Administración*, *28*, 115–134. https://doi.org/10.1108/ARLA-05-2013-0052

Ozel, B., Kretschmer, H., & Kretscmer, T. (2014). Co-authorship pair distribution patterns by gender. *Scientometrics*, *98*, 703–723. https://doi.org/10.1007/s11192-013-1145-y

Pacheco, G. G., Pinedo, R. D. Y., Ditta, A., Ruiz, M., & Varela, A. (2018). Gender difference in publication among recent or/MS scientific publications in top journals. *Espacios*, *39*, 20–33.

Pina, D. G., Barać, L., Buljan, I., Grimaldo, F., & Marusić, A. (2019). Effects of seniority, gender and geography on the bibliometric output and collaboration networks of European research council (ERC) grant recipients. *PLoS One*, *14*, 1–16. https://doi.org/10.1371/journal.Pone.0212286.

Rey-Rocha, J., Martín-Sempere, M., & Garzón-García, B. (2002). Research productivity of scientists in consolidated vs non-consolidated teams: The case of Spanish university geologists. *Scientometrics*, *55*, 137–156. https://doi.org/10.1023/A:1016059222182

Ronda-Pupo, G. A., Díaz-Contreras, C., Ronda-Velázquez, G., & Ronda-Pupo, J. C. (2015). The role of academic collaboration in the impact of Latin-American research on management. *Scientometrics*, *102*, 1435–1454. https://doi.org/10.1007/s11192-014-1486-1

Rossoni, L., & Guarido Filho, E. R. (2007). Cooperação interinstitucional no campo da pesquisa em estratégia [Interinstitutional cooperation in the research field of strategy]. *Revista de Administração de Empresas*, *47*, 74–88. http://dx.doi.org/10.1590/S0034-75902007000400007

Rossoni, L., & Guarido Filho, E. R. (2009). Cooperação entre programas de pós-graduação em administração no Brasil: Evidências estruturais em quatro áreas temáticas [Scientific cooperation among graduate programs in the field of business in Brazil: structural evidence in four thematic areas]. *Revista de Administração Contemporânea*, *13*, 366–390. http://dx.doi.org/10.1590/S1415-65552009000300003

Sidone, O. J. G., Haddad, E. A., & Mena-Chalco, J. P. (2016). A ciência nas regiões brasileiras: Evolução da produção e das redes de colaboração científica [Science in Brazilian regions: development of scholarly production and research collaboration networks]. *Transinformação*, *28*, 15–31. http://dx.doi.org/10.1590/2318-08892016002800002

Stefano, D. D., Fuccella, V., Vitale, M. P., & Zaccarin, S. (2013). The use of different data sources in the analysis of co-autorship networks and scientific performance. *Social Networks*, *35*, 370–381. https://doi.org/10.1016/j.socnet.2013.04.004

Stephan, P. E. (2010). The economics of science. In B. H. Hall, & N. Rosenberg, (Eds.), *Handbook of the economics of innovation* (pp. 217–273). Oxford, United Kingdom: Elsevier.

Stvilia, B., Hinnant, C. C., Schindler, K., Worrall, A., Burnett, G., Burnett, K., & Marty, P. F. (2011). Composition of scientific teams and publication productivity at a national science lab. *Journal of the American Society for Information Science and Technology*, *62*, 270–283. https://doi.org/10.1002/asi.21464

Tsai, C. C., Corley, E. A., & Bozeman, B. (2016). Collaboration experiences across scientific disciplines and cohorts. *Scientometrics*, *108*, 505–529. https://doi.org/10.1007/s11192-016-1997-z

van den Besselar, P., & Sandström, U. (2016). Gender differences in research performance and its impact on careers: A longitudinal case study. *Scientometrics*, *106*, 143–162. https://doi.org/10.1007/s11192-015-1775-3.

Wood, T., Jr, & Chueke, G. V. (2008). Ranking de produção científica em administração de empresas no Brasil [Ranking of scientific production in business administration in Brazil]. *Ram. Revista de Administração Mackenzie*, *9*, 13–31. http://dx.doi.org/10.1590/S1678-69712008000400003

Xie, Y., & Shauman, K. (2003). *Women in science: Career processes and outcomes*. Cambridge, MA: Harvard University Press.

***Corresponding author**
Alexandre Dias can be contacted at: alexandredias_usp@yahoo.com.br

Associate editor: Renata Schirrmeister