

RESEARCH

Open Access



Gender and researchers with institutional affiliations in the global south/north in social network science

Alejandro Espinosa-Rada^{1*}  and Francisca Ortiz^{2,3}

*Correspondence:
alejandro.espinosa@gess.ethz.ch

¹ Social Networks Lab,
Department of Humanities,
Social and Political Sciences, ETH
Zürich, Zürich, Switzerland

² Millennium Institute for Care
Research MICARE, Santiago, Chile

³ The Mitchell Centre for Social
Network Analysis, The University
of Manchester, Manchester, UK

Abstract

The following article aims to understand the prevalence of ascribed social characteristics such as the role of gender and the country of institutional affiliation of the authors in two prominent journals of social network science. Accordingly, we explore the Social Networks journal that has been extensively analysed to understand the evolution of the social network perspective and the development of this area of interest. Also, we explore the REDES journal, which mirrors the same journal but aims to represent the current state of social network science in Iberian America. For the analysis, we explore the network of these two journals, considering 301 papers from the Social Networks journal and 86 papers from REDES journal. For the analysis, we use exponential random graph models to control for simultaneously operating micro-mechanisms to understand the potential effects that allowed the emergence of these scientific networks. Our main results indicate that the country of institutional affiliation creates a centre-periphery tendency in both journals. Furthermore, there is a tendency of women to be an underrepresented group in the papers published in the period analysed.

Keywords: Scientific networks, Social networks, Women in science, Centre-periphery, Global south and north

Introduction

As social fields, scientific networks are often characterised by systemic inequalities, with authors accumulating (dis)advantages based on ascribed and/or acquired sociodemographic characteristics (Merton 1968; 1988). Disadvantages, such as those involving the interactions and relationships of researchers (de Solla Price 1965), are often represented in empirical settings through formal channels, such as references in scientific works, co-authorships and mentorship relationships among others (Gläser 2001). These systematic disadvantages can be explained through the analysis of local network mechanisms at the micro-level (Crane 1972; Mullins and Mullins 1973; Chubin 1976; Wuchty et al. 2007). Such mechanisms can shape inequalities at the macro-level, leading to tendencies such as preferential attachments (de Solla Price 1965; Barabási and Albert 1999; Newman 2001). Some of these disadvantages can be seen in the prevalence or absence of micro-mechanisms. In this research, we explore how gender and the country of institutional

affiliation of published authors are less prevalent in two prominent journals of social network science.

This research considers how some attributes, such as gender and country of institutional affiliation, shape the network of core-set (Collins 1974) journals in social network science. The framework used relies on the relevance of these network micro-mechanisms—as explicit internal structures of entities and relations represented as subgraphs (Stadtfeld and Amati 2021)—also called local configurations (Lusher et al. 2012). In this research, processes are investigated in the frame of the sociology of science and knowledge (Crane 1972; Schrum and Mullins 1988) by explicitly stating the relevance of attributes in creating cumulative (dis)advantages (Cole and Cole 1973; Merton 1988), local structures such as dyads and triads (Mullins 1972 1973; Mullins and Mullins 1973) or similar structural positions in the network (White and Breiger 1975; Breiger 1976; Mullins et al. 1977). These micro-mechanisms were examined to understand the evolution of scientific networks, often called ‘invisible colleges’ (de Solla Price 1965; Crane 1972) or specialities (White and Breiger 1975; Breiger 1976; Mullins et al. 1977; Burt and Doreian 1982). Recent investigations aim to revitalise this line of research to understand how social ties form and why networks arise from simultaneously operating micro-mechanisms (e.g., Kronegger et al. 2012; Dahlander and McFarland 2013; Ferligoj et al. 2015; Zinilli 2016; Sciabolazza et al. 2017; Gondal 2018; Akbaritabar et al. 2020; Purwitasari et al. 2020).

Previous research has done extensive work to characterise and understand the evolution of the social network science perspective (Mullins and Mullins 1973; Freeman 2004; Scott 2011; Batagelj et al. 2014; Maltseva and Batagelj 2019). However, as far as we are aware, the framework of considering simultaneously operating micro-mechanisms has not yet been applied to the field of social network science.

In this research, we address the prevalence of two micro-mechanisms in relation to two core-set journals of the social network science community, *Social Networks* and *Revista Hispana para el Análisis de Redes Sociales (REDES)*. Specifically, we focus on understanding how gender and authors’ countries of institutional affiliation shape the networks of these journals. The strategy used for data collection involved manually identifying the gender and country of institutional affiliation of each author. The analysis also applied an ERGM model. In total, we reviewed a two-mode network of 387 papers with 874 authors. Our main results indicate that the country of institutional affiliation creates a centre-periphery tendency in both journals, and there was a tendency for women to be under-represented in published papers during the period under analysis.

The following article presents its argument in four sections. First, we begin with the literature review to examine previous research on gender and institutional affiliation of authors and its relationship with publication. Second, we describe the material and methods applied, including data collection and analysis strategies. Third, we show the results obtained and discuss the main results. Finally, we draw some conclusions, address their limitations and present advice for further research.

Literature review

The social network perspective (Mitchell et al. 1969; Wasserman and Faust 1994; Freeman 2004), also known as (social) network science (Brandes et al. 2013; Newman 2018),

is a field that has been fundamental to the understanding of scientific networks (e.g., de Solla Price 1963 1965; Crane 1972; Mullins 1972 1973; Chubin 1976; Schrum and Mullins 1988; Barabási and Albert 1999; Newman 2001). Social network science has been considered an area where members share epistemic perspectives and practices (Knox et al. 2006; Venturini et al. 2019), being described previously as an (in) visible college (Freeman and Freeman 1980; Hummon and Carley 1993; Freeman 2004; Maltseva and Batagelj 2019). In recent years, this field has expanded and evolved significantly in the intersection between the social sciences and other disciplines, such as physics (Bonacich 2004; Lazer et al. 2009; Brandes and Pinch 2011; Freeman 2011; Scott 2011; Batagelj et al. 2014), 'data science' (Shafie and Brandes 2018) or the study of social animals (Maltseva and Batagelj 2019 2021). The field has created new bridges between professionals in different disciplines, as demonstrated in the Networks 2021 conference involving both social scientists (who often gather in the SUNBELT conference and the International Network for Social Network Analysis) and the so-called natural sciences (usually congregating at NetSci conferences and the Network Science Society).

While extensive effort has been made to understand the development of the social network perspective, there is scarce research into the sociodemographic attributes of researchers and how these can lead to disadvantages. In particular, there is comparatively less understanding of women researchers and researchers affiliated to institutions in the Global South.

Recent research had started to fill this gap and reconstruct the history of the social network perspective in communities such as Iberian America (Espinoza 2005; Molina 2007; Ortiz et al. 2021; Vélez et al. 2021) and countries from Latin America, such as Argentina (Tevez and Pasarin 2014), Brazil (Varanda et al. 2012), Colombia (Palacio and Vélez 2014), Chile (Gaete and Pino 2014) and Mexico (Ramos et al. 2014). This community has been characterised as demanding, active, critical and one that is still in process of learning (Gaete and Pinto 2014). The interdisciplinary nature and diversity of topics for research has also been highlighted (Tevez and Pasarin 2014). Some countries, like Argentina and Mexico, have a longer tradition with the network's community (Molina 2007; Tevez and Pasarin 2014; Ramos et al. 2014), which makes them more connected to the global community. Moreover, a particular aspect of this community is that its literature has started to be translated over the past two decades (Molina 2007). A special case is Brazil, which is historically linked to Portugal and has a shared language (Varanda et al. 2012). The Hispanic community had also become more visible from its contributions to the journal REDES and the SUNBELT session "Mesa hispana sobre análisis de redes sociales" (Ramos et al. 2014; Ortiz et al. 2021).

Current initiatives, such as Women in Network Science, have started to address the underrepresentation and recognition of women, transgender and non-binary network scientists in this field. However, there is no clear understanding of the local mechanisms responsible for the emergence of the network of social network researchers, particularly considering sociodemographic characteristics, such as gender and the country to which researchers are institutionally affiliated.

Gender

Articles are the primary way of communicating within scientific communities, which aim to advance science, report new discoveries and build on previous research. However, the availability of documents and the underlying social patterns that shape science publication can blur or distort a scientific fields' trends, giving more (dis)advantages to some social groups over others (Cole and Cole 1973; Merton 1988). One of these social characteristics is the ascribed gender of researchers, with certain groups been under-represented in scientific contribution. For example, in academic awards, there has been a persistent gender gap in life sciences, computer science and mathematics, where women have been less favoured (Meho 2021). Chatterjee and Werner (2021) found gender disparities in citations between men and women in high-impact medical journals, where papers written by women received fewer citations than men. Moreover, women who did win awards tended to receive less money and prestige for their discoveries, as shown in the case of biomedical awards (Ma et al. 2019).

Some studies have concentrated on gender disparities in science using papers as a proxy for scientific collaborations. However, previous studies have already identified some gendered stratification patterns in areas of recruitment, socialisation of young investigators, access to publications, recognition (of citations and awards) and research facilities (Zuckerman 1970). Historically, compared to men, women tend to publish fewer articles as first or last authors (Huang et al. 2020). There can also be a more profound disparity depending on the discipline they work in. For example, in engineering, it has been found that male engineers produce 80% of its scientific publications, and while female engineers tend to publish in journals with higher impact factors, they appear to get less recognition (Ghiasi et al. 2015). Studies have established that men dominate scientific publication in almost every country of the world (Larvière et al. 2013). Globally, women have less than 30% of fractionalised authorships, and for each article in which a woman is the first author, there are almost two led by men (Sugimoto 2013). The authors' place in the authorship could signify the importance of their contributions to the paper, however it has been found that women contribute in more practical tasks, like in the development of experiments (Macaluso et al. 2016). While it has been shown that gender disparities exist in science and the scientific community, as far as we know, there are few studies that consider these disparities in the context of (social) network science.

One of the main indicators of gender inequality in science is the number of publications each group completes. Previous research had demonstrated that women tend to publish less (Larvière et al. 2013; Athanasiou et al. 2016; Cainelli et al. 2015). Therefore, we envisage that:

H1 Two-mode networks of published authors shall demonstrate that women publish less papers than men.

Institutional affiliation (country)

If we focus on the progress of scientific collaboration, we should also consider the country of an author's institutional affiliation. This indicator can show us if the country makes a difference when publishing research in the community. Gazni et al. (2011)

studied 14,000,000 documents from the Web of Science to look deeply into international collaborations. Their results suggest that Western countries are situated at the core of their map and that they collaborate extensively with one another. Also, they found that high-impact institutions collaborate more often than low-impact institutions, as previously stated (e.g., Wagner and Leydesdorff 2005). Another study (Murray et al. 2019) indicates that this type of behaviour also happens among reviewers: they found higher rates of acceptance of an article when gender was the same and when the gatekeeper and the corresponding author also came from the same country. Another research study by Sugimoto et al. (2015) contrasts the development indicators of a country with gender to evaluate possible disparities. Their conclusions showed that countries with low levels of development had the lowest participation of women in science and less engagement internationally. These antecedents appear to be crucial to an author's propensity for collaboration in science.

The country of the author's institutional affiliation can have different structural advantages or disadvantages associated with it, which may help provide information about this disparity. Hence, we envisage that:

H2 Two-mode networks of published authors shall demonstrate that researchers affiliated with institutions from the Global South publish less papers than researchers affiliated with institutions from the Global North.

To categorise each country, we grouped them into countries from the Global South or Global North. We used the definition proposed by Bonaventura de Sousa Santos and Maria Paula Meneses (2014) for this process. Accordingly, the Global South countries (1) had been colonised by other countries during their history and (2) are geographically situated in America, Africa or Asia. Countries like Sweden, the United States, the United Kingdom, Italy and Luxemburg were categorised as part of the core, or Global North. Meanwhile, Chile, México and Argentina, among others, were considered periphery or members of the Global South.

Network processes

While our hypotheses mainly focus on the attributes that create comparative (dis)advantages (Cole and Cole 1973; Merton 1988), we will also control for the presence of network mechanisms. Social network mechanisms can be classified into different types of structures, such as relational, assortativity or proximity-based mechanisms (Rivera et al. 2010), which are often operationalised into less complex and concrete micro-mechanisms expressed in subgraphs (Stadtfeld and Amati 2021). Relational mechanisms are often based on structures that consider direct or indirect paths of actors within a network, such as dyads and triads (Wasserman and Faust 1994). While assortativity mechanisms, on the other hand, rely on the (dis)similarity of actors in creating social ties, such as homophily (Lazarsfeld and Merton 1954; McPherson 2001). Finally, the proximity mechanisms are based on the importance of the physical and cultural environment to shape networks, such as the tendency of actors to create ties when they share different types of activities (Feld 1981 1982).

One of the most recurrent and frequently used mechanisms in the context of scientific networks is the Matthew effect or peer recognition (Zuckerman 1967; Merton 1968), also known as preferential attachment (de Solla Price 1965; Barabási and Albert 1999; Newman 2001). At the level of micro-mechanisms and in the context of a network perspective, the Matthew effect is often operationalised as (in) degree effects (Borgatti and Balgin 2011) following a relational-based type of mechanism. However, when a two-mode network is considered, as the relationships between authors publishing papers, the effects can be dissected into two complementary processes in the frame of a proximity-based mechanism. The former is often referred as weighted degree distribution of researchers or alternating-author-k-star, which captures the effect of multiple papers authored by the same researcher when authors and their works are considered. Previous research using a two-mode network of authors citing papers interpreted this effect as a type of preferential attachment to citing reputable authors that are visibly cited by other scholars (Gondal 2011). The second effect is the weighted degree distribution of publications or alternating-paper-k-star, which for the context of authorship networks often refers to the variation in the level of productivity of the authors. For other contexts that measure citation, this effect is considered as the tendency to cite the same multiple other authors or bibliographic coupling (from the perspective of the papers) (Gondal 2011). Path distances, on the other hand, are often used to identify levels of 'overlapping chains' instead of dense clusters. However, in relatively small collaboration networks, it might be difficult to have sufficient variation of authors publishing shared papers. Hence, a simple two-path effect measure can be used instead to control for the extent to which two papers are published from the same author.

These effects can be considered as a proximity-based mechanism, as the frame of a scientific paper often relies on a common activity shared by the authors. Feld (1981) considered the focus of activities as contexts in which activities are organised, consisting in several joint focuses of activities (e.g., workplaces, voluntary organisations, hangouts, families, among others) and individuals that actively bring people together or passively constrain them to interact. These focuses of activities are often represented as a two-mode network (Borgatti and Halgin 2011). Previous research has considered projects for team formation as a focus of activities (Zhu et al. 2013), and it could be argued that papers are often the results of previously shared common activities.

Finally, assortativity-based mechanisms are often explored considering homophily between the actors. Homophily, a tendency of people to create ties with those that share similar attributes (Lazarsfeld and Merton 1954), has been extensively studied in empirical research (McPherson 2001). For the context of scientific collaboration, previous research has emphasised the importance of similarities, such as in gender, language, ethnicity, joint affiliation within colleges or departments, spatial proximity and similarity between topics or disciplines (Kronegger et al. 2012; Dahlander and McFarland 2013; Cimenler et al. 2015; Peng 2015; Dhand et al. 2016; Luke et al. 2016; Zinilli 2016; Fagan et al. 2018; McLevey et al. 2018; Wang et al. 2018; Akbaritabar et al. 2021). However, in empirical analysis, these attributes can only be tested if publication data can be retrieved, while extra assumptions are required to cluster research areas into similar topics or disciplines.

The aforementioned micro-mechanisms are often represented using simultaneously operating subgraphs that together resemble the examined network (Robins et al. 2005). More concretely, the assumption of micro–macro linkage is often explored by simulating networks that are constrained by the estimated parameters corresponding to specific statistics (i.e., micro-mechanisms) in a random network that aims to replicate the observed system (i.e., the ‘macro level’). A formal way of evaluating the linkage between these analytical levels is by using statistical goodness-of-fit for social networks (Snijders and Steglich 2015; Stadtfeld 2018). These diagnostics compare observed features of the networks that are not directly included in the model, with a simulated population of networks that are constrained by the parameters (Hunter et al. 2008). If the model is not capable of reproducing some of the structures of the complete network using these micro-mechanisms, then is often believed that the model is not accurately representing the observed network.

Materials and methods

Sample and participants

To understand the underlying mechanisms of gender and institutional affiliation in recent publications, this study will examine two journals considered the core-set of social network science. One of the journals—Social Networks—has been extensively studied to describe the history and current development of this research area (Hummon and Carley 1993; Freeman 2004; Knox et al. 2006; Maltseva and Batagelj 2019 2021). Founded in 1978, Social Networks is one of the oldest academic journals exclusively created to study social networks and is the main journal of the International Association for Social Network Analysis (INSNA). Another relevant journal for the Iberian America community, also considered one of the official publications of INSNA, is the journal REDES. REDES has been a critical channel to describe this field’s history and current developments in the Iberian American community (Molina 2007; Vélez et al. 2021). However, up to now, no study has compared both journals simultaneously or has used them to examine how women and researchers affiliated with institutions from the Global South may be represented in this field.

For data collection, this study considered all articles published in REDES and Social Networks journals over a five-year period (2015 to 2019). This resulted in 86 papers from REDES and 301 from Social Networks.

Another methodological consideration was the research scope. At the start of this study, we tried to analyse the network’s journals from the Global South. However, only the REDES journal was chosen for three main reasons: first, this journal has characteristics that make it comparable with Social Networks journal, as was previously mentioned; second, REDES has been recently indexed by Scopus, which provides up-to-date resources and websites unlike other databases; finally, the authors can only analyse articles in Spanish, English and Portuguese, as those are the languages known to them. REDES journal publishes in those three languages, however the language barrier meant this project could not analyse studies from other countries, such as those of Asia and Africa. Other than this, every result came under this scope.

REDES allows us to analyse a significant part of the Global South, although it does have limitations. As mentioned, the journal publishes only in Portuguese, Spanish and English, which leaves out articles written in other languages from the Global South. Another aspect is that the analysis considers the countries of the institutional affiliations rather than the World Bank specifications of low-, middle- and high-income countries. These categories are based on the definitions of Global North and South by Bonaventura de Sousa Santos and Maria Paula Meneses (2014), as explained before. To finalise, while the number of articles examined was small, although it needs to be considered that we had to compare both journals, and REDES has only been published for the last 20 years.

Data collection

We collected all the research articles published in REDES and the Social Networks journal between 2015 and 2019. Each journal required a different mechanism for data collection. For the REDES journal, we manually collected the information needed from its official website. All book reviews and other types of articles were left out. The data collected included authors, institutional affiliation of each author, title, year of publication, abstracts and keywords. After creating this first database, we completed it by searching for the city and country of each institutional affiliation. Finally, we added the gender of each author.

In the case of the Social Networks journal, the first database was downloaded from Web of Science. This provided us with information that had already been categorised, such as the country of each institutional affiliation. Accordingly, with the other database, all book reviews and other types of articles were omitted. For the gender of each author, we followed the same procedure as with REDES.

As mentioned, the last step to completing each database was to add the gender of the authors in the sample. From the 387 papers, the gender of all 874 authors was identified following three stages. First, we search for the official profile of each author and their institutional affiliations. The pronouns used in each biography were used to identify the person's gender. Second, the researchers looked for pronouns on the personal website of each author. Third, it was checked if the author had a Twitter account with pronouns mentioned in the profile. Finally, and this was only used for seven authors in total, press reports or other publications that mentioned the author were examined.

Although the data was collected in an innovative way, there were some difficulties and limitations. Selecting this information from three different web resources allowed us to compare data and ensure consistency. Also, there was no discrepancy between biographies, which was helpful to validate information. However, not all the authors had a personal website or Twitter account. At the beginning of data collection, the classification of gender was open to any type of spectrum. However, all pronouns found were female or male, which is why only these are used in this article. As researchers of this study, we understand gender as a broader concept and are willing to consider non-binary genders. However, in the data collection, this did not appear. This is relevant as a limitation of this classification: it is possible that some people, who recognise themselves as non-binary, did not publish this information on public platforms.

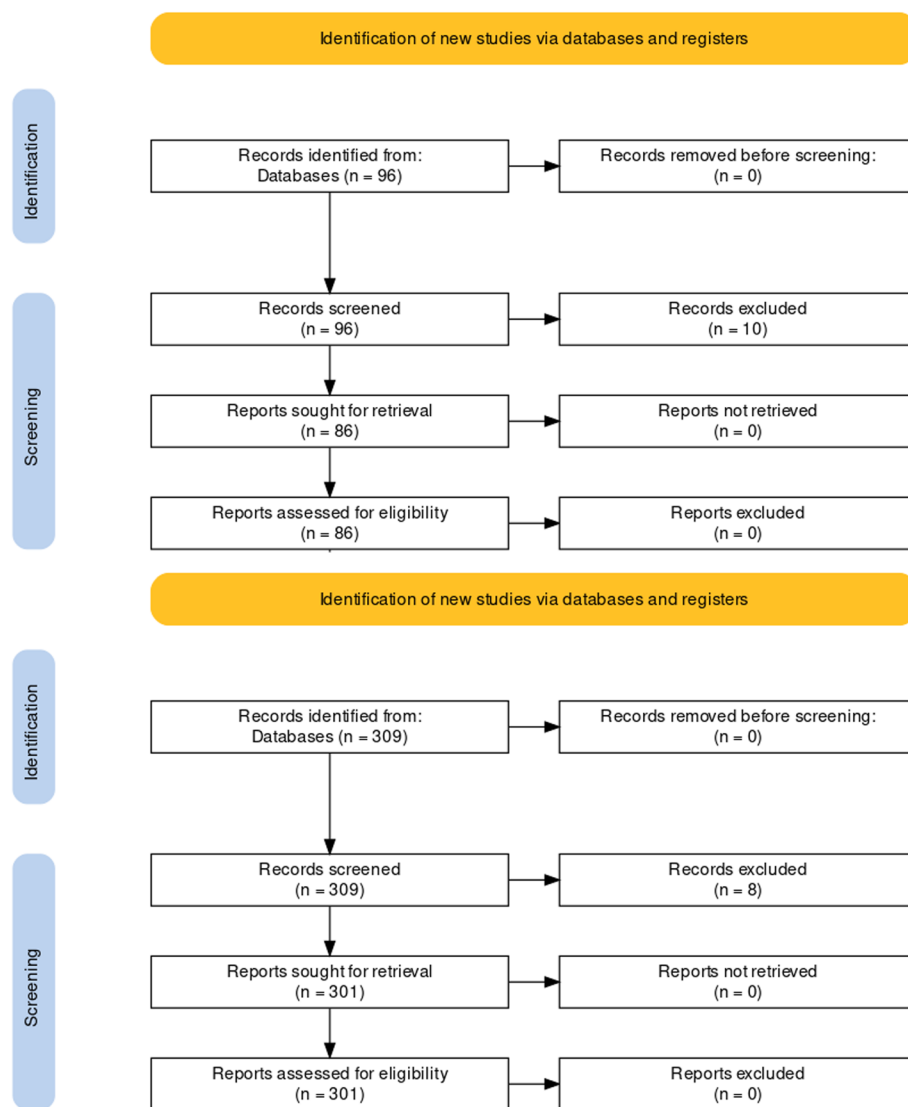


Fig. 1 Flow diagram construction of database. Source: Elaborated by the authors using the PRISMA diagram (Tricco et.al 2018; Page et.al 2020). The first one is the process of REDES Journal, and the one below, it is for the Social Networks Journal

All processes followed the PRISMA recommendations (Tricco et.al 2018; Page et.al 2020). The process of the data collection filter is represented in Fig. 1.

For each journal there were some inclusion and exclusion criteria. There were included all the “research articles” published between years 2015 and 2019. As the research project started in 2020, the data base was constructed using the last 5 years from there. In the REDES journal, there were 10 articles excluded because they were book review. In the Social Network journal, there were excluded three book reviews, three corrections, and two editorial materials.

Strategies of analysis

We used ERGMs for the analysis, as these statistical models can control for simultaneously operating configurations and the interdependency of social networks, allowing us to test our hypotheses (Lusher et al. 2012; Amati et al. 2018; Schweinberger et al. 2020). The ERGMs can be expressed in their general form as a probability function,


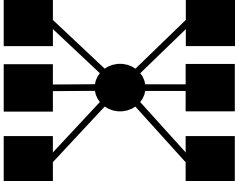
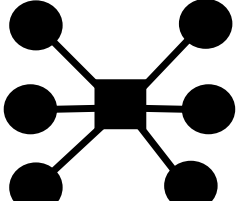
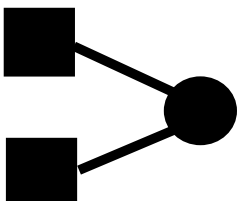



$$\Pr(X = x|\theta) \equiv P_{\theta}(x) = \frac{1}{\kappa(\theta)} \exp \{ \theta_1 z_1(x) + \theta_2 z_2(x) \dots + \theta_k z_k(x) \} \quad (1)$$

In which x is a realisation of a graph from random variable X that is a set of tie variables X_{ij} . Likewise, the function $z_k(x)$ counts the effects and configurations in the graph x (the ‘neighbourhood’) and θ are the unknown parameters weighting the relative importance of the counts of these sufficient statistics. Also, the $\kappa(\theta) = \sum_{x' \in X} \exp \{ \theta_1 z_1(x') + \theta_2 z_2(x') \dots + \theta_k z_k(x') \}$ is a normalisation term to ensure that the sum of the probability mass function, $P_{\theta}(x)$, over all possible graphs is one. For the following analysis, the graph has a two-mode structure with n nodes from set of researchers R and m nodes in set of papers P , and is represented using a $n \times m$ rectangular matrix where the cell $x_{ij} = 1$ if there is a tie between researcher i and j paper, and $x_{ij} = 0$ otherwise. Hence, and in the following, we use an ERGM for two-mode networks because using projections often implies losing information, which is applicable in the case of ERGMs (Wang et al. 2009). Previous research using exponential random graph models to analyse scientific networks often projects the network to analyse collaboration (e.g., Fagan et al. 2018; Ferligoj et al. 2015; Akbaritabar et al. 2020), neglecting the weighted ties created in the transformation or the potential overabundance of triangles that might appear—issue that can be further explored through the usage of visual goodness-of-fit (Hunter et al. 2008). Likewise, using two-mode networks might also disentangle one of the potential limitations involved in the interpretation of weighted degree parameters, as this effect often confounds edges and triangles (Levy 2016) with triangle structures often forbidden in this type of two-mode networks. As in standard interpretations, positive effects indicate that the corresponding configuration is more likely than chance in x , and that the configuration under consideration affected the observed structure of x .

For the hypothesis testing, two different types of sufficient statistics rely on actor attributes, and we also control for endogenous effect (Table 1). The differences between these effects rely on the authors’ attributes considered exogenous variables and the endogenous effects, which are often considered local subgraphs responsible for the emergence of the global network (Robins et al. 2005). Moreover, these effects are often tie-based, rather than actor-oriented (Block et al. 2019), and together they aim to understand how and why social networks arise (Lusher et al. 2012).

For the actor covariates, we used the gender of authors to identify whether being female or male affects the network. A similar effect was used according to the country of institutional affiliation, distinguishing between countries from the Global South and places of the Global North. We also controlled for the number of times the researchers were first-mentioned authors. These effects are often considered as exogenous variables that affect social ties, and when undirected networks are considered,

Table 1 Effects for the ERGM model

Effects	Subgraphs	Description
<i>Endogenous effects</i>		
Density		Baseline tendency for researchers to publish papers
Weighted degree distribution of researchers or alternating-author-k-star		Variation in the level of productivity
Weighted degree distribution of publications or alternating-paper-k-star		Variation in tendency for team size
Dyadic shared partners for publication dyads or paper-two-paths		Effect of the researchers in having two papers in the journals
Researchers' attributes effects		
H1 Gender activity		Gender of the researchers
H2 Countries activity		Country in which researchers are institutionally affiliated
Cumulated first authorships		Number of times the researchers were first author

they are often referred to as ‘activity of individual attributes’. Accordingly, the effects suggest that actors have more ties (i.e., increase their activity within the network) because of their attributes (Lusher et al. 2012).

The endogenous effects—as the operationalisation of the micro-mechanisms and considered patterns that arise solely from the structure of the social network—can be considered a tendency for the Matthew effect for each level, operationalised as a weighted degree distribution of researchers and publications. Also, it is not typical for an author to publish many papers in one journal, so we also controlled for shared partners for publication dyads to identify the relevance of publishing two papers in the same journal during the period under review.

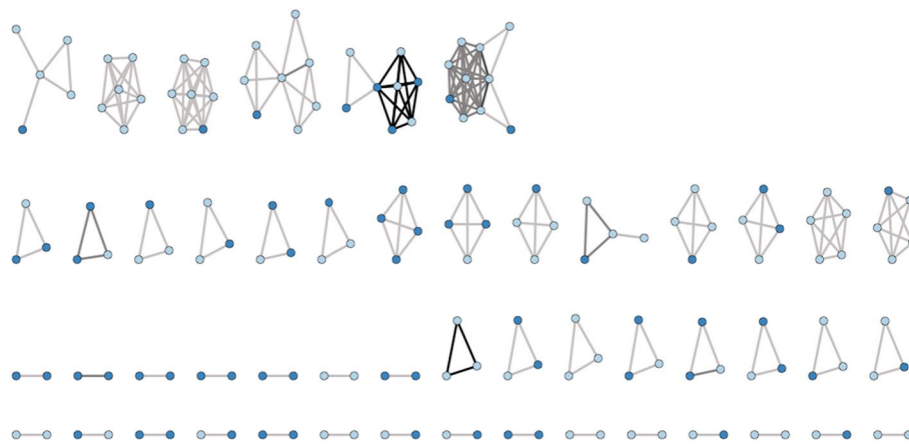


Fig. 2 REDES Journal's co-authorships. Source: Elaborated by the authors using the database of this research

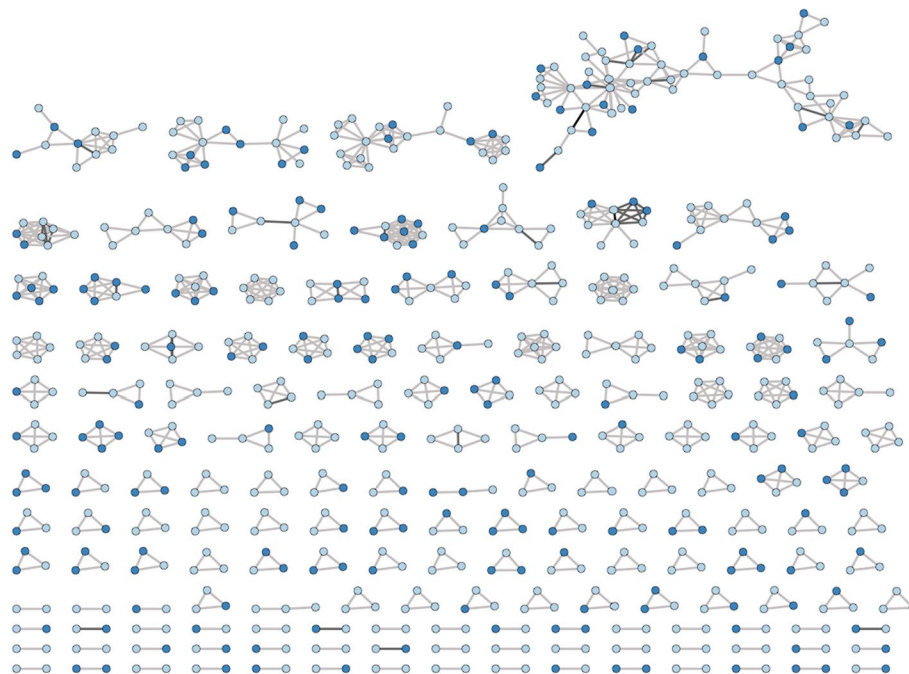


Fig. 3 Social network analysis journal's co-authorships. Source: Elaborated by the authors using the database of this research

Results

Of the 86 authors of the REDES journal papers, 71 were women and 109 men. Also, considering the matrix X , we projected the matrix considering the product of the matrix X with its transpose to create the $X'X$ projected matrix as the number of common oeuvres (i.e., an author's body of work (White and Griffith 1981)) that share author i and j (i.e., collaboration network). Using the projected adjacent matrix to describe the data, and the journal of Social Networks 199 were women and 495 men. Regarding the number of binary links (co-authorships) between genders in REDES, there were 111 man-man, 82 woman-woman and 30 man-woman ties.

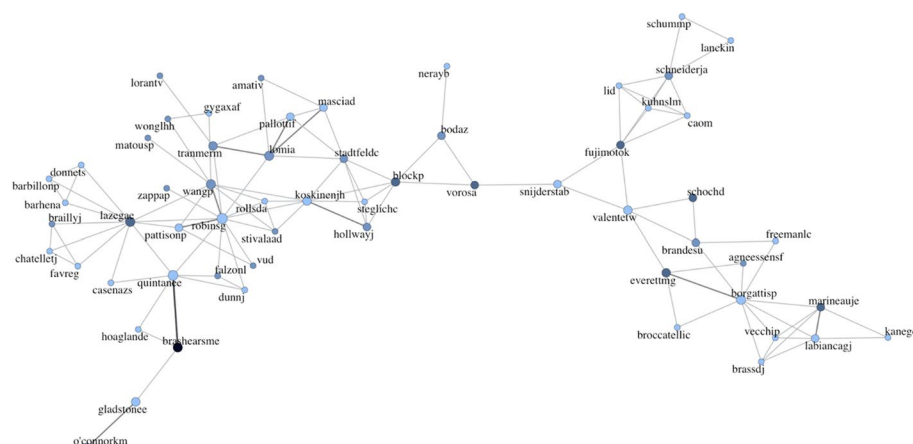


Fig. 4 Social Network Analysis Journal's main component. Source: Elaborated by the authors using the database of this research

Visual exploration of gender and country of the authors

This second figure illustrates a larger community with more people involved in co-authorships. Hence, we see more complex structures that show a more extensive community. There are more triads (54) than dyads (48) and many network cliques of four (23) and five (15) co-authors. The main component is considerably larger than the REDES journal, which has 60 nodes. There are more men (light blue) than women (dark blue), and there are also more authors with institutional affiliations from the Global North.

Exponential random graph models for two-mode networks

Table 2 Exponential random graph model for the social networks and REDES journals

	Social Networks		REDES	
	Model 1	Model 2	Model 3	Model 4
Edges (density)	− 5.678 *** (0.315)	− 8.124 *** (0.573)	− 4.181 *** (0.314)	− 5.277 *** (0.543)
Weighted degree distribution of researchers	3.464 *** (0.523)	4.805 *** (0.534)	4.016 *** (1.116)	5.098 *** (1.206)
Weighted degree distribution of publications	4.475 *** (0.822)	4.554 *** (0.872)	2.980 *** (1.006)	2.987 *** (1.034)
Dyadic shared partners for publication dyads	− 1.656 *** (0.225)	− 1.806 *** (0.191)	− 3.242 *** (0.323)	− 3.249 *** (0.323)
Gender (1 = Woman)		− 0.972 *** (0.222)		− 0.590 (0.430)
Countries (1 = Global North)		1.671 *** (0.461)		1.679 *** (0.423)
First author position		1.527 *** (0.142)		0.426 (0.384)
<i>AMEs and second differences</i>				
Edges (density)	− 0.011 *** (0.001)	− 0.016 *** (0.001)	− 0.011 *** (0.001)	− 0.020 *** (0.002)
Weighted degree distribution of researchers	0.007 *** (0.001)	0.009 *** (0.001)	0.010 *** (0.003)	0.020 *** (0.005)
Weighted degree distribution of publications	0.009 *** (0.002)	0.009 *** (0.002)	0.008 *** (0.003)	0.012 *** (0.004)
Dyadic shared partners for publication dyads	− 0.003 *** (0.000)	− 0.004 *** (0.000)	− 0.008 *** (0.001)	− 0.013 *** (0.001)
Gender (1 = Woman)		− 0.002 *** (0.000)		− 0.002 (0.002)
Countries (1 = Global North)		0.003 *** (0.001)		0.007 *** (0.002)
First author position		0.003 *** (0.000)		0.002 (0.001)
AIC	10,414.280	10,256.750	1917.409	1899.647
BIC	10,455.395	10,328.701	1947.807	1952.845
Log Likelihood	− 5203.140	− 5121.375	− 954.704	− 942.824

AME standard errors are calculated with the Delta methods, and the AMEs are calculated on the scale of ties probability

*** $p < 0.01$; ** $p < 0.05$; * $p < 0.1$

so we provided parsimonious models that address the leading hypotheses to explore the data, as is often suggested for ERGMs (Wang et al. 2009). Likewise, to overcome degeneracy problems, curved effects (Snijders et al. 2006; Hunter and Handcock 2006) were included for two-mode networks (Wang et al. 2013). Moreover, convergences were achieved with reasonable goodness-of-fit (Hunter et al. 2008), and the researchers undertook a visual inspection of crucial features not directly included in the model (Additional file 1: A and B). Also, to overcome issues related to scaling in the frame of ERGMs, the average marginal effects are considered in which the standard errors are obtained using the Delta method, as presented in Duxbury (2021).

The two journals were explored using exact specifications, and, overall, there are some similarities between them (Table 2). The estimated models behave in a similar fashion,

where the coefficients have similar directions and effect sizes. We conducted some additional analysis on models that did not achieve convergence or have the exact specification for both journals (Additional file 1: C, D and E). Some differences can be seen, as the controlled author covariates are significant in all cases in the Social Networks journal, while in REDES journal, some of these attributes are less significant.

For the two models applied to the Social Networks data, an increase in the weighted degree distribution of the researchers—interpreted as the variation in the level of productivity—correlates with an average 0.009 increase in tie probability. In the case of the REDES journal, the average is 0.010 for the first model and 0.020 in the complete model that includes some of the researchers' attributes. While this parameter is difficult to understand (Levy 2016), the standard interpretation is that a positive parameter indicates no centralisation, and that the edges are not accruing among a small number of high-degree nodes¹. From a substantive interpretation, the effects might represent the presence of more minor accumulated published papers written by researchers already publishing in these journals, which would not be expected by chance. Similarly, the weighted degree distribution of the papers—interpreted as the variation in the size of research teams—has a similar tendency. There is also a positive effect that can be interpreted as a propensity against publishing papers with too many authors. We also control for shared partners for publication dyads, which we interpret as the effect of the researchers having two papers in the journals. As shown, the effect is negative, which might be interpreted as a tendency to avoid having too many papers from the same authors, so as to prevent internal endogamy within the journals.

Some of the attribute effects of the authors are less significant in REDES than Social Networks, and the size of these effects are relatively small. As expected, women have fewer papers published in these journals, but this effect is more significant in the Social Networks journal. Regarding the history of the social network perspective (Mullins and Mullins 1973; Freeman 2004), first-mentioned researchers were predominantly men, and we expect that further research should consider (proxies of) seniority into the model. Nonetheless, authors with more papers as the first author were more likely to appear in the journals than would be expected by chance. For the gender and first author, the effect is relatively small (~ 0.002 – 0.003) compared to the endogenous effects of the restricted model in both cases. Finally, published papers were more likely to be affiliated with institutions from Global North compared with the Global South—an effect that is more significant for both journals.

Conclusions

In this research, we explored how the gender and countries of institutional affiliation of published authors are less prevalent in two main core-set journals of social network science, controlling for the presence of network micro-mechanisms. To conclude this article, we would like to highlight that both journals have similar tendencies in their parameters, differing slightly in the size of the effects and their significance. Overall, the main hypotheses are supported, with some cautions in the case of gender for REDES

¹ For the estimation, we use a low decay parameter ($\theta_s = 0.05$) in which $\theta_s \rightarrow 0$ gives more changes to low-degree nodes than changes to high-degrees (Levy, 2016).

journal. Hence, in the period under analysis, papers were predominantly published from researchers with institutional affiliations from the Global North and were predominantly men. This tendency can be observed in the global community through the Social Networks journal and in the Iberian American region through the REDES journal.

Regarding the methodological decisions taken, there were three that we would like to highlight as being innovative. First, the research used a two-mode network for analysis instead of a projection, which we believe recovered the information more accurately without losing or creating potential artefacts in its projections. However, much more research is needed to contrast both approaches. Second, the inclusion of non-English language journals in the analysis is uncommon. Hence, this aspect should be relevant in promoting a more decolonised environment for authors. Furthermore, for further research, and if the resources allow, it would be an enriching approach to include as many languages as possible. Finally, the inclusion of gender for each author, considering their pronouns, could be considered an effort to advance the recognition of structural inequalities faced by women and non-binary researchers.

Among the many limitations of this research, we believe that the models are sufficiently parsimonious to better understand the two journals at the core-set of social network science. Nonetheless, much more work is needed to extend the size of the network, as explored by Matseva and Batagelj (2019, 2021). This could help identify whether the prevalence of ascribed characteristics also applies to other network science journals or broader specifications of the boundaries of network science. Furthermore, we acknowledge that this topic could be studied from a qualitative point of view, which has not been included here. This might provide a more nuanced understanding of the topic and give further explanations of the network. For example, there are previous experiences that gather qualitative information about social network science (e.g., Mullins and Mullins 1973; Freeman 2004). Recent efforts have collected interviews of social network researchers, who share their experiences and perspectives about the social network science community through the podcast ‘Knitting Networks/Tejiendo Redes’, sponsored by INSNA². We believe that this information could be used as an ‘open science’ repository for qualitative research to gain a better understanding of ascribed characteristics as explored here. Also, as in many other studies on gender and co-authorship, gender designations used here have not been entirely auto-reported, as databases did not have this information.

In this research we used cross-sectional ERGMs that considered the state of the journals as a ‘stable process’ to distinguish the prevalence of different micro-mechanisms in the network. However, considering the information from a more granular perspective, novel statistical models, such as stochastic actor-oriented models (Snijders 2001), relational event models (Butts 2008) or dynamic network actor models (Stadtfeld and Block 2017), might be useful for providing more detail if the aggregate stable tendencies hold or the effects lessen their stability when the temporality is explored further. However, as mentioned in previous research, auto-regressive temporal ERGMs can be challenging to interpret (Block et al. 2019). Among some of the current limitations of auto-regressive

² The chapters are available in the following link: <https://anchor.fm/tejiendoredes>

temporal ERGMs, it is worth mentioning that these models might require a constant length interval between two waves. Also, the micro-level interpretation is generally not possible and does not consider the mechanisms created and changed in the networks in the previous state. Other models such as LERGMs are still under development and might be suitable for this type of analysis (Lusher et al. 2012; Koskinen and Lomi 2013; Koskinen et al. 2015). Stochastic actor-oriented models (Snijders 2001), on the other hand, have some assumptions that might be challenging to fulfil for bibliometric data in open systems. For these models, the actors are assumed to be in control of their outgoing ties, implying that actors are aware of others' attributes, their position in the network and their perceptions about the rest of the network. In scientific fields, this assumption might be reasonable for geographically-bounded systems (Bourdieu 1975) or through the presence of invisible colleges (Crane 1972) of relatively few people (Mullins and Mullins 1973) who push towards institutional homogenisation (DiMaggio and Powell 1983). Likewise, other models, such as relational event models (Butts 2008) and dynamic network actor-oriented models (Stadtfeld and Block 2017), require a sequence of events representing more fine-grained temporal processes. Yet, publication data are often aggregated by year, and it can be difficult to establish the exact moment they were written, submitted and published without creating sequences of simultaneous events. Further research is needed to explore with more details some of these alternatives.

Network science in general, and social network science in particular, is a relatively young field that has the potential to become a solid scientific enterprise. The field still retains some practices of other areas of research where the presence of comparative disadvantages persist. Despite this, we are confident that social network science can achieve a more inclusive, diverse and heterogeneous platform and that it can include a greater segment of its community. This research is an attempt to contribute to such progress.

Abbreviation

ERGMs Exponential random graph models

Supplementary Information

The online version contains supplementary material available at <https://doi.org/10.1007/s41109-022-00478-8>.

Additional file 1. A. Goodness of fit (Social Network Journal). B. Goodness of fit (REDES). C. Exponential Random Graph Model adding Gender Homophily. D. Exponential Random Graph Model adding weighted dyad wise shared partners of authors. E. Exponential Random Graph Model modifying the Time Windows.

Acknowledgements

We would like to acknowledge Brooke Foucault Welles (Department of Communication Studies, Northeastern University, USA), Olga Sarmiento (School of Medicine, Universidad de Los Andes, Colombia), Ana Maria Jaramillo (BioComplex Laboratory, Department of Computer Science, University of Exeter, UK), and Mariana Macedo (BioComplex Laboratory, Department of Computer Science, University of Exeter, UK) for coordinating the monograph "Networked Inequality: Studies on Diversity and Marginalization". Also, we appreciate comments of early versions given by members of the Social Networks Lab at ETH Zürich. We thanks to the reviewers for their suggestions, they were very helpful and improved this paper.

Author contributions

AER collect the information from Web of Science, coded and construct the models used. FO collect the information of gender and countries lost from the first collection. All authors revised literature about the topic, analyzed the data, read and approved the final manuscript.

Funding

Open access funding provided by Swiss Federal Institute of Technology Zurich. This work was supported by the Chilean National Agency of Research and Development (ANID) Fondecyt Program, grant number 1220560 and ANID PFCHA/

DOCTORADO BECAS CHILE/2018, grant number 72190281. Finally, this work received funding from the ANID Millennium Science Initiative Program (ICS2019_024).

Availability of data and materials

The datasets generated and/or analysed during the current study are not publicly available due some of it is not own by the authors to be share but are available from the corresponding author on reasonable request.

Declarations

Competing interests

The authors declare that they have no competing interests.

Received: 10 December 2021 Accepted: 31 May 2022

Published online: 15 June 2022

References

- Akbaritabar A, Barbato G (2021) An internationalised Europe and regionally focused Americas: a network analysis of higher education studies. *Eur J Educ* 56(2):219–234. <https://doi.org/10.1111/ejed.12446>
- Akbaritabar A, Traag VA, Caimo A, Squazzoni F (2020) Italian sociologists: a community of disconnected groups. *Scientometrics* 124:2361–2382. <https://doi.org/10.1007/s11192-020-03555-w>
- Amati V, Lomi A, Mira A (2018) Social network modeling. *Ann Rev Stat Appl* 5:343–369. <https://doi.org/10.1146/annurev-statistics-031017-100746>
- Athanasίου T, Patel V, Garas G, Ashrafian H, Hull L, Sevdalis N, Harding S, Darzi A, Paroutis S (2016) Mentoring perception, scientific collaboration and research performance: is there a 'gender gap' in academic medicine. An academic health science centre perspective. *Postgrad Med J* 92(1092):581–586. <https://doi.org/10.1136/postgradmedj-2016-134313>
- Barabási AL, Albert R (1999) Emergence of scaling in random networks. *Science* 286(5439):509–512. <https://doi.org/10.1126/science.286.5439.509>
- Batagelj V, Doreian P, Ferligoj A, Kežžar N (2014) Understanding large temporal networks and spatial networks: Exploration, pattern searching, visualization and network evolution. Wiley, Hoboken
- Block P, Stadtfeld C, Snijders TA (2019) Forms of dependence: comparing SAOMs and ERGMs from basic principles. *Sociol Methods Res* 48(1):202–239. <https://doi.org/10.1177/0049124116672680>
- Bonacich P (2004) The invasion of the physicists. *Social Networks* 26:285–288. <https://doi.org/10.1016/j.socnet.2004.06.002>
- Borgatti S, Halgin D (2011) Analyzing affiliation networks. In: Scott J, Carrington P (eds) *The sage handbook of social network analysis*. Sage Publications, New York, pp 417–433
- Bourdieu P (1975) The specificity of the scientific field and the social conditions of the progress of reason. *Soc Sci Inf* 14(6):19–47. <https://doi.org/10.1177/053901847501400602>
- Brandes U, Pich C (2011) Explorative visualization of citation patterns in social network research. *J Soc Struct* 12(8):1–19. <https://doi.org/10.21307/joss-2019-037>
- Brandes U, Robins G, McCranie A, Wasserman S (2013) What is network science? *Netw Sci* 1(1):1–15. <https://doi.org/10.1017/nws.2013.2>
- Breiger RL (1976) Career attributes and network structure: a blockmodel study of a biomedical research specialty. *Am Sociol Rev* 41(1):117–135. <https://doi.org/10.2307/2094376>
- Burt RS, Doreian P (1982) Testing a structural model of perception: conformity and deviance with respect to journal norms in elite sociological methodology. *Qual Quant* 16(2):109–150. <https://doi.org/10.1007/BF00166880>
- Butts CT (2008) 4. A relational event framework for social action. *Sociol Methodol* 38(1):155–200. <https://doi.org/10.1111/j.1467-9531.2008.00203.x>
- Cainelli G, Maggioni MA, Uberti TE, de Felice A (2015) The strength of strong ties: how co-authorship affect productivity of academic economists? *Scientometrics* 102(1):673–699. <https://doi.org/10.1007/s11192-014-1421-5>
- Chatterjee P, Werner R (2021) Gender disparity in citations in high-impact journal articles. *JAMA Netw Open* 4(7):1–8. <https://doi.org/10.1001/jamanetworkopen.2021.14509>
- Chubin DE (1976) State of the field the conceptualization of scientific specialties. *Sociol Q* 17(4):448–476. <https://doi.org/10.1111/j.1533-8525.1976.tb01715.x>
- Cimenler O, Reeves KA, Skvoretz J (2015) An evaluation of collaborative research in a college of engineering. *J Informet* 9(3):577–590. <https://doi.org/10.1016/j.joi.2015.05.003>
- Cole JR, Cole S (1973) *Social stratification in science*. University of Chicago Press, Chicago
- Collins HM (1974) The TEA set: Tacit knowledge and scientific networks. *Sci Stud* 4(2):165–185. <https://doi.org/10.1177/030631277400400203>
- Crane D (1972) *Invisible colleges: diffusion of knowledge in scientific communities*. University of Chicago Press, Chicago
- Dahlander L, McFarland DA (2013) Ties that last: tie formation and persistence in research collaborations over time. *Adm Sci Q* 58(1):69–110. <https://doi.org/10.1177/0001839212474272>
- de Solla Price DJ (1963) *Little science, big science*. Columbia University Press, Columbia
- de Solla Price DJ (1965) Networks of scientific papers. *Science* 149(3683):510–515. <https://doi.org/10.1126/science.149.3683.510>
- Dhand A, Luke DA, Carothers BJ, Evanoff BA (2016) Academic cross-pollination: the role of disciplinary affiliation in research collaboration. *PLoS ONE* 11(1):e0145916. <https://doi.org/10.1371/journal.pone.0145916>

- DiMaggio PJ, Powell WW (1983) The iron cage revisited: institutional isomorphism and collective rationality in organizational fields. *Am Sociol Rev* 48(2):147–160. <https://doi.org/10.2307/2095101>
- Duxbury SW (2021) The problem of scaling in exponential random graph models. *Sociol Methods Res*. <https://doi.org/10.1177/0049124120986178>
- Espinoza V (2005) Genealogía de los usos actuales del análisis de redes en Latinoamérica. In: Porras JI, Espinoza V (eds) *Redes. Enfoques y aplicaciones del análisis de redes sociales (ARS)*. Ediciones Universidad Bolivariana, Chile
- Fagan J, Eddens KS, Dolly J, Vanderford NL, Weiss H, Levens JS (2018) Assessing research collaboration through co-authorship network analysis. *J Res Adm* 49(1):76. <https://doi.org/10.1186/s12961-016-0104-5>
- Feld SL (1981) The focused organization of social ties. *Am J Sociol* 86(5):1015–1035. <https://doi.org/10.1086/227352>
- Feld SL (1982) Social structural determinants of similarity among associates. *Am Sociol Rev* 47(6):797–801. <https://doi.org/10.2307/2095216>
- Ferligoj A, Kronegger L, Mali F, Snijders TAB, Doreian P (2015) Scientific collaboration dynamics in a national scientific system. *Scientometrics* 104(3):985–1012. <https://doi.org/10.1007/s11192-015-1585-7>
- Freeman L (2004) *The development of social network analysis. A study in the sociology of science*. Empirical Press, New York
- Freeman L (2011) The development of social network analysis—with an emphasis on recent events. In: Scott J, Carrington PJ (eds) *The sage handbook of social network analysis*. SAGE Publications Ltd, New York, pp 26–39
- Freeman LC, Freeman SC (1980) A semi-visible college: structural effects on a social networks group. In: Henderson MM, MacNaughton MJ (eds) *Electronic communication: technology and impacts*. Westview Press Inc, Boulder, pp 77–85
- Gaete JM, Pino R (2014) De la investigación social a la técnica profesional: una crónica histórica del ARS en Chile (1995–2014). *Redes: Revista Hispana Para El Analisis De Redes Sociales* 25(1):94–113. <https://doi.org/10.5565/rev/redes.504>
- Gazni A, Sugimoto C, Didegagh F (2011) Mapping world scientific collaboration: authors, institutions, and countries. *J Am Soc Inform Sci Technol* 63(2):323–335. <https://doi.org/10.1002/asi.21688>
- Ghiassi G, Larivière V, Sugimoto C (2015) On the compliance of women engineers with a gendered scientific system. *PLoS ONE* 10(12):1–19. <https://doi.org/10.1371/journal.pone.0145931>
- Gläser J (2001) Scientific specialties as the (currently missing) link between scientometrics and the sociology of science. In: Davis M, Wilson CS (eds) *Conference on scientometrics and informetrics proceedings*. Bibliometric and Informetric Research Group, Sydney, pp 191–210
- Gondal N (2011) The local and global structure of knowledge production in an emergent research field: an exponential random graph analysis. *Soc Netw* 33(1):20–30. <https://doi.org/10.1016/j.socnet.2010.09.001>
- Gondal N (2018) Duality of departmental specializations and PhD exchange: a weberian analysis of status in interaction using multilevel exponential random graph models (mERGM). *Soc Netw* 55:202–212. <https://doi.org/10.1016/j.socnet.2018.07.005>
- Handcock MS (2003) Statistical models for social networks: inference and degeneracy. In: Breiger R, Carley K, Pattison P (eds) *Dynamic social network modeling and analysis: workshop summary and papers 1–2*. National Academies Press, Washington
- Huang J, Gates A, Sinatra R, Barabási AL (2020) Historical comparison of gender inequality in scientific careers across countries and disciplines. *Proc Natl Acad Sci: PNAS* 117(9):4609–4616. <https://doi.org/10.1073/pnas.1914221117>
- Hummon NP, Carley K (1993) Social networks as normal science. *Soc Netw* 15(1):71–106. [https://doi.org/10.1016/0378-8733\(93\)90022-D](https://doi.org/10.1016/0378-8733(93)90022-D)
- Hunter DR, Handcock MS (2006) Inference in curved exponential family models for networks. *J Comput Graph Stat* 15(3):565–583. <https://doi.org/10.1198/106186006X133069>
- Hunter DR, Goodreau SM, Handcock MS (2008) Goodness of fit of social network models. *J Am Stat Assoc* 103(481):248–258. <https://doi.org/10.1198/016214507000000446>
- Knox H, Savage M, Harvey P (2006) Social networks and the study of relations: networks as method, metaphor and form. *Econ Soc* 35(1):113–140. <https://doi.org/10.1080/03085140500465899>
- Koskinen J, Lomi A (2013) The local structure of globalization. *J Stat Phys* 151(3):523–548. <https://doi.org/10.1007/s10955-013-0732-x>
- Koskinen J, Caimo A, Lomi A (2015) Simultaneous modeling of initial conditions and time heterogeneity in dynamic networks: an application to foreign direct investments. *Netw Sci* 3(1):58–77. <https://doi.org/10.1017/nws.2015.3>
- Kronegger L, Mali F, Ferligoj A, Doreian P (2012) Collaboration structures in Slovenian scientific communities. *Scientometrics* 90(2):631–647. <https://doi.org/10.1007/s11192-011-0493-8>
- Larivière V, Ni C, Gingras Y, Sugimoto C (2013) Global gender disparities in science. *Nature* 504:211–213. <https://doi.org/10.1038/504211a>
- Lazarsfeld PF, Merton RK (1954) Friendship as a social process: a substantive and methodological analysis. In: Berger M, Abel T, Page CH (eds) *Freedom and control in modern society*. D. Van Nostrand Company, Princeton, pp 18–66
- Lazer D, Mergel I, Friedman A (2009) Co-citation of prominent social network articles in sociology journals: the evolving canon. *Connections* 29(1):43–64
- Levy MA (2016) gwdegree: Improving interpretation of geometrically-weighted degree estimates in exponential random graph models. *J Open Source Softw* 1(3):36. <https://doi.org/10.21105/joss.00036>
- Luke DA, Baumann AA, Carothers BJ, Landsverk J, Proctor EK (2016) Forging a link between mentoring and collaboration: a new training model for implementation science. *Implement Sci* 11(1):1–12. <https://doi.org/10.1186/s13012-016-0499-y>
- Lusher D, Koskinen J, Robins G (2012) *Exponential random graph models for social networks: theory, methods, and applications*. Cambridge University Press, Cambridge

- Ma Y, Oliveira D, Woodruff T, Uzzi B (2019) Women who win prizes get less money and prestige. *Nature* 565:287–288. <https://doi.org/10.1038/d41586-019-00091-3>
- Macaluso B, Larivière V, Sugimoto T, Sugimoto C (2016) Is science built on the shoulders of women? *Acad Med* 91(8):1136–1142. <https://doi.org/10.1097/ACM.0000000000001261>
- Maltseva D, Batagelj V (2019) Social network analysis as a field of invasions: bibliographic approach to study SNA development. *Scientometrics* 121(2):1085–1128. <https://doi.org/10.1007/s11192-019-03193-x>
- Maltseva D, Batagelj V (2021) Journals publishing social network analysis. *Scientometrics* 126(4):3593–3620. <https://doi.org/10.1007/s11192-021-03889-z>
- McLevey J, Graham AV, McIlroy-Young R, Browne P, Plaisance KS (2018) Interdisciplinarity and insularity in the diffusion of knowledge: an analysis of disciplinary boundaries between philosophy of science and the sciences. *Scientometrics* 117(1):331–349. <https://doi.org/10.1007/s11192-018-2866-8>
- McPherson M, Smith-Lovin L, Cook JM (2001) Birds of a feather: homophily in social networks. *Ann Rev Sociol* 27(1):415–444. <https://doi.org/10.1146/annurev.soc.27.1.415>
- Meho L (2021) The gender gap in highly prestigious international research awards 2001–2020. *Quant Sci Stud* 2(3):976–989. https://doi.org/10.1162/qss_a_00148
- Merton RK (1968) The Matthew effect in science: the reward and communication systems of science are considered. *Science* 159(3810):56–63. <https://doi.org/10.1126/science.159.3810.56>
- Merton RK (1988) The Matthew effect in science, II: cumulative advantage and the symbolism of intellectual property. *Isis* 79(4):606–623. <https://doi.org/10.1086/354848>
- Mitchell JC (1969) *Social networks in urban situations: analyses of personal relationships in Central African towns*. Manchester University Press, Manchester
- Molina JL (2007) The development of social network analysis in the Spanish-speaking world: a Spanish chronicle. *Soc Netw* 29:324–329. <https://doi.org/10.1016/j.socnet.2006.07.003>
- Mullins NC (1972) The development of a scientific specialty: The phage group and the origins of molecular biology. *Minerva* 10(1):51–82. <https://doi.org/10.1007/BF01881390>
- Mullins NC (1973) The development of specialties in social science: the case of ethnomethodology. *Sci Stud* 3(3):245–273. <https://doi.org/10.1177/030631277300300302>
- Mullins NC, Mullins CJ (1973) *Theories and theory groups in contemporary American sociology*. Harper and Row, New York
- Mullins NC, Hargens LL, Hecht PK, Kick EL (1977) The group structure of cocitation clusters: a comparative study. *Am Sociol Rev* 42(4):552–562. <https://doi.org/10.2307/2094554>
- Murray D, Silver K, Vincent L, Chan WM, Collings A, Raymond J, Sugimoto C (2019) Author-reviewer homophily in peer review. *PLoS Biol*. <https://doi.org/10.1101/400515v3.full>
- Newman ME (2001) Scientific collaboration networks. I. Network construction and fundamental results. *Phys Rev E* 64(1):016131. <https://doi.org/10.1103/PhysRevE.64.016131>
- Newman M (2018) *Networks*. Oxford University Press, Oxford
- Ortiz F, Contreras C, García A (2021) Social network analysis from the Ibero-American community in 2020. *Redes Revista Hispana Para El Análisis De Redes Sociales* 32(2):105. <https://doi.org/10.5565/rev/redes.929>
- Page MJ, McKenzie JE, Bossuyt PM, Boutron I, Hoffmann TC, Mulrow CD, Shamseer L et al (2021) The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. *Int J Surg* 88:105906. <https://doi.org/10.31222/osf.io/v7gm2>
- Palacio J, Vélez G (2014) Análisis de redes en Colombia: expansión e irrupción en el campo global. *Redes: Revista Hispana Para El Análisis De Redes Sociales* 25(1):68–84. <https://doi.org/10.5565/rev/redes.503>
- Peng TQ (2015) Assortative mixing, preferential attachment, and triadic closure: a longitudinal study of tie-generative mechanisms in journal citation networks. *J Informet* 9(2):250–262. <https://doi.org/10.1016/j.joi.2015.02.002>
- Purwitasari D, Faticah C, Sumpeno S, Steglich C, Purnomo MH (2020) Identifying collaboration dynamics of bipartite author-topic networks with the influences of interest changes. *Scientometrics* 122(3):1407–1443. <https://doi.org/10.1007/s11192-019-03342-2>
- Ramos-Vidal I, Contreras-Ibáñez C, García-Macías A (2014) México un eje central en el desarrollo de las redes hispanas. *Redes: Revista Hispana Para El Análisis De Redes Sociales* 25(1):49–67. <https://doi.org/10.5565/rev/redes.929>
- Rivera MT, Soderstrom SB, Uzzi B (2010) Dynamics of dyads in social networks: assortative, relational, and proximity mechanisms. *Ann Rev Sociol* 36:91–115. <https://doi.org/10.1146/annurev.soc.34.040507.134743>
- Robins G, Pattison P, Woolcock J (2005) Small and other worlds: global network structures from local processes. *Am J Sociol* 110(4):894–936. <https://doi.org/10.1086/427322>
- Santos BdS, Meneses MP (2014) Introducción. In: Meneses MP (ed) *Epistemologías del sur perspectivas*. Ediciones Akal, Madrid, pp 7–17
- Schweinberger M, Krivitsky PN, Butts CT, Stewart JR (2020) Exponential-family models of random graphs: inference in finite, super and infinite population scenarios. *Stat Sci* 35(4):627–662. <https://doi.org/10.1214/19-STS743>
- Sciabolazza LV, Vacca R, Kennelly Okraku T, McCarty C (2017) Detecting and analyzing research communities in longitudinal scientific networks. *PLoS ONE* 12(8):e0182516. <https://doi.org/10.1371/journal.pone.0182516>
- Scott J (2011) Social physics and social networks. In: Scott J, Carrington PJ (eds) *The sage handbook of social network analysis*. SAGE Publications, New York, pp 55–66
- Shafie T, Brandes U (2018) Will there be an invasion of data scientists? Paper presented at the SUNBELT XXXVIII: International Sunbelt Social Network Conference, 26 June–1 July. University of Utrecht, Utrecht
- Shrum W, Mullins N (1988) Network analysis in the study of science and technology. In: Moed HF, Glänzel (eds) *Handbook of quantitative studies of science and technology*. Elsevier, Amsterdam, pp 107–133
- Snijders TAB (2001) The statistical evaluation of social network dynamics. *Sociol Methodol* 31(1):361–395. <https://doi.org/10.1111/0081-1750.00099>
- Snijders TA, Steglich CE (2015) Representing micro–macro linkages by actor-based dynamic network models. *Sociol Methods Res* 44(2):222–271. <https://doi.org/10.1177/0049124113494573>

- Snijders TA, Pattison PE, Robins GL, Handcock MS (2006) New specifications for exponential random graph models. *Sociol Methodol* 36(1):99–153. <https://doi.org/10.1111/j.1467-9531.2006.00176.x>
- Stadtfeld C, Amati V (2021) Network mechanisms and network models. In: Manzo G (ed) *Research handbook on analytical sociology*. Edward Elgar Publishing, Cheltenham, pp 432–452. <https://doi.org/10.4337/9781789906851.00032>
- Stadtfeld C (2018) The micro-macro link in social networks. In: Scott RA, Kosslyn SM (eds) *Emerging trends in the social and behavioral sciences*. John Wiley and Sons Ltd, New York, pp 1–15
- Stadtfeld C, Block P (2017) Interactions, actors, and time: dynamic network actor models for relational events. *Sociol Sci* 4:318–352. <https://doi.org/10.15195/v4.a14>
- Sugimoto S, Ni C, Larivière V (2015) On the relationship between gender disparities in scholarly communication and country-level development indicators. *Sci Public Policy* 42(6):789–810. <https://doi.org/10.1093/scipol/scv007>
- Teves LS, Pasarin L (2014) ARS en Argentina: contrastes metodológicos y la aplicación a problemas sociales. *Redes: Revista Hispana Para El Analisis De Redes Sociales* 25(2):125–139. <https://doi.org/10.5565/rev/redes.516>
- Tricco AC, Lillie E, Zarin W, O'Brien KK, Colquhoun H, Levac D, Moher D, Peters MD, Horsley T, Weeks L, Hempel S et al (2018) PRISMA extension for scoping reviews (PRISMA-ScR): checklist and explanation. *Ann Intern Med* 169(7):467–473. <https://doi.org/10.7326/M18-0850>
- Varanda M, Rego R, Fontes B, Eichner K (2012) A análise de redes sociais no mundo lusófono: contributos para o conhecimento de uma comunidade científica. *Redes: Revista Hispana Para El Analisis De Redes Sociales* 22(7):147–188. <https://doi.org/10.5565/rev/redes.434>
- Vélez-Cuarta G, Suárez-Tamayo M, Jaramillo-Guevara L, Gutiérrez G (2021) Nuevo modelo de métricas responsables para medir el desempeño de revistas científicas en la construcción de comunidad: el caso de Redes. *Redes: Revista Hispana Para El Analisis De Redes Sociales* 32(2):110–152. <https://doi.org/10.5565/rev/redes.919>
- Venturini T, Munk AK, Jacomy M (2019) Actor-Network versus network analysis versus digital networks: are we talking about the same networks? In: Vertesi J, Ribes D (eds) *Digital STS*. Princeton University Press, Princeton, pp 510–524
- Wagner CS, Leydesdorff L (2005) Network structure, self-organization, and the growth of international collaboration in science. *Res Policy* 34(10):1608–1618. <https://doi.org/10.1016/j.respol.2005.08.002>
- Wang P, Sharpe K, Robins GL, Pattison PE (2009) Exponential random graph (p^*) models for affiliation networks. *Social Netw* 31(1):12–25. <https://doi.org/10.1016/j.socnet.2008.08.002>
- Wang P, Pattison P, Robins G (2013) Exponential random graph model specifications for bipartite networks—a dependence hierarchy. *Social Netw* 35(2):211–222. <https://doi.org/10.1016/j.socnet.2011.12.004>
- Wang B, Bu Y, Xu Y (2018) A quantitative exploration on reasons for citing articles from the perspective of cited authors. *Scientometrics* 116(2):675–687. <https://doi.org/10.1007/s11192-018-2787-6>
- Wasserman S, Faust K (1994) *Social network analysis: methods and applications*. Cambridge University Press, Cambridge
- White HC, Breiger RL (1975) Pattern across networks society. *Society* 12(5):68–74. <https://doi.org/10.1007/BF02699922>
- White HD, Griffith BC (1981) Author cocitation: a literature measure of intellectual structure. *J Am Soc Inf Sci* 32(3):163–171. <https://doi.org/10.1002/asi.4630320302>
- Wuchty S, Jones BF, Uzzi B (2007) The increasing dominance of teams in production of knowledge. *Science* 316(5827):1036–1039. <https://doi.org/10.1126/science.1136099>
- Zhu M, Huang Y, Contractor NS (2013) Motivations for self-assembling into project teams. *Social Netw* 35(2):251–264. <https://doi.org/10.1016/j.socnet.2013.03.001>
- Zinilli A (2016) Competitive project funding and dynamic complex networks: evidence from projects of national interest (PRIN). *Scientometrics* 108(2):633–652. <https://doi.org/10.1007/s11192-016-1976-4>
- Zuckerman H (1967) Nobel laureates in science: patterns of productivity, collaboration, and authorship. *Am Sociol Rev* 32(3):391–403. <https://doi.org/10.2307/2091086>
- Zuckerman H (1970) Stratification in American science. *Sociol Inq* 40:235–257. <https://doi.org/10.2307/1388725>

Publisher's Note

Springer Nature remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.

Submit your manuscript to a SpringerOpen[®] journal and benefit from:

- Convenient online submission
- Rigorous peer review
- Open access: articles freely available online
- High visibility within the field
- Retaining the copyright to your article

Submit your next manuscript at ► [springeropen.com](https://www.springeropen.com)