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## **Spanish Communication Academia: Scientific productivity vs. Social activity**

### **Abstract**

At a time when academic activity in the area of communication is principally assessed by the impact of scientific journals, the scientific media and the scientific productivity of researchers, the question arises as to whether social factors condition scientific activity as much as these objective elements. This investigation analyzes the influence of scientific productivity and social activity in the area of communication. We identify a social network of researchers from a compilation of doctoral theses in communication and calculate the scientific production of 180 of the most active researchers who sit on doctoral committees. Social network analysis is then used to study the relations that are formed on these doctoral thesis committees. The results suggest that social factors, rather than individual scientific productivity, positively influence such a key academic and scientific activity as the award of doctoral degrees. Our conclusions point to a disconnection between scientific productivity and the international scope of researchers and their role in the social network. Nevertheless, the consequences of this situation are tempered by the non-hierarchical structure of relations between communication scientists.

### **Keywords**

Social networks, bibliometrics, thesis, invisible colleges, communication research, university.

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## 1. Introduction

The development and the future of scientific activity have generally been treated as endogenous aspects linked to the evolution of research, significant scientific discoveries and the process of transferring scientific knowledge and know-how, etc., generating unstoppable, gradual and, in some cases, exponential progress. However, for many decades, a strong social element has clearly been identified in scientific activity that can determine its creation, diffusion and demarcation to an extraordinary extent (Kuhn, 1962; Merton, 1973). Scientific activity may be the origin and/or the result of social structures, giving rise to specific disciplines, such as the sociology of science (Ben-David & Sullivan, 1975; Lamo-de-Espinosa & al., 1994).

Special attention is given to the social structures that underlie scientific activity, because of the relative youth of social sciences and the habitual coexistence of possible paradigms and currents of thought that may be reflected upon simultaneously, which may at times assume opposing and antagonistic positions (Rodríguez, 1993). Many scientific communities, to a greater or lesser extent, have geographical boundaries that depend on their scope of knowledge, while academic traditions, linguistic environments and the physical structures of scientific activity more often than not generate its national geographical environment. It is therefore of interest to know the particularities of the scientific communities in each country or region.

In this context, it appears pertinent to look into the social aspects of the Spanish scientific community linked to the field of communication. University studies in this field are recent (the first faculty was founded in 1971) and arise out of the framework of the so-called «Napoleonic» university model, centred on professional training. At present, a transition to the Humboldtian model is underway, the main aim of which is the generation and transference of scientific knowledge (Ginés, 2004: 14). This change is leading to a slow increase in the specific weight attached to research in the promotion of university teaching staff. At the same time, communication represents fertile territory, as in other social disciplines with high levels of interdisciplinary studies, in which social aspects are given a prominent place in scientific activity. Less than 50% of Spanish contributions to communication journals listed on the Social Science Citation Index (SSCI) are from faculties and departments of communication (Masip, 2011: 7). In addition, it appears especially relevant to link social activity in this field to aspects that are related to scientific communication, as the current trend is to assess scientists and academics in their discipline in accordance with their publications and the impact factors of the journals in which they publish (Soriano, 2008; Perveval & Fornieles, 2008; Fernández-Quijada, 2010; Masip, 2011; Castillo & Ruiz, 2011). Studies on Spanish Communication Academia have concentrated on the most relevant journals, on their role in the furtherance of knowledge and on detecting the structure of the field through bibliometric studies (Castillo & Carretón, 2010; López-Ornelas, 2010; Martínez & Saperas, 2011; Castillo, Rubio & Almansa, 2012). However, it would be worth asking whether the weight of such apparently objective measures of scientific prominence (publications and citations) is the cri-

terion shaping the structure of Spanish communication academia and whether the baseline of social relations between scientists plays a defining role in their scientific activity.

This work has the objective of determining whether the demonstrated relevance of a researcher in the field of communication, measured in terms of scientific productivity, and the researcher's social position, measured in terms of membership of the active core of academia, have an influence on important decisions for academic and scientific activity. In response to that question, we will study how both scientific productivity and social activity influence a key academic decision in the scientific community: the choice of committee members that evaluate doctoral theses in the field of knowledge. Social network analysis was selected as a referential framework in which to conduct an acceptable analysis of social ties between scientists arising from the academic act of the reading of a doctoral thesis (Scott, 1991).

## **2. The academic and scientific community in the field of communication**

The analysis of social factors in scientific production has a long tradition and has generated a particular field of knowledge: the sociology of science (Merton, 1973). The influence of social structures on scientific production may be conceptualised as invisible colleges. De Solla Price (1963) pointed to the existence of groups of scientists that were basically constituted by a contact and by informal communication that generated a stable social structure (highlighting the role of the elite within it). Where De Solla Price highlighted the role of informal communication as the basis of the social structure, Crane (1969; 1972) stressed the possibility of belonging to the group (invisible college) through indirect contacts between scientists between whom multiple simultaneous relations are established (co-authorships, citations, exchange of drafts, joint presence at events and in organizations, management of doctoral theses, etc.). Crane (1969; 1972) used an incipient network analysis to highlight the appearance of emergent social structures in the scientific field in the form of invisible colleges or social circles. To do so, she used various relations between scientists and pointed out that the set of relations comprised a social circle in an informal way (an informal social structure with fuzzy limits).

Zuccala (2006) proposed the concept of the invisible college as the organizational structure of a set of social actors (researchers) who exchange formal and informal information on the framework of the rules in a discipline and certain research problems. She used social network analysis and the analysis of co-citations to identify these invisible colleges in a particular field. Moody (2004) used the relation of co-authorship to describe the collaborative networks in social science and constructed various models to test how collaboration affects scientific practice (appearance of small relatively isolated groups, exchanges between groups with different interests, and networks dominated by star scientists). The first two possibilities were also explored by Crane (1969). In the field of communication, invisible colleges and their definition have also been explored through bibliometric studies (Chang & Tai, 2005; Tai, 2009).

The Spanish communication academia may be studied in terms of an invisible college that generates a tie of membership between its members and that will generate a series of formal and informal contacts between them at various scientific gatherings (congresses, workshops, academic proceedings and professional events, etc.), transference of information and knowledge between them and both direct and indirect informal communication.

Various researchers have brought up the existence of these networks in communication. The majority used the analysis of co-authorships in articles published in scientific journals from the discipline (López-Ornelas, 2010; Masip, 2011). Fernández-Quijada (2011) established a network of collaborations between professors belonging to the different Spanish universities based on a bibliometric study of co-authorships in Spanish communication journals with the highest impact. This author suggests the need for more in-depth studies for an understanding of how these networks are formed and how they function.

Martínez Nicolás (2006) studied the quality of research in the area of journalism and related it to the structure of the scientific community. This structure responds to the “vicissitudes of its historic constitution and development”. Empirical studies focusing on the groups that have been identified would be of interest. The pioneering bibliometric studies of Daniel E. Jones and others (2000) should be highlighted, in relation to the study of doctoral theses on communication, which have contributed an important body of knowledge that has served as the basis for subsequent investigations.

Repiso, Torres, and Delgado analysed social networks in communication on the basis of the members of the doctoral thesis committees. They structured the research system into different specialities such as television (Repiso & al., 2011a), radio (Repiso & al., 2011b) and cinema (Repiso & al. 2011c), in Spain, around the main university chairs in those disciplines.

The reading of a doctoral thesis represents an important part of scientific activity within the Spanish communication academia, because of the characteristics of its contribution and because of the fact that it implies a validation of the research capabilities of the doctoral students. It is therefore very important that each thesis should be evaluated by qualified researchers. Its defence is conducted before a panel made up of various doctors in the field and from other related disciplines. The director of the doctoral thesis and the departmental members intervene in a decisive way in the choice of the committee members through informal processes, which are therefore based on considerations that go beyond the purely scientific. These choices should be based on criteria that should be objective, arising from the research capabilities of the members that sit on the doctoral committees. The scientific productivity of academics is a measure of the success of their scientific activity, marking the road towards professional progress (Alcántara, 2000; Joy, 2009). Therefore, the professional development of researchers and, consequently, their selection by the academic community to conduct research-related activities will be conditioned by what they are objectively able to contribute. Thus,

- Hypothesis 1: The selection of doctoral committee members in the field of communication will be positively influenced by their scientific productivity, measured by their publications and the number of citations received.

Furthermore, a complementary hypothesis may be developed that links social factors to relevant decisions of scientific activity in communication. It appears logical to think that social structures that take shape in the network of researchers and academics in an area of knowledge might determine or condition the evaluation of a first rate piece of research and the accreditation within the scientific community of the investigative worth of the doctorand. The idea of the aforementioned social circles or invisible colleges (Crane, 1972) and the network structure in the academic relations between researchers (Molina, Muñoz & Doménech, 2002) help explain a possible association between personal and professional knowledge transfer between communication researchers and academics and the choices that they make, so that other actors evaluate the theses that they have directed. In an empirical way and using social network analysis, Sierra (2003) demonstrated, on the basis of the composition of CSIC thesis committees, that the choice of committee members did not follow random criteria, but that there is a social grounding for those decisions. Likewise, Casanueva and Larrinaga (2013) presented evidence that social factors and, in particular, the previous contact between other members of the network significantly influenced the choice of doctoral committee members and their chairpersons in the discipline of accounting and finance. The following hypothesis may therefore be formulated:

- Hypothesis 2: the selection of doctoral committee members in the field of communication will be positively influenced by the social activity of the members of the academia.

### **3. Methods**

#### **3.1. The network in the field of communication based on doctoral committees**

The network constituted by researchers and academics from the field of communication who have participated in doctoral committees from 2000 up until 2012 is selected as the area of study, in order to test the two hypotheses on the influence of scientific productivity and social activity in scientific decisions. The Teseo database was used to demarcate the area of study, which provides different information on doctoral theses read in Spain. This database is still the most complete resource available and an essential reference for the consultation of doctoral theses in Spanish universities (Sorli & Merlo, 2002: 203), even though it presents a series of drawbacks such as lack of standardization, incompleteness, duplication of entries and omissions (Repiso & al., 2011: 419). The definition of the theses within the area is complicated, insofar as there are no suitable descriptors that mark out clear frontiers, without overlaps in the area of communication. Therefore, our strategy involved the identification of all theses produced in departments of audiovisual communication, marketing and journalism from all Spanish universities. In total, 1298 doctoral theses read in the period under consideration were analysed. Almost 2500 different doctors had a role in those theses as directors and members of the doctoral committees, as researchers in the same or in other similar disciplines in Spain or as foreign doctors. Many of these actors had

no relevant role in the network. A relational criterion was therefore chosen, in line with Laumann and others (1989), when defining the network, in order to conduct a more suitable empirical analysis that would respond to the purpose of this investigation, in such a way that only those doctors who sat on eight committees or more were analysed. This meant a more manageable and sufficiently broad network in terms of its analysis that would limit itself to the 180 most active doctors on the doctoral committees.

Data obtained on these 180 researchers in the field of communication refer to their affiliations and to their scientific productivity. The number of publications and the number of citations from those same publications were used for the calculation of scientific production. The information contained in the most standardized international databases (SSCI and Scopus) produced no search results that clearly differentiated between the 180 members chosen from the network in terms of their scientific production. For example, only 27.22% of them had one or more publications in SSCI. This finding is consistent with earlier studies that described the limited internationalization of publications from communication academics in Spain (Masip, 2011). So, we referred to Google Scholar to obtain the most important data on the scientific production of the 180 actors. Harzing's Publish or Perish (version 2.8.3.4792), available as an on-line programme, was used to systematise the search. Data referring to articles in journals, books, and chapters of books were all considered. Manual inspection the data gathered in this way and its registration was done, as this tool is not very discriminatory with regard to names and document types.

### **3.2. Analysis of social networks**

The study of the influence of social relations in academic decisions, and more specifically in the selection processes for the committees that will evaluate doctoral theses should pay specific attention to the social relations that they engender and the social structure that arises from them. An acceptable analysis of social structures should be based on specific data, not on the characteristics, but on the social ties of the individual. Social network analysis is used for this purpose (Wellman & Berkowitz, 1988).

Unlike quantitative methods of investigation in social sciences, based on the analysis of the attributes of sample elements (Wasserman & Faust, 1994), social network analysis centres its attention on the identification of the ties that are generated between a series of nodes or actors that constitute the network. Social network analysis attempts to reveal the overall structure of the ties between actors, identifying the existence of general relational patterns that result from the abstraction of individual choices or from the links between the nodes.

A network may be defined in a simple way as a set of interrelated nodes. So, the starting point of network analysis is the study of these two basic units: the nodes that represent the actors or elements of the network and the ties between those nodes. Since its recent origin, social network analysis has been applied to the study of scientific activity (Crane, 1972). It has undergone notable development

over recent years with the availability of massive bibliographies on co-authorships in scientific publications (Moody, 2004; Newman, 2001).

### 3.3. Variables

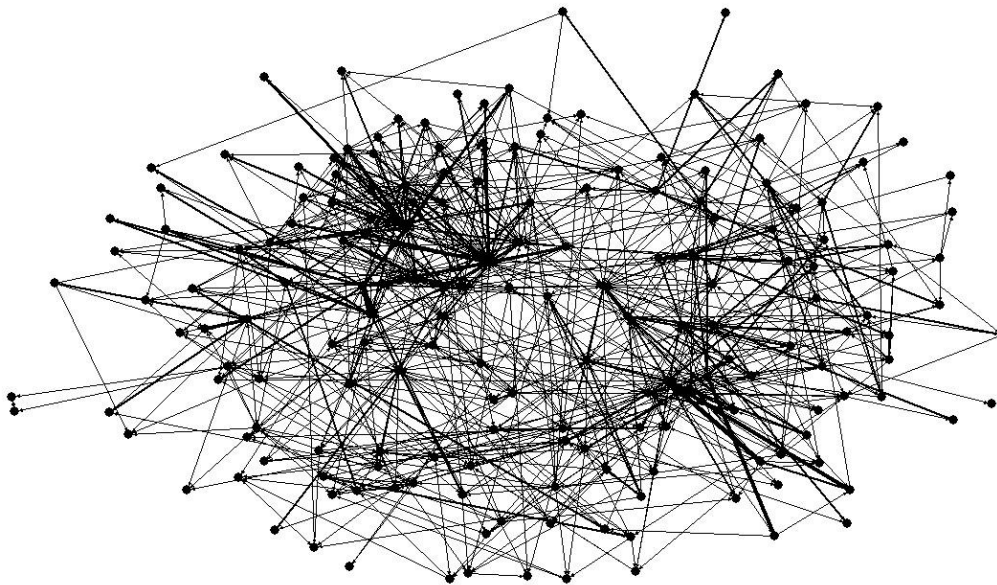
Different regression models were prepared to test the hypothesis, the variables of which are explained below:

- **Dependent Variable.** As an outcome variable, the dependent variable used the sum of the times that each of the 180 doctors who represent the sample of the most active doctors was chosen to participate in a doctoral committee. As mentioned earlier, the minimum value of this variable was set at 8.
- **Independent Variables.** Four basic indicators of scientific productivity were used for their measurement. In the first place, 'Publications' measured the breadth of scientific production throughout the professional career of each network member. These included books, book chapters, and publications in scientific journals that have been cited at least once. They are taken in aggregate, without differentiating between document types. In second place, the variable 'Citations' corresponds to the number of citations of each author received by the aforementioned publications. The third variable seeks an overall measurement of publication capacity and of the impact of the published documents measured by the number of citations they have received: 'the h-Index'. An author will have an h-index of 10, if 10 of the author's articles have received at least 10 citations. The fourth variable, 'International', takes a value of 1 if the member of the network has published in an SSCI journal, which was taken as a reference to indicate the international scope of an author, and a value of 0 if otherwise. The preparation of the indicator of social activity was more complex. In the first place, a new network was constructed, in which the link under consideration was the joint presence of academics at the reading of a doctoral thesis. In other words, each thesis brings together committee members, directors, and co-directors of the thesis at a single academic act (from which other social events often arise). This mutual contact means that the members of the network get to know each other (or their familiarity is deepened). The social network programme UCINET (Borgatti, Everett & Freeman, 2002) was used to construct the indicator, which divides the network into two groups by means of a process of iteration. The first of these is made up of the core of the network and second by its periphery. The variable 'Core' is determined by the doctor forming part of that network core with a joint presence on doctoral committees in the field of communication.

**Control Variables.** Two control variables were used. The 'Chair' variable seeks to reflect the value of occupying the most senior posts in the academic hierarchy as a predictor of academic elections, as highlighted in earlier studies in the context of Spain (Casanueva & Larrinaga, 2013) and in the context of Germany (Muller-Camen & Salzgeber, 2005). A dichotomic variable was constructed with a value of 1 for academics that occupy a university chair. The second control variable 'Journal Editorial Board' measures whether a member of the network forms part

of the managerial, scientific and/or editorial boards of the nine journals (Revista Latina, Comunicación y Sociedad, Comunicar, Estudio del Mensaje Periodístico, Zer, Trípodos, Ámbitos, Análisi y Telos) in the first quartile of the In-Recs index for 2011.

#### 4. Results



Graph 1. Graph of the network of 180 researchers.

Graph 1 shows the network of the 180 most active doctoral committee members. Even though the existence of very dense zones may be appreciated in the graph of the network, it is better to study the indicators that arise from the analysis of social networks, as graphic representations offer a very limited scope for analysis. Table 1 presents the most relevant indicators of the complete network of the selection of the doctoral committee members in the field of communication together with those same indicators referring to the network that comprises the 180 doctors selected for the empirical analysis. Data on academic networks from another two areas of the social sciences are shown, to facilitate a comparative analysis of the data on network structure: marketing (Casanueva & Espasandín, 2004) and accounting and finance (Casanueva, Escobar & Larrinaga, 2007).

| <b>Table 1. Characteristics of the doctoral committee member selection networks</b> |                  |                |                        |           |
|---|------------------|----------------|------------------------|-----------|
|   | Complete Network | Network of 180 | Accounting and Finance | Marketing |
| Nodes   | 2496             | 180            | 255                    | 84        |
| Density   | 0.001            | 0.0498         | 0.0250                 | 0.0267    |
| Indegree  | 2.46%            | 12.67%         | 11.94%                 | 14.37%    |
| Outdegree   | 6.91%            | 15.48%         | 15.50%                 | 22.90%    |
| Betweenness   | 2.69%            | 12.8%          | 7.21%                  | 12.25%    |



The first row of Table 1 shows the size of the network, which serves as a good reference in order to analyse its structure, as many indicators of the network structure will depend on it. The size of the network of all the doctors participating in the doctoral committees under consideration is 2496, while the ties between the 180 most active members were carefully analysed, as opposed to the 255 for accounting and the 84 for marketing.

The density is shown in the second row of Table 1. Density refers to the number of real ties in the network in comparison with all the possible ties between its members. The low density of the complete communication network, with only 0.1% of possible links, is principally because of the large number of nodes that make up that network in relation to the number of people that can intervene in each event (reading of a thesis). The density in the second network increases by a factor of 50, almost reaching 5%. This relational level is already moderately high and shows that the 180 actors in the network show significant cohesion between each other and that they have had the opportunity of sharing tasks with many other members of the doctoral committees. In fact, the density is twice that of the two previously mentioned areas of knowledge, such that selection in the field of communication is considerably more interconnected than in other areas of the social sciences in Spain.

Indegree centralization indicates how the network is concentrated around certain points, but the level for ties relating to selection is very low in the complete network (2.46%) and is not considerable (12.67%) in the case of the 180 most active members. It leads one to think that the network is not very centralized and, therefore, not very hierarchical. This is very important, as it suggests that the academic act of reading a thesis is quite open to the participation of many actors and is not focused on a social structure with a dominant central core.

Conversely, outdegree centralization is an indicator of the level at which the thesis management process is focused on a few doctors. The values are low for both the overall network (almost 7%) and the 180 members (15.48%), such that once again the activity of managing a thesis is on the whole not linked to a central group. Similar values are found in the two other areas under analysis.

Betweenness centralization presents low values in the four networks presented in Table 1, such that only with difficulty can doctors exploit their position as intermediaries or brokers (in general terms) to connect more distant or separate parts of the network and to gain advantage from that position. This situation is an indicator that the network is well connected and that anyone can access another node in the network along different paths. Once again, it suggests that this structure is far removed from a hierarchical one.

Table 2 shows the mean and the standard deviation of the previously explained variables. The most striking point is that average scientific productivity of the 180 most active members of the doctoral committees in the field of communication is quite high, close to 20 publications with at least one citation on average, the same as the impact of the journal, as the average number of citations that they have is 186. This last point should be qualified, as the dispersion is very high. These data may be explained because there are certain members of the network

with numerous citations, basically because their works are standard references in their field. The fact that approximately half of the network members are university chairs and that a third participates or have participated in the management of the most relevant scientific journals in the field is also noteworthy.

**Table 2. Descriptive statistics and correlations (Pearson) between variables**

|                        | Mean   | Std. Dev. | Medium | Selection | University Chair | Editorial board | Publication | Citations | h-Index | Intr'l |
|------------------------|--------|-----------|--------|-----------|------------------|-----------------|-------------|-----------|---------|--------|
| <b>Selection</b>       | 14.86  | 8.994     | 12     |           |                  |                 |             |           |         |        |
| <b>Chair</b>           | 0.48   | 0.501     | 0      | 0.304**   |                  |                 |             |           |         |        |
| <b>Editorial Board</b> | 0.35   | 0.480     | 0      | 0.206**   | 0.211**          |                 |             |           |         |        |
| <b>Publications</b>    | 19.84  | 24.014    | 12     | 0.077     | 0.266**          | 0.214***        |             |           |         |        |
| <b>Citations</b>       | 186.27 | 359.578   | 66     | 0.052     | 0.248**          | 0.118           | 0.883**     |           |         |        |
| <b>h-Index</b>         | 4.79   | 3.409     | 4      | 0.104     | 0.348**          | 0.237**         | 0.891**     | 0.846**   |         |        |
| <b>International</b>   | 0.27   | 0.446     | 0      | 0.085     | -0.017           | 0.432**         | 0.153       | 0.067     | 0.170*  |        |
| <b>Core</b>            | 0.76   | 0.431     | 1      | 0.400**   | 0.240**          | 0.260***        | 0.160**     | 0.167**   | 0.189** | 0.057  |

\*\* . The correlation is significant at a level of 0.01 / \* . The correlation is significant at a level of 0.05

A joint regression analysis with the variable 'Selection' as the dependent variable was used to compare the hypotheses presented in the conceptual framework. Table 3 presents three regression models. The standardized coefficients of the variables and their level of meaning appears in the same table. Model 1 is the control model. It includes the control variables University Chair and Editorial Board. The model is significant and the percentage variance explained is considerable ( $R^2=0.114$ ). The results show a positive and significant relation (although at a different level) of the dependent variable with the control variables.

Model 2 is intended to test Hypothesis 1. The four variables that measure scientific productivity now intervene as independent variables. The model is significant and presents a  $R^2=0.116$ . Almost no increase in the explained variance was observed as a result of the inclusion of the new variables in the model. Once again, a positive and significant relation was shown in Model 2 between the condition of university chair and the dependent variable, whereas the relations with the four independent variables that measure scientific productivity (Publications, Citations, h-Index and Internationalization) are not significant. No support is therefore forthcoming for Hypothesis 1.

Model 3 serves to test Hypothesis 2, including the variable 'Core' in the model. The first thing that may be seen is the important increase of  $R^2$  that rises to a value of 0.218. The independent variable 'Core' shows a positive and significant relation (with a high degree of meaning) with the dependent variable. Hypothesis 2, which states that the selection of doctoral committee members in the field of communication is positively associated with the social activity of the academics, is therefore confirmed.

Table 3. Regressions between variables

|                  | Model 1  | Model 2  | Model 3  |
|------------------|----------|----------|----------|
| Editorial Board  | 0.149*   | 0.136    | 0.055    |
| University Chair | 0.271*** | 0.287*** | 0.232**  |
| Publications     |          | 0.000    | 0.035    |
| Citations        |          | -0.029   | -0.081   |
| h-Index          |          | -0.009   | -0.025   |
| International    |          | 0.034    | 0.050    |
| Core             |          |          | 0.340*** |
| R <sup>2</sup>   | 0,114    | 0.116    | 0.218    |

\*\*\* p>0.001; \*\* p>0.01; \* p>0.05

## 5. Conclusions and discussion

This research has proposed two, in principle, complementary hypotheses, on the way in which decisions are taken that affect research within Spanish academia in the field of communication. The first of these links the selection of members of academia with those who have a more productive scientific activity either in terms of publications (and its type) or in terms of the impact (measured by the number of citations or by the h-index) of those publications. The second hypothesis links these decisions to the social activity of the scientists following the assumptions of the sociology of science and the logic of invisible colleges (Crane, 1972; De-Solla-Price, 1963; Kuhn, 1962; Merton, 1973). The results offer no support for the first and uphold the second of these hypotheses.

These findings have three important implications. The first is that social factors play a prominent role in scientific activity and can condition it, as confirmed in earlier studies in other knowledge areas of the social sciences (Casanueva & Espasandín, 2004; Casanueva & Larrinaga, 2013). Scientific productivity (and its underlying indicators, which have a day-to-day effect on the activities of researchers and academics in the field of communication, such as publications, citations or the impact factor of the journals in which they publish) as an objective measure of good scientific practice does not occupy the most relevant place among the selection criteria in important scientific activities, such as those analysed here. This raises problems of incentives for the most active researchers who may encounter limitations to their possibilities of progressing towards a position in the social elite. It also erodes the dominant discourse on the immediate relation between scientific productivity and academic and investigative development. The third implication is that it leaves each of the two earlier positions as a sort of alternative model in which, on the one hand, the social and the subjective predominates and, on the other, the scientific and the objective. In this interplay, the social component appears as a momentary victor.

It may be asked whether a model in which the social aspect predominates over the scientific aspect is unfair and even perverse. The consideration of social structures arising from the network of the academia of communication in Spain has provided a partial response to this question. A problem would arise if the situation were one in which the social aspect was fundamental and in which the

social structure was dominated by a more-or-less closed elite or core that could control the processes as they were happening. Our earlier analyses of the characteristics of the networks in the area would suggest that we can discard that scenario. The different centrality measures were found to be very low, so the concentration of selection in one part of the network may, it appears, be discounted. An additional analysis was completed to confirm this idea. The correlation between the matrix of choices of doctoral committee members with its transposed matrix were tested to validate the degree of symmetry in the choices. The correlation level is over 0.400 and significant, such that we have relations that are basically symmetric where the roles of those selecting and those selected interchange, which discards the idea of a hierarchical structure in the network of communication academics. Although it could also reflect zones in the network in which reciprocal choices occur and in which rather more closed social sub-groups are forming.

This work presents a series of limitations. The first is the impossibility of generalization from the network of the 180 most active doctors to the complete network, as the latter was not randomly chosen. The second is related to the degree of adjustment between indicators and the phenomenon to be measured. Particularly, the use of the core as a reference for social activity, based on how many people know each other, will be a possible approximation to a more complex phenomenon. Neither has the time factor been taken into account that might add some bias to the analyses. An interesting line of future research would perhaps be a longitudinal analysis of the variables to analyse their evolution and the institutional aspects and context that might influence them. The most promising line of work, however, would be to look more deeply into the question of whether a real and a single invisible college exists in communication and to look more closely at the connections between the invisible college in communication and other elements of scientific activity such as the means of scientific communication (basically journals and their impact) or other social and conceptual networks (the existence of which may be deduced from co-citations, co-authorships and citations). The results leave open other questions, such as whether the most scientifically productive thesis directors also choose doctoral committee members using social criteria and whether social activity conditions the type and the quantity of scientific production.

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