A novel approach based on journal coupling to determine authors who are most likely to be part of the same invisible college

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ABSTRACT

Purpose: In this paper, we use author clustering based on journal coupling (i.e., shared academic journals) to determine researchers who have the same scientific interests and similar conceptual frameworks. The basic assumption is that authors who publish in the same academic journals are more likely to share similar conceptual frameworks and interests than those who never publish in the same venues. Therefore, they are more likely to be part of the same invisible college (i.e., authors in this subgroup contribute materially to research on the same topic and often publish their work in similar publication venues).

Design/methodology/approach: Test in a controlled exercise the grouping of authors based on journal coupling to determine invisible colleges in a research field using a case study of 302 authors who had published in the Information Science and Library Science (IS&LS) category of the Web of Science Core Collection. For each author, we retrieved all the scientific journals in which this author had published his/her articles. We then used the cosine measure to calculate the similarity between authors (both first and second order).

Findings: In this paper, using journal coupling of IS&LS authors, we found four main invisible colleges: “Information Systems”, “Business and Information Management”, “Quantitative Information Science” and “Library Science.” The main journals that determine the existence of these invisible colleges were Inform

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Syst Res, Inform Syst J, J Bus Res, J Knowl Manage, J Informetr, Pro Int Conf Sci Inf, Int J Geogr Inf Sci, J Am Med Inform Assn, and Learn Publ. However, the main journals that demonstrate that IS&LS determine a field were J Am Soc Inf Sci Tec/J Assoc Inf Sci Tech, Scientometrics, Inform Process Manag, and J Inf Sci.

Research limitations: The results shown in this article are from a controlled exercise. The analysis performed using journal coupling excludes books, book chapters, and conference papers. In this article, only academic journals were used for the representation of research results.

Practical implications: Our results may be of interest to IS&LS scholars. This is because these results provide a new lens for grouping authors, making use of the authors' journal publication profile and journal coupling. Furthermore, extending our approach to the study of the structure of other disciplines would possibly be of interest to historians of science as well as scientometricians.

Originality/value: This is a novel approach based on journal coupling to determine authors who are most likely to be part of the same invisible college.

Keywords: Authors; Journal Coupling; Clustering; Invisible College; IS&LS Category; Web of Science Core Collection.

1 Introduction

Borgman and Furner (2002) highlighted the importance of choosing the publication venue for scholars, "matching the topic of the paper with the scope statement of the journal and the topicality of previous articles published." However, authors and their publications determine the creation of intellectual knowledge and social identity of those same journals where they publish their work. This is because by publishing in a certain journal, scholars become active participants in the group of authors associated with the journal. It is then that their academic identity is added to that of the other authors who have also published there, contributing to the thematic configuration of that publication venue. In the literature there are several definitions of the academic identity of an author. For example, White (2001) defined an author's citation identity as the set of authors that an author cites. Assuming an author has been cited at all, White and McCain (1998) also defined an author's citation image as the set of all authors with whom an author has been co-cited.

In this scenario, the grouping of authors according to the shared academic journals can provide evidence for the existence of social and intellectual communities of scholars. Price and Beaver (1966) introduced the concept of "invisible college", highlighting the importance of the social grouping of scholars. The basic phenomenon behind invisible colleges is that in the most active and competitive research fields there seems to exist an "in-group" of academics. Authors in this subgroup contribute materially to research on the same topic and often publish their work in similar publication venues. As suggested in (Price & Beaver, 1966), the problem is that although it is relatively easy to find a well-known scholar in a chosen field of research, it is considerably more difficult to select a group of authors who make up the majority of a single invisible college. The basic difficulty is capturing and dissecting that group of scholars within a specific field of research or discipline (Price & Beaver, 1966).

In this paper, following these ideas, we propose a clustering of authors according to their journal publication profile. Using this approach, the similarity between authors is computed based on the shared academic journals. Therefore, the basic assumption will be that authors who published in the same journals are more likely to share similar conceptual frameworks and interests (and therefore, they are more likely to be part of the same invisible college) than those who never publish in the same journals (Garcia et al., 2012; Ni et al., 2013; Price & Beaver, 1966). Thus, in our study, the mention of the name of a journal evokes all the articles that have been published by that journal and consequently represents a "conceptual marker," (Ni et al., 2013). Our model is based on this idea: if the journal in which scholars published their work represents a conceptual marker, it follows that authors can be identified by the journals in which they publish their research (Garcia et al., 2012; Ni et al., 2013). In this way authors belonging to a research area can differentiate themselves by identifying an underlying group of journals. The authors will thus be grouped both socially and intellectually, the latter being the norm in citation studies.

In disciplines with high degrees of single authorship, hyper-authorship behavior does not determine a good descriptor of the interaction structure between the authors of the discipline. Therefore, in this scenario, collaborative networks based on hyper-authorship behavior are not appropriate. Alternatively, our approach identifies similarities between authors based on similarities in their journal publication profiles, and consequently, it does not matter whether or not authors interact with their community through co-authorship. Therefore, we follow (Minguillo, 2010)'s fundamental premises that "journals act as platforms of interaction and membership for scientific fields." He stated that "analysis of the relation between authors and journals makes it possible to see how communication among scientists overall forms the structure of highly specialized and well-controlled scientific (sub)fields influenced by the reputational system and cognitive limitations."

Using this premise, our research will investigate the degree to which authors (who published in information science and library science journals) are related to each other, based on their journal publication profile (i.e., their research output). Therefore, the grouping of authors using journal coupling (i.e., the shared academic journals) provides a new approach to examine the social and intellectual coherence of the considered set of authors.

In this study, after presenting our approach, we find the clusters of authors (or invisible colleges) in the information science and library science (IS&LS) category of the Web of Science Core Collection. Therefore, our results may be of interest to IS&LS scholars. This is because these results provide a new lens for grouping authors, making use of the authors' journal publication profile and journal coupling. Furthermore, extending our approach to the study of the structure of other disciplines would possibly be of interest to historians of science as well as scientometricians.

2 Related works

To demonstrate the structure of scientific domains, several methods based on co-occurrence and coupling have been proposed. On the one hand, co-citation, co-wording, and co-authorship methods, are based on the co-occurrence of elements (Qiu et at., 2014; Small, 1973; Tijssen & Van Raan, 1994; White & McCain, 1998). For example, co-citation establishes a co-occurrence relationship between cited references. On the other hand, Kessler (1963) proposed the concept that "two documents are related if they share the same set of citations." Bibliographic coupling is based precisely on this concept and, thus, researchers want to observe how many common references two articles share. Later Small and Koenig (1977) also proposed using bibliographic coupling of journals. In our study, the similarity of authors is based on this type of coupling assumption. We then claim that two authors are related if they share similar publication venues. This is journal coupling of authors. We used journals to discover relationships among authors. In journal coupling of authors, the number of shared publication venues among authors can be used to measure their relationships.

In relation to research works that connect authors through journals, Garcia et al. (2012) presented a novel methodology to map academic institutions based on their journal publication profiles. Using a sample of Spanish universities as a case study, Garcia et al., (2012) mapped the study sample according to the overall research output of each institution and in different disciplinary contexts. Furthermore, Robinson-Garcia et al., (2013) presented a descriptive analysis of Spanish universities according to their journal publication profile in five scientific domains during the period 2007-2011. In their study, two universities had a similar journal publication profile if they published in a high number of common journals. This idea led them to the possibility of mapping universities and thus offering an enriched view of the Spanish higher education system. Extending the idea of bibliographic coupling, Ni et al., (2013) proposed a metric called author-publication-place coupling that identifies similarities between journals based on the similarities of their author profiles. The use of this method in information science and library science journals provided evidence of four distinct subfields, namely, management information systems, specialized information and library science, library science-focused, and information science-focused research.

Therefore, our study introduces a novel approach for clustering authors on the basis of the common publication in academic journals. A map of authors can then be used to visualize the relationships between these authors using journal coupling. This tool will make it possible for individual scholars to see how they relate to other authors. Also, it may be relevant for studies exploring the scholars in a discipline or area, or, more in general, within the research management context (Noyons, 2004).

When visualizing the structure of science, the authors' maps are commonly visualized as node-edge diagrams, similar to those used in network science. On one hand, the representation of the authors is carried out by placing each of them in a two-dimensional space (Klavans & Boyack, 2009). On the other hand, relationships between authors are represented by the explicit linking of pairs of authors (Klavans & Boyack, 2009). Henry Small and colleagues (Griffith et al., 1974; Small & Koenig, 1977; Small & Garfield, 1985) were the first to use bibliometric methodologies to map all of science. Their approach was simple: focus their attention on highly co-cited articles. In their developments, they defined these highly co-cited articles as pairs of references that coexist in bibliographies at least five times in a year. Using a different level of granularity than articles when visualizing the structure of science, specifically publication venues, Narin et al., (1972) chose academic journals as the basic unit for mapping science. To do this, Narin et al. (1972) first divided the journals into a certain number of groups and then used a visualization algorithm to generate a layout of the previously obtained groups. More recently, different techniques have been used to create discipline-based maps. For this, the large amounts of data that are currently available on scientific publications have been used. In addition to new visualization tools. Using this approach, Moya-Anegón et al., (2004, 2007) created several discipline-based maps. They used the Thomson Scientific disciplinary classification system. Leydesdorff and Rafols (2009) represents another relevant example of discipline-based maps.

In information science (IS) and library science (LS), different bibliometric analyzes have been carried out to study the structure of the research area. For example, Saracevic, (1999) seeing "the two as separate but closely related fields." Analyzing the structure of library and information science (LIS), Moya-Anegón et al., (2006) found LS, together with information management, "being included or excluded depending on what level the co-citation analyzes" were done. However, according to a set of citation analyzes performed in (Astrom, 2010), "the patterns in the citation data support the concept of a joint LIS field with information science and library science being the two main subfields." In our study, we determine the structure of information science and library science using journal coupling.

Several previous studies identified the most influential journals in the LIS field. For example, Vinkler, (2019) identified the core journals in scientometrics using the frequency of articles in academic journals in the elite publication subgroups of Price medalists. Nixon (2014), Walters and Wilder (2015), and Weerasinghe (2017) also found the most important journals for determining the structure of the research area using different approaches, mainly reflecting reputational factors based on bibliometric indicators or expert surveys. In a more recent paper, Safón and Docampo (2023) found trendy journals which are the most read by scholars who are publishing within the scope of a consolidated discipline. In the following sections, we also analyze the most relevant journals to determine the structure of information science and library science when using journal coupling. Our results are consistent with those of previous studies that identify which journals are truly influential within the discipline.

3 Data and methods

In this article we present an automatic system for grouping academics from a research area. The first choice in our model is related to the research production units that we will use as author descriptors. Here, given the availability of large amounts of data on scientific publications, we have used academic journals to represent the scholars' research output. With this choice, instead of using more complex descriptors, we will avoid the problems shown in (Salton & Buckley, 1988). However, this will force us to use as descriptors the journals in which the author has published, which may not determine a complete identification of an author's scientific results. This balance between precision and complexity will allow us to develop an operational representation of academics' research output.

Taking all this into account, and with the aim of improving the use of academic journals as descriptors, it will be mandatory to differentiate the most important journals from those that are less important when grouping authors based on their shared academic journals, using journal coupling. Therefore, in our modeling we are going to introduce journal weights that allow us to make distinctions between those venues in which an academic has published, based on their value as a descriptor when using journal coupling. This will be shown in the following sections, where we present the generation of effective weighting factors attached to journals that act as author descriptors.

Therefore, in our problem, for each author in a discipline or research area, we record the academic journals in which these authors published their articles. Next, using the list of academic journals in which scholars have published their research results, we construct a journal-by-author matrix. In this matrix, each row contains the weights of the individual journals for each of the authors considered (see Section 3.1). These weights must take into account that journals in which a large proportion of academics have published are a poor indicator of the similarity between two specific authors. That is why in our model, as shown in Section 3.1, we will calculate the weights associated with journal descriptors using the inverse frequency method (Salton & Buckley, 1988).

Based on this journal-by-author matrix, we next measure the similarity between two authors using the approach for calculating the similarity between two documents proposed by (Ahlgren & Colliander, 2009). However, the similarity between authors can be obtained using two different approximations as briefly described below (see Section 3.2 for more details). Specifically, first-order similarities can be obtained by measuring the similarity between columns in a journal-by-author matrix. In this first-order approach, one focuses on the direct similarity between two authors. However, we can also obtain similarities by measuring the similarity between columns in this first-order author-by-author similarity matrix (see Section 3.2). This approach produces a new author-by-author similarity matrix, populated with second- order similarities. This second-order approach finds that two authors are similar by detecting that there are other scholars such that both authors are similar to each of them. In a scientometric context, Ahlgren and Colliander (2012), and Janssens (2007) found that the second-order approach works better than the first-order.

There is only one step left to execute if we want to obtain the clusters of authors that arise from the second-order similarities. Clustering analysis is then used to group the authors based on the similarity values (see Section 3.3). More precisely, we used hierarchical clustering and the complete linkage method to cluster analysis (Everitt et al., 2001). In this article, we illustrate the performance of our approach using a set of 302 authors who have published articles in the IS&LS category of the Web of Science Core Collection (see Section 4). For this group of scholars, we found four main invisible colleges that are made up of authors who frequent the same journals, and therefore, share similar conceptual frameworks.

All the software used in this analysis and the raw data collected are available at https://github.com/rosadecsai/grouping_authors.git

3.1 Journal vector for author representation

We assume a given set of authors $A = \{a_i\}$ that we want to study to find invisible colleges in a research area. In our study, the basic assumption is that relationships between the research output of different authors in A can be found by comparing the academic journals in which these authors published their work. Therefore, two authors in A are related if they share similar publication venues (journal publication profiles). Our grouping of authors is then based on journal coupling.

In our model, $J = \{j_m\}$ represents the list of journals where authors in A published their work. We then constructed a journal-by-author matrix $W = \{w_{m,i}\}$, with $w_{m,i}$ being the weight for representing the a_i's research output using as descriptor the journal j_m. Therefore, the author a_i can be represented using a vector of descriptors and journal weights as follows (see (Salton & Buckley, 1988) for further details):

$$J_{a_i} = (j_1, w_{1,i}; j_2, w_{2,i}; \ldots; j_M, w_{M,i}) \quad (1)$$

with M being the size of $J = \{j_m\}$.

In our model, each journal receives a weight that represents its level of relevance as a descriptor of the author. The journal weights $w_{m,i}$ can vary their value between 0 and a maximum value. This determines a greater degree of discrimination between the journals of J that intervene as descriptors. Thus, the most relevant journals as descriptors of an author receive a greater weight. On the contrary, academic journals that are less relevant as author descriptors will receive lower weight assignments, close to 0, or even a value of 0 if the author has not published any work in the journal. In this approach, therefore, there is no threshold for considering a journal to be relevant.

An author may have published several articles in different academic journals. However, when we compare this author with the rest in A, not all of these journals will be equally relevant when acting as descriptors of the author's scientific production. In that sense, the best descriptors will be those journals that are truly capable of distinguishing certain authors from the rest in A. This implies that the best journals j_m for representing the research output of author a_i should have high journal frequencies (i.e., journals in which a_i frequently published their work) but low overall frequencies across authors in A.

In our model, $freq_{m,i}$ represents the number of papers that author a_i published in journal j_m. Since a journal in which a large proportion of scholars published their work often is a bad indicator of similarity between authors, it is reasonable to weight a journal j_m in accordance with how frequently different authors in A published their work in this journal. In our model, we used the inverse frequency factor to perform this function (Salton & Buckley, 1998):

$$\log\left(\frac{N}{n_m}\right) \quad (2)$$

with N being the size of $A = \{a_i\}$; and n_m being the number of scholars who published in journal j_m.

Therefore, in our model, the value of journal j_m as descriptor of author a_i ($w_{m,i}$) is the product of the journal frequency and the inverse frequency factor (Ahlgren & Colliander, 2009; Salton & Buckley, 1988):

$$w_{m,i} = freq_{m,i} \times \log\left(\frac{N}{n_m}\right) \tag{3}$$

where $freq_{m,i}$ is the number of articles that author a_i published in journal j_m; and the inverse frequency factor $\log\left(\frac{N}{n_m}\right)$ varies inversely with the number of scholars who published in j_m.

3.2 Author-author similarities based on journal coupling

Now, the similarity between authors in A is determined based on the number of shared journals between these authors. That is, the similarity value is measured using journal coupling. Recall that, following (Garcia et al., 2012; Ni et al., 2013), the underlying assumption of our approach is that authors who publish in the same journals are more likely to share similar conceptual frameworks, and thus to be part of the same invisible college, than those who never publish in the same venues.

From equation (1), the similarity between authors a_i and a_j in A could be calculated using the vector product formula. However, this formula does not take into account that the weights of the journals must depend to some extent on the values of the weights assigned to the other journals in the same vector. In our model, we solve this problem by using a length normalized journal-weighting system. However, introducing this normalization, as demonstrated in (Baeza-Yates & Ribeiro-Neto, 1999), the value of the similarity between two authors turns out to be the cosine of the angle between the two journal vectors that represent authors a_i and a_j:

$$B(a_i, a_j) = \frac{\sum_m w_{m,i} \times w_{m,j}}{\sqrt{\sum_m (w_{m,i})^2}\sqrt{\sum_m (w_{m,j})^2}} \tag{4}$$

with $w_{m,i}$ ($w_{m,j}$) being the j_m 's weight for representing author a_i (a_j); and sums are over all journals in the set J.

This first-order approach measures the similarity between two authors directly using their journal vector representation. However, alternatively, a second-order strategy finds that two authors are similar by detecting that there are other scholars in A such that both authors are similar to each of them. Thus, using equation (4), a second-order similarity matrix is defined as follows (see (Ahlgren & Colliander, 2009) for more details):

$$S(a_i, a_j) = \frac{\sum_k B(a_k, a_i) \times B(a_k, a_j)}{\sqrt{\sum_k (B(a_k, a_i))^2}\sqrt{\sum_k (B(a_k, a_j))^2}} \tag{5}$$

where sums are over all authors in the set A. Therefore, this second-order approach measures the similarity between two authors using the first-order measure of similarity between scholars in A.

3.3 Clustering analysis

The last stage of our approach (before interpreting the results obtained) will be to group the authors in A using agglomerative hierarchical clustering. In this effort, we first obtain dissimilarity values between authors in A. For its calculation we use the second-order similarity values obtained in the equation (5). The dissimilarity value is obtained by subtracting the given similarity value from 1.

In our clustering analysis, we will initially have as many clusters as there are individual authors in A. That is, each author determines a single cluster. However, subsequently and at each stage of the agglomerative grouping, the closest clusters according to a measure of distance between them, join together forming a new, larger group of authors. Agglomerative hierarchical clustering stops when a single author group remains, which will consist of all authors of A.

In our analysis, the distance measure between clusters is obtained using the complete linkage method proposed in (Everitt et al., 2001). Therefore, the distance between two clusters is obtained by calculating the maximum distance between pairs of authors, the first of them belonging to one cluster and the second author to the other cluster. To do this, at each stage of the agglomerative clustering, the distance between two groups of authors is calculated as the maximum second-order dissimilarity between two authors, one from the first group and one from the second.

In our study, we used the SciPy package (Virtanen et al., 2020) to perform the complete linkage clustering based on second-order dissimilarities between authors in A. The components at each iterative step of the agglomerative clustering are always a subset of authors or groups of authors. Hence, a tree diagram, or dendrogram will be used to represent the grouping of authors. At a given level of the clustering, the clusters that exist above and below a grouping threshold are obtained simply using horizontal slices of the tree. Thus, in the next section, dendrograms illustrate the agglomerative hierarchical clustering of authors based on journal coupling. However, what will be the cutoff threshold defined in the agglomerative hierarchical clustering? In our experiments we used the maxclust criterion in fcluster of the SciPy package (Virtanen et al., 2020): fcluster (Z,numclust,criterion=‘maxclust’). Using the maxclust criterion, we find an optimal distance between each pair of points which are going to be in the same cluster. All the software used in this analysis is available at https://github.com/rosadecsai/grouping_authors.git.

4 Case of study: Map of IS&LS authors based on journal coupling

In this section, we illustrate the grouping of authors using journal coupling. The results shown in this paper are from a controlled exercise. We analyzed 302 authors who had published in the IS&LS category of the Web of Science Core Collection. These were authors who published an article between 2022 and 2024 or who published a highly cited article between 2014 and 2024.

We downloaded the complete list of academic journals in which they had published all their works. For each author, we retrieved all the scientific journals in which this author had published his/her articles. We then used the cosine measure to calculate the similarity between authors (both first and second order).

Figure 1 illustrates the dendrogram of IS&LS authors according to their journal publication profile (using journal coupling as described above). To obtain this dendrogram of IS&LS authors, we used the complete linkage method for clustering the 304 IS&LS authors, using second-order dissimilarities. Based on the maxclust criterion of the SciPy package (Virtanen et al., 2020), we found four distinct clusters according to similarities in their research output. Authors who frequent the same journals are more likely to be part of the same invisible college (Price & Beaver, 1966). This is because by publishing in the same journals, they share similar conceptual frameworks. Thus, from the four distinct clusters in Figure 1 using the maxclust criterion, we found four invisible colleges in the list of authors. Figure 2 illustrates a visualization in VOSviewer of these four invisible colleges. This map is a node-edge diagram, which places each author on the plane and links pairs of scholars using their corresponding author-author similarities.

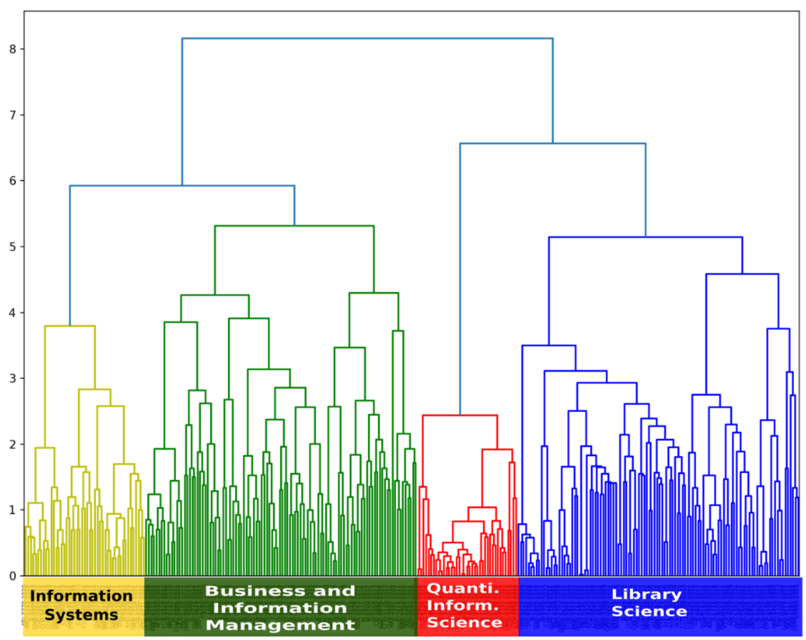


Figure 1. Dendrogram of IS&LS authors according to their journal publication profile.

The four invisible colleges using journal coupling of authors were: (i) "Information Systems" invisible college (see Figure 3); (ii) "Business and Information Management" invisible college (see Figure 4); (iii) "Quantitative Information Science" invisible college (see Figure 5); and (iv)

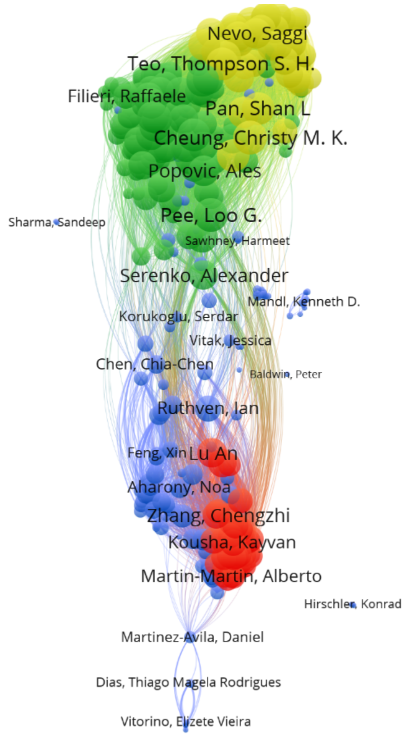


Figure 2. Visualization in VOSviewer of a map for IS&LS authors using journal coupling.

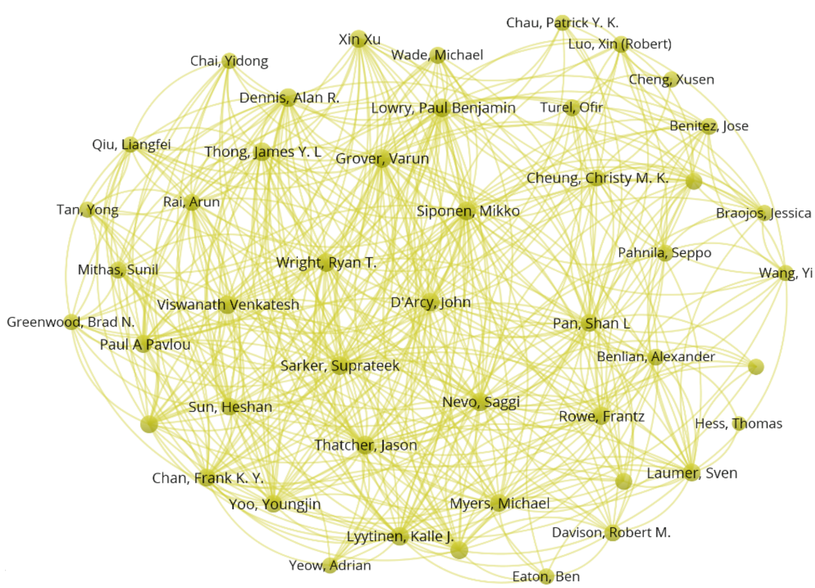


Figure 3. Visualization in VOSviewer of the 'Information Systems' invisible college.

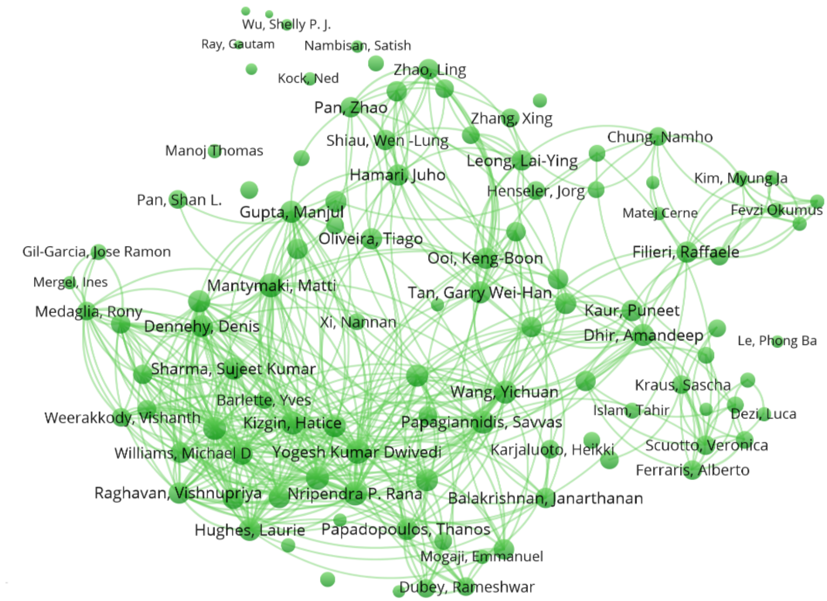


Figure 4. Visualization in VOSviewer of the “Business and Information Management” invisible college.

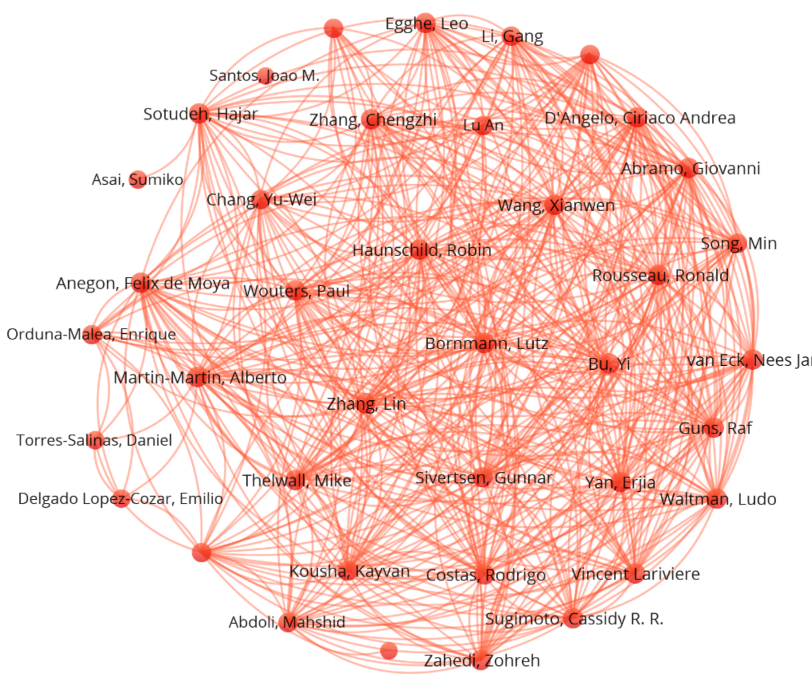


Figure 5. Visualization in VOSviewer of the “Quantitative Information Science” invisible college.

"Library Science" invisible college (see Figure 7). From the dendrogram of the agglomerative hierarchical clustering (see Figure 1), we see that the invisible colleges of "Quantitative Information Science" and "Information Systems" determine two very strong groupings. However, the invisible colleges of "Library Science" and "Business and Information Management" are relatively less strong clusters and show a more diversified journal publication profile (see Figures 3, 4, 5, and 7). Tables 1-4 illustrate the 100 journals of higher weight to determine each invisible college based on journal coupling.

For example, for the invisible college of "Information Systems", the academic journals with the highest weights for representing the research output of authors are five (see Table 1): (1) INFORM SYST RES; (2) INFORM SYST J; (3) J MANAGE INFORM SYST; (4) J ASSOC INF SYST; and (5)EUR J INFORM SYST. These five journals publish studies of the highest quality in the field of information systems. Their articles promote knowledge about the design, management, use, assessment and impacts of information technologies by individuals, groups, organizations, societies and nations for the improvement of economic and social well-being. To this end, they integrate technological disciplines with social, contextual and management issues. Distinguished scholars within this invisible college would be, for example, Dennis, Davinson, Chan, Sarker, Grover, Pan, Benitez, and Lowry (see Figure 3). Table A1 (in Appendix) illustrates the complete list of authors in this invisible college of "Information Systems" using journal coupling.

However, for the invisible college of "Business and Information Management", the academic journals with the highest weights for representing the authors' research output are six (see Table 2): (1) J BUS RES; (2) J KNOWL MANAG; (3) INT J INFORM MANAGE; (4) PROD PLAN CONTROL; (5)J HOSP MARKET MANAG; and (6) INT J CONTEMP HOSP MANAG. These journals aim to publish research that examines a wide variety of business decision contexts, processes, and activities. These articles also focus on the challenge for information management and the emerging needs of the industry. This includes the management of activities that generate changes in the behavioral patterns of customers, people and organizations, as well as information that leads to changes in the way people use information to participate in knowledge-focused activities. Distinguished scholars within this invisible college of "Business and Information Management" would be, for example, Pandey, Dwivedi, Dennehy, Meissner, Kar, Khare, Pappas, Papadopoulos, and Popa (see Figure 4). Table A2 (in Appendix) illustrates the complete list of authors in this invisible college of "Business and Information Management" using journal coupling.

For the invisible college of "Quantitative Information Science", the academic journals with the highest weights for representing the research output are four (see Table 3): (1) J INFORMETR; (2) PRO INT CONF SCI INF; (3) PROF INFORM; and (4) QUANT SCI STUD. This group of authors included several scholars who are among the recipients of the Derek de Solla Price Memorial Medal, the first and the most important international prize in scientometric studies, e.g., Bornmann, Thelwall, Waltman, Rousseau, and Egghe (see Figure 5). In this group we also found some of the most significant and influential LIS scholars during the time examined, e.g., Lariviere,

Table 1. The 100 journals of higher weight to determine the invisible college of "Information Systems".

Information Systems					
Rank	Journal Abbreviation	Weight	Rank	Journal Abbreviation	Weight
1	INFORM SYST RES	153.88	51	J GLOB INF MANAG	6.33
2	INFORM SYST J	122.69	52	J ORGAN END USER COM	6.24
3	J MANAGE INFORM SYST	117.14	53	ELECTRON COMMER RES	6.24
4	J ASSOC INF SYST	110.90	54	J BUS ETHICS	6.24
5	EUR J INFORM SYST	104.67	55	EUR J OPER RES	6.24
6	MIS QUART	75.66	56	MANAGE SCI	6.04
7	P ANN HICSS	71.39	57	INT FED INFO PROC	5.75
8	INFORM MANAGE-AMSTER	52.36	58	J ELECTRON COMMER RE	5.75
9	BUS INFORM SYST ENG+	49.91	59	UROLOGY	5.55
10	J STRATEGIC INF SYST	38.82	60	PERS INDIV DIFFER	5.55
11	J INF TECHNOL-UK	38.12	61	BEHAV BRAIN RES	5.55
12	DECISION SCI	36.04	62	J ENDOUROL	5.55
13	INT J INFORM MANAGE	30.78	63	DES ISSUES	5.55
14	DECIS SUPPORT SYST	29.06	64	CHINA ECON REV	5.55
15	INFORM MANAGE	26.34	65	TELECOMMUN POLICY	5.55
16	J UROLOGY	26.34	66	LECT NOTES BUS INF P	5.47
17	DATA BASE ADV INF SY	25.65	67	J ORG COMP ELECT COM	4.89
18	PROD OPER MANAG	24.95	68	INT J HUM-COMPUT ST	4.89
19	ELECTRON MARK	22.18	69	IFIP ADV INF COMM TE	4.85
20	OMEGA-INT J MANAGE S	19.41	70	J INFORM TECHNOL	4.16
21	MIS Q EXEC	19.41	71	PERS PSYCHOL	4.16
22	COMMUN ACM	19.27	72	RES TECHNOL MANAGE	4.16
23	ORGAN SCI	18.02	73	J TRADIT CHIN MED	4.16
24	MIT SLOAN MANAGE REV	15.25	74	ECON MODEL	4.16
25	ELECTR J INF SYS DEV	14.56	75	J MARKETING RES	4.16
26	INT J ELECTRON COMM	13.86	76	J ASIAN NAT PROD RES	4.16
27	IEEE T ENG MANAGE	13.52	77	WORLD ECON	4.16
28	ADV MANAG INFORM SYS	13.17	78	INT J PROD RES	4.16
29	J BUS RES	13.17	79	IEEE T SYST MAN CY C	4.16
30	GROUP DECIS NEGOT	13.17	80	CHIN MED-UK	4.16
31	IND MANAGE DATA SYST	12.48	81	J INFECT DIS	4.16
32	IT PROF	12.48	82	J DECIS SYST	4.16
33	L N INF SYST ORGAN	12.48	83	CHANDOS ASIAN STUD	4.16
34	COMPUT SECUR	12.48	84	INT J ACCOUNT INF MA	4.16
35	PAC ASIA J ASSOC INF	11.78	85	J POLYNESIAN SOC	4.16
36	WIRTSCHAFTSINF	11.09	86	J ORGAN EFF-PEOPLE P	4.16
37	ELECTRON COMMER R A	10.07	87	ACM TRANS MANAG INF	4.16
38	SMALL GR RES	9.70	88	FEBS LETT	4.16
39	INFORM SYST MANAGE	9.70	89	BIOCHEM INT	4.16
40	ORGAN BEHAV HUM DEC	9.70	90	J SMALL BUS MANAGE	3.47
41	DATA BASE	9.70	91	J OPER RES SOC	3.47
42	J INF TECHNOL	9.01	92	ACAD MANAGE J	3.47
43	J OPER MANAG	9.01	93	INF SYST E-BUS MANAG	3.47
44	INFORM ORGAN-UK	9.01	94	J AM MED INFORM ASSN	3.47
45	J APPL PSYCHOL	8.32	95	INFORM TECHNOL DEV	3.47
46	IEEE T PROF COMMUN	7.62	96	ANN OPER RES	3.47
47	COMPUT HUM BEHAV	7.19	97	INFORM SOC	3.47
48	J MARKETING	6.93	98	FRONT PSYCHOL	2.88
49	J ACAD MARKET SCI	6.93	99	J GLOB INF TECH MAN	2.88
50	PEDIATR INFECT DIS J	6.93	100	BIOMED PHARMACOTHER	2.77

Table 2. The 100 journals of higher weight to determine the invisible college of "Business and Information Management".

Business and Information Management					
Rank	Journal Abbreviation	Weight	Rank	Journal Abbreviation	Weight
1	J BUS RES	172.59	51	REV MANAG SCI	19.41
2	J KNOWL MANAG	135.86	52	BENCHMARKING	19.41
3	INT J INFORM MANAGE	92.92	53	SPRINGERBRIEF BUS	19.41
4	PROD PLAN CONTROL	85.95	54	J CONSUM BEHAV	19.41
5	J HOSP MARKET MANAG	70.70	55	INT J PROD ECON	18.99
6	INT J CONTEMP HOSP M	70.01	56	J TECHNOL TRANSFER	18.71
7	J TRAVEL RES	69.31	57	IEEE T ENG MANAGE	18.41
8	ANN OPER RES	67.24	58	INNOV PUBLIC SECT	18.02
9	TECHNOL FORECAST SOC	66.74	59	SERV IND J	17.33
10	IND MANAGE DATA SYST	64.46	60	INT J E-BUS RES	16.64
11	ANN TOURISM RES	59.61	61	ECON RES-EKON ISTRAZ	16.64
12	INT J HOSP MANAG	59.61	62	J STRATEG MARK	16.64
13	J SUSTAIN TOUR	52.68	63	TECHNOVATION	16.64
14	INT J INDIAN CULT BU	51.29	64	J DESTIN MARK MANAGE	16.64
15	INT J ELECTRON GOV R	49.21	65	PUB ADMIN INF TECH	15.94
16	INT J PROD RES	49.21	66	CREAT INNOV MANAG	15.25
17	BUS STRATEG ENVIRON	48.52	67	ENTERP INF SYST-UK	15.25
18	COMPUT HUM BEHAV	46.03	68	INT J TOUR RES	15.25
19	J INTELLECT CAP	44.36	69	J UNIVERS COMPUT SCI	15.25
20	INFORM SYST MANAGE	44.36	70	EUR MANAG J	15.25
21	J ENTERP INF MANAG	40.90	71	TOUR ANAL	15.25
22	INT J ENTREP BEHAV R	40.20	72	INT J INNOV LEARN	13.86
23	GOV INFORM Q	39.70	73	RESOUR CONSERV RECY	13.86
24	IND MARKET MANAG	38.12	74	INT MARKET REV	13.86
25	EUROMED ACAD BUS CON	37.43	75	INT J CONSUM STUD	13.86
26	INT J MOB COMMUN	36.04	76	EUR MANAG REV	13.86
27	INT J BANK MARK	33.96	77	INT J RETAIL DISTRIB	13.86
28	J RETAIL CONSUM SERV	33.66	78	J BUS IND MARK	13.86
29	TOUR REV	33.27	79	J HOSP TOUR TECHNOL	13.86
30	BRIT FOOD J	33.27	80	INT J OPER PROD MAN	13.86
31	INT ENTREP MANAG J	31.88	81	ELECTRON MARK	13.17
32	TRANSFORM GOV-PEOPLE	31.19	82	EUR J INFORM SYST	13.17
33	P ANN HICSS	30.50	83	MANAGE DECIS	12.95
34	EUR J INT MANAG	29.11	84	J SERV MARK	12.48
35	PSYCHOL MARKET	29.11	85	INT J LOGIST MANAG	12.48
36	J HOSP TOUR RES	27.73	86	BRIT J MANAGE	12.48
37	EUR J MARKETING	27.73	87	PUBLIC MANAG REV	12.48
38	BUS PROCESS MANAG J	27.73	88	INT J EMERG MARK	12.48
39	TOTAL QUAL MANAG BUS	26.34	89	J PROD BRAND MANAG	12.48
40	ADV THE PRAC EMER MA	26.34	90	SUSTAINABILITY-BASEL	12.37
41	J HOSP TOUR MANAG	26.34	91	EUR J INNOV MANAG	11.78
42	J TRAVEL TOUR MARK	26.34	92	INT J INNOV MANAG	11.09
43	ROUTLEDGE STUD MARK	24.95	93	FOOD QUAL PREFER	11.09
44	INNOV TECH KNOWL MAN	24.95	94	IFAC PAPERSONLINE	11.09
45	INFORM MANAGE-AMSTER	23.88	95	CORP SOC RESP ENV MA	11.09
46	ASIA PAC J TOUR RES	23.57	96	INT J ENTREP VENTUR	11.09
47	J INNOV KNOWL	22.18	97	COMPUT IND ENG	11.09
48	TOUR MANAG PERSPECT	20.79	98	J ORGAN BEHAV	11.09
49	TOURISM MANAGE	20.43	99	J INT MANAG	11.09
50	CURR ISSUES TOUR	20.10	100	J INT CONSUM MARK	11.09

Table 3. The 100 journals of higher weight to determine the invisible college of "Quantitative Information Science".

Quantitative Information Science					
Rank	Journal Abbreviation	Weight	Rank	Journal Abbreviation	Weight
1	J INFORMETR	366.67	51	FRONT INFORM TECH EL	4.16
2	PRO INT CONF SCI INF	234.28	52	ACM-IEEE J CONF DIG	4.16
3	PROF INFORM	99.12	53	INVESTIG BIBLIOTECOL	4.16
4	QUANT SCI STUD	74.86	54	CAN J SOCIOL	4.16
5	RES EVALUAT	42.98	55	ACTA PHYS POL A	4.16
6	MATH COMPUT MODEL	34.66	56	INT CONF BIG DATA	4.16
7	J DATA INFO SCI	31.19	57	THEOR CHEM ACC	4.16
8	J AM SOC INFORM SCI	29.11	58	NAT HUM BEHAV	4.16
9	SPRINGER HBK	29.11	59	HIGH EDUC	4.03
10	REV ESP DOC CIENT	27.03	60	INFORM RES	4.03
11	SCI PUBL POLICY	26.34	61	DATA KNOWL ENG	3.47
12	ONLINE INFORM REV	16.40	62	LIBRI	3.47
13	J DOC	14.67	63	HUM SOC SCI COMMUN	3.47
14	COLLNET J SCIENTOMET	14.56	64	COMUNICAR	3.47
15	CURR SCI INDIA	13.86	65	RES POLICY	3.45
16	EMBO REP	13.86	66	ELECTRON LIBR	3.16
17	LEARN PUBL	13.17	67	J SUPERCOMPUT	2.77
18	ASLIB J INFORM MANAG	12.95	68	J ORTHOP SURG RES	2.77
19	P ASIST ANNU	11.09	69	ECON POLIT-ITALY	2.77
20	J CHEM PHYS	11.09	70	CHIMIA	2.77
21	ELIFE	9.70	71	DATA	2.77
22	SCI ENG ETHICS	9.70	72	J LIBR INFORM STUD	2.77
23	J SCIENTOMETR RES	9.70	73	INT J HEALTH POLICY	2.77
24	ASLIB PROC	9.70	74	PHYS LETT B	2.77
25	NATURE	9.21	75	INFORM VISUAL	2.77
26	CLIMATE	8.32	76	MATHEMATICS-BASEL	2.77
27	REV ESP SALUD PUBLIC	8.32	77	UNIV PSYCHOL	2.77
28	J ECON SURV	6.93	78	J EVOL ECON	2.77
29	BMC BIOINFORMATICS	6.93	79	J ALZHEIMERS DIS	2.77
30	CRIMINOLOGIE	6.93	80	PAC J MATH	2.77
31	PRESSE MED	6.93	81	STUD CLASS DATA ANAL	2.77
32	LIBR INFORM SCI RES	6.33	82	RES HIGH EDUC	2.77
33	J INTELL FUZZY SYST	6.24	83	ACTA PAEDIATR	2.77
34	LIBR INFORM SCI SER	6.24	84	ANN I H POINCARE B	2.77
35	MEAS-INTERDISCIP RES	5.55	85	INT J STROKE	2.77
36	IEEE INT CON MULTI	5.55	86	ESTUD MENSAJE PERIOD	2.77
37	CAN J INFORM LIB SCI	5.55	87	PALGR COMMUN	2.77
38	HIGH EDUC Q	5.55	88	SOC STUD SCI	2.77
39	Z EVAL	5.55	89	EVALUATION REV	2.77
40	J ORGANOMET CHEM	5.55	90	PHYS REV LETT	2.77
41	IEEE INT CONF FUZZY	5.55	91	PSICOTHEMA	2.77
42	PUBLICATIONS	5.55	92	IEEE INT C BIO BIO W	2.77
43	J LIBR INF SCI	5.55	93	IETE TECH REV	2.77
44	MALAYS J LIBR INF SC	5.18	94	MED CLIN-BARCELONA	2.77
45	COLL RES LIBR	4.85	95	J TECHNOL TRANSFER	2.77
46	J KOREAN MED SCI	4.16	96	TECHNOVATION	2.77
47	INT CONF CONTEMP	4.16	97	EDUC XX1	2.77
48	MINERVA	4.16	98	AIP CONF PROC	2.77
49	KNOWL ORGAN	4.16	99	INFORM POL	2.77
50	FEMS MICROBIOL LETT	4.16	100	DOC BIBL	2.77

Rousseau, Ronald	Docs	%
SCIENTOMETRICS	54	23,38
J INFORMETR	49	21,21
PRO INT CONF SCI INF	21	9,09
J AM SOC INF SCI TEC	17	7,36
J ASSOC INF SCI TECH	12	5,19
J DATA INFO SCI	10	4,33
MALAYS J LIBR INF SC	9	3,9
COLLNET J SCIENTOMET	7	3,03
PROF INFORM	3	1,3
J DOC	3	1,3
NATURE	2	0,87
J INF SCI	2	0,87
PLOS ONE	1	0,43
SPRINGER HBK	1	0,43
ASLIB J INFORM MANAG	1	0,43
RES EVALUAT	1	0,43
QUANT SCI STUD	1	0,43

Total commons journals 17

similarity 0.99

Bornmann, Lutz	Docs	%
SCIENTOMETRICS	100	24,81
J INFORMETR	86	21,34
J ASSOC INF SCI TECH	34	8,44
J AM SOC INF SCI TEC	25	6,2
PLOS ONE	19	4,71
PRO INT CONF SCI INF	14	3,47
PROF INFORM	13	3,23
RES EVALUAT	13	3,23
QUANT SCI STUD	11	2,73
COLLNET J SCIENTOMET	7	1,74
J INF SCI	6	1,49
J DOC	6	1,49
ONLINE INFORM REV	4	0,99
NATURE	2	0,5
MALAYS J LIBR INF SC	2	0,5
ASLIB J INFORM MANAG	2	0,5
SPRINGER HBK	1	0,25
J DATA INFO SCI	1	0,25

similarity 0.66

Total commons journals 7

Stuart, Emma	Docs	%
J ASSOC INF SCI TECH	5	18,52
J DATA INFO SCI	3	11,11
ONLINE INFORM REV	2	7,41
J DOC	2	7,41
QUANT SCI STUD	2	7,41
PLOS ONE	1	3,7
SCIENTOMETRICS	1	3,7

Figure 6. Detail of journal similarities among Bornmann, Rousseau, and Stuart according to the IS&LS category of the Web of Science Core Collection.

Costas, Sugimoto, D’Angelo, Abramo, Wouters, Zahedi, Delgado Lopez-Cozar, Moya-Anegón, and so on (see Figure 5). The academics in this cluster have a high level of production and more links with the rest of the authors who seem to surround them. Table A3 (Appendix) illustrates the complete list of authors in this invisible college of “Quantitative Information Science” using journal coupling.

In Figure 6, we can see how high levels of similarity correspond with similar journal publication profiles: Bornmann’s and Rousseau’s research output is very similar (similarity = 0.99) and highly focused on four main journals (SCIENTOMETRICS, J INFORMETR, J ASSOC INF SCI TECH/J AMSOC INF SCI TEC, PRO INT CONF SCI INF) which contain more than 64% of the total production for both authors. In the same Figure 6, we found that the similarity between Bornmann and Stuart is much smaller (similarity = 0.66). However, for both authors, seven journals contain more than 43% of their production (see Figure 6).

For the invisible college of “Library Science”, the academic journals with the highest weights for representing the authors’ research output are eight (see Table 4): (1) INT J GEOGR INF SCI; (2) J AM MED INFORM ASSN; (3) LEARN PUBL; (4) PROF INFORM; (5) CHANDOS INF PROF SER; (6) J LIBR ADM; (7) ASLIB PROC; and (8) J LIBR INF SCI. These journals publish

Table 4. The 100 journals of higher weight to determine the invisible college of "Library Science".

Library Science					
Rank	Journal Abbreviation	Weight	Rank	Journal Abbreviation	Weight
1	INT J GEOGR INF SCI	198.24	51	HEALTH AFFAIR	18.02
2	J AM MED INFORM ASSN	120.61	52	COLLECT BUILD	18.02
3	LEARN PUBL	113.68	53	PEDIATRICS	17.33
4	PROF INFORM	92.19	54	APPL CLIN INFORM	17.33
5	CHANDOS INF PROF SER	83.18	55	IEEE J-STARS	16.64
6	J LIBR ADM	67.93	56	NPJ DIGIT MED	16.64
7	ASLIB PROC	58.92	57	PUBLIC LIBR Q	16.64
8	J LIBR INF SCI	57.53	58	APPL GEOGR	15.25
9	REV BELGE PHILOL HIS	56.84	59	AGR FOREST METEOROL	15.25
10	EDINB STUD CLASS ISL	48.52	60	JAMA-J AM MED ASSOC	15.25
11	AM HIST REV	44.36	61	MALAYS J LIBR INF SC	15.25
12	LIBR MANAGE	44.36	62	J DOC	14.96
13	EM QUESTAO	42.98	63	JAMA NETW OPEN	13.86
14	J AUST LIB INF ASSOC	37.43	64	GISCI REMOTE SENS	13.86
15	T GIS	37.43	65	INTERLEND DOC SUPPLY	13.86
16	LIBR HI TECH	36.54	66	INFORM SOC-ESTUD	13.86
17	ISPRS INT J GEO-INF	34.66	67	INT J CLIN MONIT COM	13.86
18	LANDSCAPE URBAN PLAN	33.27	68	DIGIT LIBR PERSPECT	13.86
19	J GEN INTERN MED	31.88	69	AUST ACAD RES LIBR	12.48
20	SYNTH REACT INORG M	30.50	70	BMJ QUAL SAF	12.48
21	COMPUT ENVIRON URBAN	29.11	71	NEW REV ACAD LIBR	12.48
22	SPECULUM	27.73	72	JOURNALISM	12.48
23	J ASIAN AFR STUD	27.73	73	NEW LIB WORLD	11.09
24	HEALTH INFO LIBR J	26.34	74	MUSLIM WORLD AGE CRU	11.09
25	IFLA J-INT FED LIBR	26.34	75	JAMA INTERN MED	11.09
26	LIBRI	25.65	76	ANN EMERG MED	11.09
27	IEEE T GEOSCI REMOTE	24.95	77	LANDSCAPE ECOL	11.09
28	REV IBERI-AM CIENC I	24.95	78	ISLAM	11.09
29	GLOB KNOWL MEM COMMU	23.59	79	LECT NOTES GEOINF CA	11.09
30	INT J REMOTE SENS	23.57	80	HEALTH SERV RES	11.09
31	AFR J LIBR ARCH INFO	23.57	81	EVID BASED LIB INF P	11.09
32	QUAL QUANT METHODS L	23.57	82	RDBCI-REV DIG BIB CI	11.09
33	J ACAD LIBR	23.01	83	PHOTOGRAMM ENG REM S	11.09
34	LIBR RESOUR TECH SER	22.18	84	INF DISCOV DELIV	10.93
35	J TRANSP GEOGR	20.79	85	REMOTE SENS ENVIRON	10.40
36	S AFR J INFORM MANAG	20.79	86	PORTAL-LIBR ACAD	10.40
37	ANN INTERN MED	20.79	87	ONLINE INFORM REV	10.07
38	LIBR REV	20.79	88	ASLIB J INFORM MANAG	9.78
39	B SCH ORIENT AFR ST	20.79	89	COLLECT CURATION	9.70
40	ANN AM ASSOC GEOGR	20.79	90	CAT CLASSIF Q	9.70
41	AM J MANAG CARE	20.79	91	SCI CHINA SER D	9.70
42	INFORM DEV	20.71	92	HEALTHCARE-J DEL SCI	9.70
43	J INFORM OPTIM SCI	19.41	93	J SCHOLARLY PUBL	9.70
44	NEW ENGL J MED	19.41	94	SERIALS REV	9.70
45	ELECTRON LIBR	19.27	95	PERFORM MEAS METR	9.70
46	S AFR J LIBR INF	18.71	96	JAMIA OPEN	9.70
47	PERSPECT CIENC INF	18.02	97	BIBLIOS	9.70
48	ENCONTROS BIBLI	18.02	98	INT J APPL EARTH OBS	9.70
49	PEDIATR RES	18.02	99	ARCH INTERN MED	9.70
50	DESIDOC J LIB INF TE	18.02	100	IEEE T NEUR NET LEAR	9.70

articles that reflect all aspects of library and information science. They focus on the practices, perspectives and tools of management, information technology, education and other areas of libraries. This includes the collection, organization, preservation and dissemination of information resources. They also cover the political economy of information, as well as the design, implementation and use of geographic information, medical in- formation and other special libraries for monitoring, prediction and decision making. Distinguished scholars within this invisible college of 'Library Science' would be, for example, Zipf, Ho, Nicholas, Yuvaraj, Holley, Verma, Jamali, Rodriguez-Bravo, and Boukacem-Zeghmouri (see Figure 7). Table A4 (In Appendix) illustrates the complete list of authors in this invisible college of "Library Science" using journal coupling.

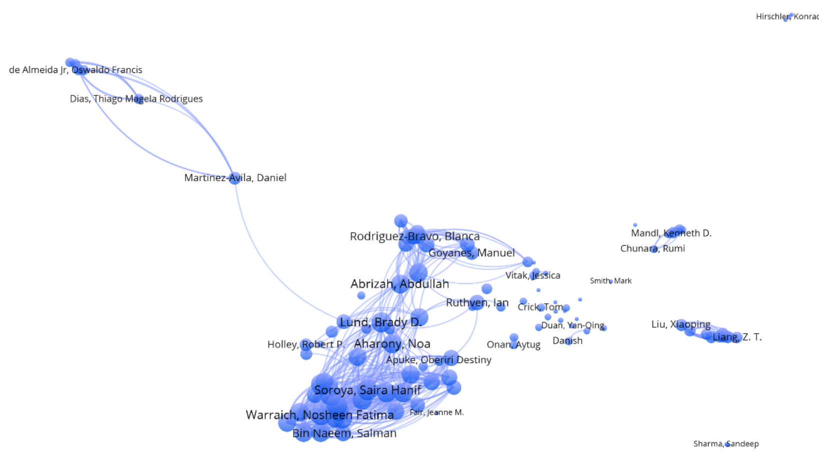
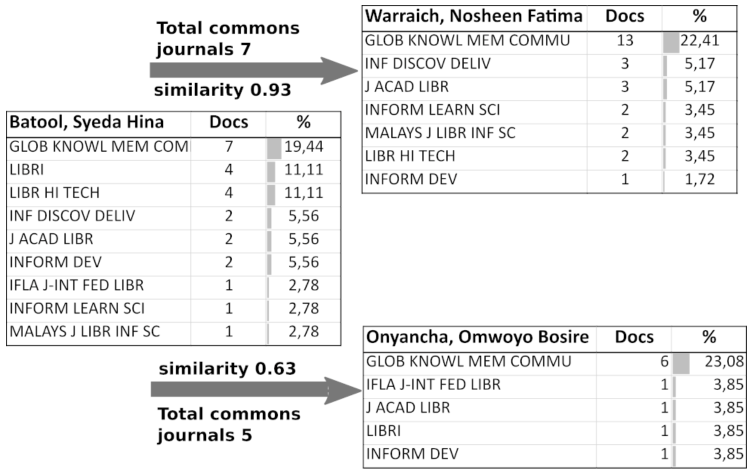


Figure 7. Visualization in VOSviewer of the "Library Science" invisible college.

For the invisible college of library science, Figure 8 illustrates some details of journal similarities among Batool, Warraich, and Onyancha according to the IS&LS category of the Web of Science Core Collection. We can see how high and low levels of similarity correspond with certain journal publication profiles. For example, Batool's and Warraich's research output is similar (similarity = 0.93) and highly focused on seven main journals which contain 53% and 45% of the total production, respectively. In the same Figure 8, we found that the similarity between Batool and Onyancha is smaller (similarity = 0.63). However, only five journals still contain 44% and 38% of their production, respectively (see Figure 8).

Figure 9 illustrates the map of invisible colleges according to their journal publication profile in IS and LS. This map is a node-edge diagram, which places each invisible college on the plane and links pairs of invisible colleges using their second-order similarities. On one hand, the invisible college "Quantitative Information Science" has the highest production by author (represented by node size) and a moderately strong link to Library Science. On the other hand, Information Systems and Business & Information Management are (relatively) less productive invisible colleges that show similarities with each other in certain fields of activity. They have weak links to Quantitative Information Science and Library Science (see Figure 9).



Warraich, Nosheen Fatima	Docs	%
GLOB KNOWL MEM COMMU	13	22,41
INF DISCOV DELIV	3	5,17
J ACAD LIBR	3	5,17
INFORM LEARN SCI	2	3,45
MALAYS J LIBR INF SC	2	3,45
LIBR HI TECH	2	3,45
INFORM DEV	1	1,72

Batool, Syeda Hina	Docs	%
GLOB KNOWL MEM COM	7	19,44
LIBRI	4	11,11
LIBR HI TECH	4	11,11
INF DISCOV DELIV	2	5,56
J ACAD LIBR	2	5,56
INFORM DEV	2	5,56
IFLA J-INT FED LIBR	1	2,78
INFORM LEARN SCI	1	2,78
MALAYS J LIBR INF SC	1	2,78

Onyancha, Omwoyo Bosire	Docs	%
GLOB KNOWL MEM COMMU	6	23,08
IFLA J-INT FED LIBR	1	3,85
J ACAD LIBR	1	3,85
LIBRI	1	3,85
INFORM DEV	1	3,85

Figure 8. Detail of journal similarities among Batool, Warraich, and Onyancha according to the IS&LS category of the Web of Science Core Collection.

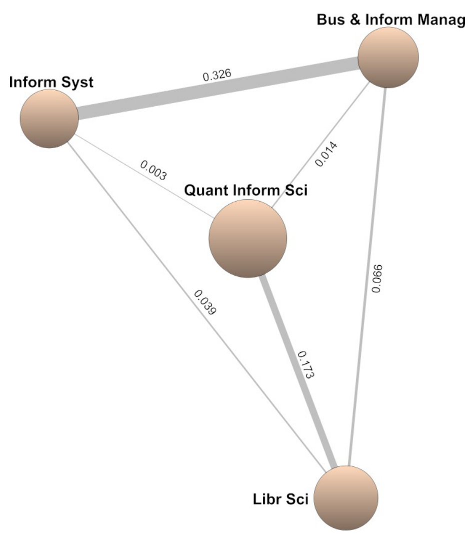


Figure 9. Map of invisible colleges according to their journal publication profile in IS and LS.

However, what are the academic journals that demonstrate that IS and LS determine a single field of research, since authors from all the invisible colleges publish in these journals? Are there academic journals of this type and what are they? Table 5 shows the list of academic journals in which authors from all the invisible colleges have published. In this table we see that authors from all invisible colleges have published in Plos One and Lect Notes Compt Sc. Academic journals

Table 5. Academic journals in which authors from all the invisible colleges have published.

Journal Abbreviation	Inform Syst	Bus & Inform Manag	Quant Inform Sci	Libr Sci
ADV MATER RES-SWITZ	7	3	2	10
BEHAV INFORM TECHNOL	20	39	1	2
COMM COM INF SC	4	9	8	14
COMMUN ACM	67	12	1	2
COMMUN ASSOC INF SYS	123	22	1	8
COMPUT EDUC	2	13	1	3
ENVIRON SCI POLLUT R	1	5	1	20
EXPERT SYST APPL	2	82	3	28
IEEE ACCESS	1	8	3	11
IEEE T ENG MANAGE	47	72	1	3
INFORM PROCESS MANAG	10	5	79	42
INFORM SCIENCES	2	3	2	12
INFORM SYST FRONT	25	207	1	11
INFORM TECHNOL MANAG	1	7	2	1
INFORM TECHNOL PEOPL	35	79	3	7
INT J ENV RES PUB HE	5	7	2	15
INT J HUM-COMPUT INT	2	28	2	3
INT J INFORM MANAGE	107	366	3	34
INT J MED INFORM	2	4	1	27
INTERNET RES	55	81	4	8
J AM SOC INF SCI TEC	20	7	252	18
J ASSOC INF SCI TECH	9	10	256	35
J CLEAN PROD	2	78	1	116
J COMPUT INFORM SYST	10	65	1	5
J COMPUT-MEDIAT COMM	1	3	3	7
J ENVIRON MANAGE	2	7	1	34
J INF SCI	3	5	61	66
J MED INTERNET RES	9	10	3	24
LECT NOTES ARTIF INT	3	3	4	10
LECT NOTES COMPUT SC	13	158	26	67
NEW MEDIA SOC	1	5	3	12
P NATL ACAD SCI USA	3	1	4	7
PLOS ONE	6	12	124	72
SCI REP-UK	3	6	5	19
SCIENTOMETRICS	2	7	846	41
TECHNOL FORECAST SOC	5	249	7	6
TELEMAT INFORM	3	74	3	17
TOURISM MANAGE	1	71	1	21

such as Expert Syst Appl, Internet Res, Technol Forecast Soc, or Telemat Inform also appear on this list. But what are the specific journals of the research area in which authors from all the invisible colleges publish? There are seven main journals that stand out in this regard and they are J Am Soc Inf Sci Tec/J Assoc Inf Sci Tech, Scientometrics, Int J Inform Manage, Inform Process Manag, Inform Technol Peopl, Inform Syst Front, and J Inf Sci (see Table 5). These journals tell us about the existence of a unique research field, which appears to encompass several subfields of research (i.e., the detected invisible colleges).

5 Discussion and conclusions

Our results based on journal coupling show four main invisible colleges in LIS (i.e., Library Science, Quantitative Information Science, Information Systems, and Business and Information Management). These results are consistent with those obtained in (Astrom, 2010) using co-citation maps, as well as the co-occurrence of shared references between IS and LS authors. Using citation data from publications in LIS journals, Astrom (2010) found that IS and LS determine two main subfields in a joint field of LIS, where a further division into more specialized research areas can also be found when analyzing data from IS citations. On the contrary, LS research areas were less visible in citation analyses. Thus, what are the academic journals that determine the existence of subfields in LIS? They are journals in which authors from a certain invisible college publish very frequently and in which the authors from other colleges have never published. For example, in the invisible college of Information Systems, there are four journals that stand out and determine a subfield of research due to their weight in the discrimination of IS and LS authors. They are Inform Syst Res, Inform Syst J, J Manage Inform Syst, and Eur J Inform Syst (see Table 1).

In the invisible college of Business and Information Management, there are two main academic journals that determine the existence of this research subfield, due to the frequency of publication in them (see Table 2): J Bus Res and J Knowl Manage.

In the invisible college where the most significant and influential LIS academics were found (Quantitative Information Science), the journals with the highest weights when it comes to discriminating this research subfield are fundamentally two (see Table 3): J Informetr and Pro Int Conf Sci Inf. Furthermore, Prof Inform and Quant Sci Stud also played a prominent role, the latter being a recently created journal (see Table 3).

Finally, three academic journals are the most important in determining the invisible college of Library Science, specifically, Int J Geogr Inf Sci, J Am Med Inform Assn, and Learn Publ (see Table 4). This tells us about the importance that special libraries have in this subfield, more precisely, geographic information and medical information.

Our results regarding the most relevant journals to determine the structure of information science and library science, are consistent with those of previous studies. For example, Vinkler (2019) identified among the core journals in scientometrics the following journals: Scientometrics; Journal of the American Society for Information Science and Technology; Information Processing and Management; Journal of Information Science; Research Policy; Library Trends; and Research

Evaluation. Our results on the most important journals for determining the structure of the research area also coincide with those presented in (Nixon, 2014; Walters & Wilder, 2015; Weerasinghe, 2017). In a more recent paper, Safón and Docampo (2023) found that "the top 10 journals that most influenced papers published between 2021 and March 2022 were: Scientometrics; International Journal of Information Management; Journal of the Association for Information Science and Technology; Quantitative Science Studies; MIS Quarterly; Information and Management; Information Processing and Management; Journal of the Association for Information Systems; Journal of Informetrics; Journal of Academic Librarianship." All these journals are, according to our approach based on journal coupling, of great importance either to define LIS as a field of research (see Table 5) or to determine the structure of IS and LS into invisible colleges (see Tables 1-4).

However, our approach and the results obtained not only inform the structure of information science and library science, but also provide an adaptable methodology that can be used in other areas of research and extended to answer additional research questions. For example, to the problem of finding potential reviewers in complex evaluation processes. Ultimately, this paper served as a proof of concept for finding invisible colleges in a research area, using journal coupling.

Regarding limitations and further research, a first limitation of our study is that the results shown in this paper are from a controlled exercise. We analyzed 302 authors who published in the IS&LS category of the Web of Science Core Collection. In future work, we will explore alternative approaches to identifying the authors that will be used to determine the structure of the research area, and compare the results with those reported here.

Second, the analysis performed using journal coupling excludes books, book chapters, and conference papers. This is a significant omission, since contributions other than articles remain important within information science and library science. This could be an interesting point of analysis for future work.

Third, although related to the previous limitation, in this paper, academic journals alone were used for research output representation. However, as suggested in (Garcia et al., 2012), "sets of journals cannot provide complete identifications of research output." In future work, we will explore the incorporation of more complex entities for author representation.

Author contributions

Jose A. Garcia (jags@decsai.ugr.es): Conceptualization (Equal), Data curation (Equal), Formal analysis (Equal), Methodology (Equal), Writing - original draft (Equal), Writing - review & editing (Equal);

Rosa Rodriguez-Sanchez (rosa@decsai.ugr.es): Conceptualization (Equal), Data curation (Equal), Investigation (Equal), Methodology (Equal), Resources (Equal), Software (Equal), Supervision (Equal), Validation (Equal);

J. Fdez-Valdivia (j.fdez-valdivia@decsai.ugr.es): Project administration (Equal), Supervision (Equal), Validation (Equal), Visualization (Equal), Writing - review & editing (Equal).

References

Ahlgren, P., & Colliander, C. (2009). Document-document similarity approaches and science mapping: Experimental comparison of five approaches. *Journal of Informetrics, 3*(1), 49-63.

Ahlgren, P., & Colliander, C. (2012). Experimental comparison of first and second-order similarities in a scientometric context. *Scientometrics, 90*(2), 675-685.

Astrom, F. (2010). The visibility of information science and library science research in bibliometric mapping of the LIS field. *The Library Quarterly: Information, Community, Policy, 80*(2), 143-159. https://doi.org/10.1086/651005

Baeza-Yates, R. A., & Ribeiro-Neto, B. A. (1999). *Modern information retrieval*. Addison-Wesley.

Borgman, C. L., & Furner, J. (2002). Scholarly communication and bibliometrics. In B. Cronin (Ed.), *Annual Review of Information Science and Technology* (Vol. 36, pp. 2-73). Medford, NJ: Information Today.

Everitt, B., Landau, S., & Leese, M. (2001). *Cluster analysis* (4th ed.). Arnold.

Garcia, J. A., Rodríguez-Sánchez, R., Fdez-Valdivia, J., Torres-Salinas, D., Robinson-García, N. (2012). Mapping academic institutions according to their journal publication profile: Spanish universities as a case study. *Journal of the American Society for Information Science and Technology, 63*(11), 2328-2340. https://doi.org/10.1002/asi.22735

Griffith, B. C., Small, H. G., Stonehill, J. A., & Dey, S. (1974). Structure of scientific literatures. 2. Toward a macrostructure and microstructure for science. *Science Studies, 4*, 339-365.

Janssens, F. (2007). *Clustering of scientific fields by integrating text mining and bibliometrics* (Unpublished doctoral dissertation). Katholieke Universiteit, Leuven.

Kessler, M. M. (1963). Bibliographic coupling between scientific papers. *American Documentation, 14*(1), 10-25.

Klavans, R., & Boyack, K. W. (2009). Toward a consensus map of science. *Journal of the American Society for Information Science and Technology, 60*(3), 455-476.

Leydesdorff, L., & Rafols, I. (2009). A global map of science based on the ISI subject categories. *Journal of the American Society for Information Science and Technology, 60*(2), 348-369.

Minguillo, D. (2010). Toward a new way of mapping scientific fields: Authors' competence for publishing in scholarly journals. *Journal of the American Society for Information Science & Technology, 61*(4), 772-786.

Moya-Anegón, F., Herrero-Solana, V., & Jiménez-Contreras, E. (2006). A connectionist and multivariate approach to science maps: The SOM, clustering, and MDS applied to Library and Information Science research. *Journal of Information Science, 32*, 63-77.

Moya-Anegón, F., Vargas-Quesada, B., Chinchilla-Rodríguez, Z., Corera-Álvarez, E., Muñoz-Fernández, F. J., & Herrero-Solana, V. (2007). Visualizing the marrow of science. *Journal of the American Society for Information Science and Technology, 58*, 2167-2179.

Moya-Anegón, F., Vargas-Quesada, B., Herrero-Solana, V., Chinchilla-Rodríguez, Z., Corera-Álvarez, E., & Muñoz-Fernández, F. J. (2004). A new technique for building maps of large scientific domains based on the co-citation of classes and categories. *Scientometrics, 61*, 129-145.

Narin, F., Carpenter, M., & Berlt, N. C. (1972). Interrelationships of scientific journals. *Journal of the American Society for Information Science, 23*, 323-331.

Ni, C., Sugimoto, C. R., & Jiang, J. (2013). Venue-author-coupling: A measure for identifying disciplines through author communities. *Journal of the American Society for Information Science and Technology, 64*(2), 265-279.

Nixon, J. M. (2014). Core journals in library and information science: Developing a methodology for ranking LIS journals. *College and Research Libraries, 75*(1), 66-90.

Noyons, C. (2004). Science maps within a science policy context. In H. F. Moed et al. (Eds.), *Handbook of Quantitative Science and Technology Research* (pp. 237-255). Kluwer Academic Publishers.

Pajek 5.18 (2023). Available from: http://mrvar.fdv.uni-lj.si/pajek/

Price, D. J. de Solla, & Beaver, D. (1966). Collaboration in an invisible college. *American Psychologist*, 2011-2018. https://doi.org/10.1037/h0024051

Qiu, J. P., Dong, K., & Yu, H. Q. (2014). Comparative study on structure and correlation among author co-occurrence networks in bibliometrics. *Scientometrics, 101*, 1345-1360. https://doi.org/10.1007/s11192-014-1315-6

Robinson-García, N., Rodríguez-Sánchez, R., García, J. A., Torres-Salinas, D., & Fdez-Valdivia, J. (2013). Network analysis of Spanish universities according to their journal publication profile in scientific areas. *Revista Española de Documentación Científica, 36*(4), (e027). https://doi.org/10.3989/redc.2013.4.1042

Safón, V., & Docampo, D. (2023). What are you reading? From core journals to trendy journals in the Library and Information Science (LIS) field. *Scientometrics, 128*, 2777-2801. https://doi.org/10.1007/s11192-023-04673-x

Salton, G., & Buckley, C. (1988). Term-weighting approaches in automatic text retrieval. *Information Processing and Management, 24*(5), 513-523.

Saracevic, T. (1999). Information science. *Journal of the American Society for Information Science, 50*, 1051-1063.

Virtanen, P., Gommers, R., Oliphant, T. E., Haberland, M., Reddy, T., Cournapeau, D., Burovski, E., Peterson, P., Weckesser, W., Bright, J., van der Walt, S. J., Brett, M., Wilson, J., Millman, K. J., Mayorov, N., Nelson, A. R. J., Jones, E., Kern, R., Larson, E., Carey, C. J., Polat, I., Feng, Y., Moore, E. W., VanderPlas, J., Laxalde, D., Perktold, J., Cimrman, R., Henriksen, I., Quintero, E. A., Harris, C. R., Archibald, A. M., Ribeiro, A. H., Pedregosa, F., van Mulbregt, P., & SciPy 1.0 Contributors. (2020). SciPy 1.0: Fundamental algorithms for scientific computing in Python. *Nature Methods, 17*(3), 261-272. https://doi.org/10.1038/s41592-019-0686-2

Small, H. (1973). Co-citation in the scientific literature: A new measure of the relationship between two documents. *Journal of the American Society for Information Science, 24*(4), 265-269.

Small, H., & Garfield, E. (1985). The geography of science: Disciplinary and national mappings. *Journal of Information Science, 11*, 147-159.

Small, H. G., & Koenig, M. E. D. (1977). Journal clustering using a bibliographic coupling method. *Information Processing and Management, 13*(5), 277-288.

Tijssen, R. J. W., & Van Raan, A. F. J. (1994). Mapping changes in science and technology: Bibliometric co-occurrence analysis of the R&D literature. *Evaluation Review, 18*(1), 98-115. https://doi.org/10.1177/0193841X9401800110

Vinkler, P. (2019). Core journals and elite subsets in scientometrics. *Scientometrics, 121*(1), 241-259.

Walters, W. H., & Wilder, E. I. (2015). Worldwide contributors to the literature of library and information science: Top authors, 2007-2012. *Scientometrics, 103*(1), 301-327.

Weerasinghe, S. (2017). Citation analysis of library and information science research output for collection development. *Journal of the University Librarians Association of Sri Lanka, 20*(1), 1-18.

White, H. D. (2001). Authors as citers over time. *Journal of the American Society for Information Science, 52*, 87-108. https://doi.org/10.1002/1097-4571(2000)9999:9999<::AID-ASI1542>3.0.CO; 2-T

White, H. D., & McCain, K. W. (1998). Visualizing a discipline: An author co-citation analysis of information science, 1972-1995. *Journal of the American Society for Information Science, 49*, 327-355.

Appendix

Table A1. "Information Systems" invisible college using journal coupling.

"Information Systems" invisible college	
Web of Science ResearcherID	Name
ABD-9343-2020	Viswanath Venkatesh
DCP-3847-2022	Laumer, Sven
E-4383-2013	Davison, Robert M.
FXX-7807-2022	Siponen, Mikko
A-2790-2008	Lowry, Paul Benjamin
I-8515-2012	Cheung, Christy M. K.
L-8364-2013	Wang, Yi
A-1774-2016	Hess, Thomas
DXR-2943-2022	Mithas, Sunil
U-9082-2019	Nishant, Rohit
ABI-7778-2020	Yoo, Youngjin
FTS-6271-2022	Rowe, Frantz
FUQ-3948-2022	Sarker, Suprateek
FZC-5401-2022	Cheng, Xusen
FZY-0677-2022	Constantiou, Ioanna
GBT-6636-2022	D'Arcy, John
M-6996-2017	Pan, Shan L
B-9123-2011	Thong, James Y. L
KHY-4609-2024	Wade, Michael
D-3561-2014	Paul A Pavlou
U-1716-2019	Turel, Ofir
O-8202-2017	Lyytinen, Kalle J.
DHU-9079-2022	Nevo, Saggi
DKI-4141-2022	Pahnila, Seppo
F-9405-2010	Myers, Michael
J-7274-2019	Yeow, Adrian
DVA-4597-2022	Karahanna, Elena
DXJ-1642-2022	Grover, Varun
DXU-1855-2022	Tarafdar, Monideepa

"Information Systems" invisible college	
Web of Science ResearcherID	Name
DZF-0654-2022	Sun, Heshan
J-6551-2017	Braojos, Jessica
L-4600-2019	Wright, Ryan T.
O-5989-2019	Greenwood, Brad N.
P-3232-2015	Teo, Thompson S. H.
ENU-4415-2022	Benitez, Jose
AAX-3120-2021	Thatcher, Jason
AFK-1224-2022	Xin Xu
A-4422-2010	Chau, Patrick Y. K.
CMB-4425-2022	Dennis, Alan R.
CNR-0824-2022	Eaton, Ben
N-7853-2014	Chan, Frank K. Y.
JDA-0030-2023	Luo, Xin (Robert)
JDK-7830-2023	Tan, Yong
FZX-5394-2022	Qiu, Liangfei
ENH-3614-2022	Chai, Yidong
DXP-7319-2022	Benlian, Alexander
GDE-9432-2022	Rai, Arun

Table A2. "Business and Information Managment" invisible college using journal coupling.

"Business and Information Management" invisible college			
Web of Science ResearcherID	Name	Web of Science ResearcherID	Name
A-5362-2008	Yogesh Kumar Dwivedi	DWC-8095-2022	Mantymaki, Matti
ABA-4719-2020	Nripendra P. Rana	DWR-2367-2022	Kraus, Sascha
H-6223-2013	Marijn Janssen	DWR-2830-2022	Weerakkody, Vishanth
JVG-3087-2024	Lu, Yaobin	AER-0191-2022	Santoro, Gabriel
U-2170-2017	Ramakrishnan Raman	ABF-6649-2021	de Reuver, Mark
S-1173-2017	Alalwan, Ali Abdallah	K-5240-2019	Ferraris, Alberto
I-4143-2019	Ooi, Keng-Boon	B-8900-2014	Mogaji, Emmanuel
B-4090-2011	Oliveira, Tiago	S-5659-2017	Leong, Lai-Ying
AAB-4953-2019	Wamba, Samuel Fosso	EHS-6062-2022	Wu, Shelly P. J.
F-1826-2013	Dhir, Amandeep	EIX-1294-2022	Zhao, Ling
C-6565-2011	Tan, Garry Wei-Han	AAE-3369-2020	Nambisan, Satish
DVF-5910-2022	Lal, Banita	AAG-7481-2020	Fevzi Okumus
N-2391-2019	Wang, Yichuan	AAO-7181-2020	Xi, Nannan
AAC-9878-2020	Edwards, John S.	AAT-2082-2020	Serenko, Alexander
AAX-8282-2020	Baabdullah, Abdullah M.	AAW-3321-2020	Luqman, Adeel

“Business and Information Management” invisible college			
Web of Science ResearcherID	Name	Web of Science ResearcherID	Name
GEW-9121-2022	Hughes, Laurie	AAY-9644-2020	Connelly, Catherine E.
HTP-3338-2023	Sharma, Sujeet Kumar	AAI-6997-2021	Sorensen, Carsten
B-9999-2009	Kar, Arpan Kumar	AAK-2553-2021	Filieri, Raffaele
JPA-1685-2023	Pappas, Ilias O	AAK-7598-2021	Popa, Simona
E-4989-2016	Hamari, Juho	ABD-5724-2021	Papadopoulos, Thanos
F-1274-2014	Queiroz, Maciel M	AAA-2954-2022	Matej Cˇerne
AFC-8878-2022	Nunkoo, Robin	AAA-3342-2022	Skerlavaj, Miha
D-4047-2012	Henseler, Jorg	AAB-3200-2022	Oscar Hengxuan Chi
DKT-5055-2022	Pan, Zhao	D-1968-2013	Neeraj Pandey
DNO-2122-2022	Raghavan, Vishnupriya	AAI-8460-2020	Kim, Myung Ja
DVQ-7879-2022	Kaur, Puneet	T-8286-2019	Liu, Zhiyong
DWA-8468-2022	Gupta, Manjul	Q-7249-2016	Mergel, Ines
DYS-7432-2022	Papagiannidis, Savvas	Q-1537-2019	Viglia, Giampaolo
ABB-8212-2020	Rauschnabel, Philipp A.	ACP-0558-2022	Rohita Dwivedi
AAA-6716-2022	Dennehy, Denis	AFA-3904-2022	De’, Rahul
GDY-0668-2022	Scuotto, Veronica	D-5700-2015	Abbas Mardani
GVC-9104-2022	Williams, Michael D	CAG-5312-2022	Manoj Thomas
C-3405-2014	Giannakis, Mihalis	CAG-7783-2022	Samuel Ribeiro-Navarrete
U-7022-2018	Dubey, Rameshwar	H-1132-2017	Kizgin, Hatice
JQV-3207-2023	Del Giudice, Manlio	J-8994-2017	Javier Llorens-Montes, Francisco
CWD-0111-2022	Ismagilova, Elvira	B-7471-2009	Leonardi, Paul M.
S-6616-2016	Del Vecchio, Pasquale	CFM-6125-2022	Basu, Sriparna
O-3577-2016	Le, Phong Ba	V-3143-2017	Chung, Namho
J-6264-2012	Coombs, Crispin	S-2888-2019	Akter, Shahriar
K-4471-2012	Chen, Jianqing	A-3493-2008	Gursoy, Dogan
L-7153-2019	Shiau, Wen -Lung	R-5799-2017	Islam, Tahir
DLK-1530-2022	Patil, Pushp	M-4488-2014	Karjaluoto, Heikki
E-6088-2014	Pee, Loo G.	H-1399-2012	Popovic, Ales
H-7874-2015	Martinez-Conesa, Isabel	H-9687-2012	Balakrishnan, Janarthanan
DSP-2717-2022	Li, Dahui	CVS-9088-2022	Hughes, D. Laurie
DTL-9991-2022	Dezi, Luca	CXJ-2695-2022	Khare, Arpita
O-3112-2013	Meissner, Dirk	C-4161-2019	Medaglia, Rony
DTW-7498-2022	Kwon, Ohbyung	CYH-0503-2022	Kock, Ned
I-1063-2015	Liebana-Cabanillas, Francisco J.	B-3927-2011	Soto-Acosta, Pedro
DUA-0379-2022	Wang, Bin	FSM-8271-2022	Pan, Shan L.
DUR-3641-2022	Zhang, Xing	A-9636-2009	Gil-Garcia, Jose Ramon
S-5893-2016	Barlette, Yves	I-7148-2012	Gong, Yeming
DVV-2537-2022	Ray, Gautam	S-9770-2019	Park, Eunil

Table A3. “Quantitative Information Science” invisible college using journal coupling.

“Quantitative Information Science” invisible college	
Web of Science ResearcherID	Name
C-1449-2013	Thelwall, Mike
B-5561-2008	Waltman, Ludo
B-6042-2008	van Eck, Nees Jan
D-1867-2009	Orduna-Malea, Enrique
A-3926-2008	Bornmann, Lutz
DVC-6550-2022	Costas, Rodrigo
I-8406-2012	Delgado Lopez-Cozar, Emilio
E-7887-2011	Yan, Erjia
G-3982-2014	Martin-Martin, Alberto
AAF-3179-2019	Vincent Lariviere
K-1903-2017	Zahedi, Zohreh
CDD-2947-2022	Wouters, Paul
AAV-2705-2021	Sugimoto, Cassidy R. R.
DBO-6351-2022	Li, Gang
M-3007-2017	Zhang, Lin
DXD-0818-2022	Rousseau, Ronald
B-1937-2010	Kousha, Kayvan
AAC-9098-2020	Abramo, Giovanni
B-4964-2018	Bu, Yi
J-8162-2012	D’Angelo, Ciriaco Andrea
AAK-9998-2020	Zhang, Chengzhi
DWI-4665-2022	Stuart, Emma
ELP-3589-2022	Abdoli, Mahshid
O-5699-2019	Singh, Vivek Kumar
GXL-0410-2022	Song, Min
A-9925-2010	Haunschild, Robin
D-5718-2016	Sotudeh, Hajar
ERH-7733-2022	Deng, Sanhong
GWE-5296-2022	Chang, Yu-Wei
E-1159-2012	Sivertsen, Gunnar
DUY-9726-2022	Asai, Sumiko
U-3206-2019	Lu An
C-4004-2009	Anegon, Felix de Moya
CQJ-3475-2022	Egghe, Leo
V-5990-2019	Santos, Joao M.
K-2360-2017	Wang, Xianwen
AAB-5998-2019	Arroyo-Machado, Wenceslao
A-3968-2010	Torres-Salinas, Daniel
D-6762-2012	Guns, Raf

Table A4. “Library Science” invisible college using journal coupling.

“Library Science” invisible college			
Web of Science ResearcherID	Name	Web of Science ResearcherID	Name
B-9630-2017	Dickson K. W. Chiu	R-2454-2019	Widdersheim, Michael Majewski
GBO-6346-2022	Liu, Xiaoping	GWM-0658-2022	Smith, Mark
DBP-3952-2022	Kshetri, Nir	G-3960-2010	Lin, Boqiang
DTV-4307-2022	Chen, Chia-Chen	AAA-5598-2022	Ameen, Kanwal
FZE-7459-2022	Duan, Yan-Qing	DWT-0761-2022	Hider, Philip
ITB-4212-2023	Zhang, Jinbao	DXD-7332-2022	Rowberry, Simon
DEJ-6792-2022	Liang, Z. T.	DYP-5974-2022	Scoulas, Jung Mi
EIW-3090-2022	Zhang, Dan	AAJ-7210-2020	Garner, Jane
GCB-7145-2022	Maier, Christian	ABI-8322-2020	Al-Okaily, Manaf
HDJ-3925-2022	Cui, Lili	AEK-5815-2022	Subaveerapandiyan, A.
L-4613-2018	Onan, Aytug	AHA-0112-2022	Boukacem-Zeghmouri, Cherifa
CTA-8464-2022	Gupta, Babita	JWF-4398-2024	Fair, Jeanne M.
C-8481-2011	Crick, Tom	DRA-2241-2022	Ruthven, Ian
L-7252-2018	Yao, Yao	DXA-2186-2022	Herman, Eti
DSB-9889-2022	Adler-Milstein, Julia	EJH-3168-2022	Arshad, Alia
DTU-2809-2022	Shaw, Shih-Lung	AAD-9788-2021	Ganaie, Shabir Ahmad
DTX-8152-2022	Liu Penghua	H-8349-2016	Martinez-Avila, Daniel
DVF-7317-2022	Chunara, Rumi	IZP-7689-2023	Feng, Xin
DWW-6778-2022	Chen, Ji	CFD-5029-2022	Blayney, Peter W. M.
DXH-2650-2022	Mandl, Kenneth D.	CFE-5681-2022	Baldwin, Peter
DXZ-6563-2022	Platt, Richard	D-2471-2009	Sittig, Dean F.
K-1500-2019	MerigoLindahl, Jose M.	DUW-9963-2022	Aharony, Noa
C-2045-2008	Buhalis, Dimitrios	DVZ-6308-2022	Sims, David
E-8297-2013	Ho, Kevin K. W.	ECT-4308-2022	Vitorino, Elizete Vieira
AAE-1652-2019	Yang Yue	G-6502-2011	Swigon, Marzena
AAF-8089-2020	Korukoglu, Serdar	FYT-0475-2022	Batool, Syeda Hina
AAC-2318-2020	Zipf, Alexander	FZV-0786-2022	Onyancha, Omwoyo Bosire
ABD-2723-2020	Testa, Paul A.	GCL-6340-2022	Tenopir, Carol
AAU-5995-2021	Nchofoung, Tii N.	GDU-9018-2022	Yu, Chuanming
AHB-0858-2022	Brian Weeks	N-8276-2014	Nicholas, David
CEO-5976-2022	Bhatti, Rubina	DKU-4430-2022	Parasie, Sylvain
A-1235-2013	Li, Xia	J-9568-2016	Cox, Andrew M.
CGP-8618-2022	Bin Naeem, Salman	CBK-7440-2022	Adekoya, Clement Ola
J-8998-2019	Manoj Kumar Tiwari	A-7857-2017	Talat Islam
AAB-6850-2020	Hanafizadeh, Payam	EOA-3184-2022	Casarin, Helen de Castro Silva
AEV-8555-2022	Danish	ETK-4724-2022	de Sousa, Ana Claudia Medeiros

"Library Science" invisible college			
Web of Science ResearcherID	Name	Web of Science ResearcherID	Name
V-2488-2018	Vitak, Jessica	GFR-8512-2022	Demeter, Marton
ABE-4906-2020	Verma, Manoj Kumar	GNP-0008-2022	Md. Atikuzzaman
C-4239-2008	Jamali, Hamid R.	AAB-1218-2020	Apuke, Oberiri Destiny
H-1731-2016	Warraich, Nosheen Fatima	IAP-8340-2023	Javier Guallar
B-8125-2010	Abrizah, Abdullah	A-5066-2019	Dias, Thiago Magela Rodrigues
A-6719-2019	Rafiq, Muhammad	H-7410-2012	Farias, Maria Giovanna Guedes
GLV-4793-2022	Lund, Brady D.	DGN-3122-2022	Monsen, Karen A.
EUS-5443-2022	Gandhar, Abhishek	B-6369-2008	Codina, Lluis
HWG-6609-2023	Soroya, Saira Hanif	DRR-2673-2022	Sawhney, Harmeet
DTH-6968-2022	Sun, Shouqiang	A-7845-2010	Oliver, Gillian
DVK-0923-2022	Ngulube, Patrick	A-3499-2014	Holley, Robert P.
EGS-0909-2022	Xu, Jie	B-6818-2008	Corrado, Edward M.
EIJ-8225-2022	Zeng, Zi Ming	ABG-1225-2020	Goyanes, Manuel
HGA-8220-2022	Mahmood, Khalid	AAO-8985-2020	Ford, Heather
CBT-0549-2022	Aljoumani, Said	CMI-6480-2022	de Almeida Jr, Oswaldo Francisco
JGU-9388-2023	Rodriguez-Bravo, Blanca	C-3046-2008	Nwagwu, Williams E.
CTR-4076-2022	Hirschler, Konrad	CRW-6031-2022	Ghosal, Tirthankar
AAT-6389-2020	Nazim, Mohammad	T-6151-2017	Celestine, Gever Verlumun
EGT-6147-2022	Yuvaraj, Mayank 49	AGT-6397-2022	Sharma, Sandeep