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Productivity, visibility, authorship, and collaboration in library and information science journals: Central and Eastern European authors

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Abstract
From the bibliometric point of view, little is known about the development and status of library and information science (LIS) in Central and Eastern European (CEE) countries. Since these countries represent a part of the European Research Area in which the LIS field plays an important role, we aim to investigate the paradigm of their scientific communication. The research sample consists of papers ($n=3301$) from authors with addresses from at least one of the 15 CEE countries (11 EU: Bulgaria, Croatia, Czech Republic, Estonia, Hungary, Latvia, Lithuania, Poland, Romania, Slovakia and Slovenia, and 4 EU potential candidate countries: Bosnia and Herzegovina, Macedonia, Montenegro, and Serbia) published in 160 LIS journals indexed in Scopus in the period 1996–2017. Analyses of productivity, citations, trends in authorship over time, and collaboration were made for the LIS field full sample and five LIS subfields: communication, computer science, information science, library science, and scientometrics. Additionally, we aimed to investigate scientific communication pattern between domestic (CEE) journals, international (non-CEE) journals and the journal *Scientometrics*. Our results show interesting data spanning 21 years including the transition period of the CEE countries.

Keywords Productivity · Authorship · Citation analysis · Library and information science · Journals · Central and East European countries

Introduction

Some countries, research centres, journals, and scientists have contributed significantly to the development of the LIS field. This primarily applies to developed countries in the Anglo-Saxon speaking area, namely the North American continent and Western Europe (Davarpanah and Asleki 2008), and recently, some Asian countries (Wang 2018). When it comes to the contribution of some smaller countries in developing the LIS field, Hungary is the only post-socialist Central and Eastern European (CEE) country with

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a special place thanks to the founders of the journal *Scientometrics* in the Akadémiai Kiadó Budapest.

According to our knowledge, there are not many published papers on the contribution and the development of LIS field in the countries of Central and Eastern Europe representing a special group of countries (Koehler 2001; Uzun 2002; Olmeda-Gómez and de Moya-Anegón 2016). Relevant research in some CEE countries will be discussed in the literature background chapter. In order to understand the situation in the CEE countries, it is important to emphasize that these countries have a common historical socialistic heritage that has influenced society, economic relations, culture, development, and communication in science, especially in social sciences making a clear distinction to Western European countries. Additionally, it is important to emphasize that all CEE countries use their native languages in scientific research and only partially communicate with each other. Interesting examples are Czech Republic and Slovakia, and, to some extent, the countries of the former Yugoslavia. Until the 1990s, most of these countries did not extensively use the English language as a lingua franca in social sciences. Characteristic features of most CEE countries are that libraries, primarily national and those in central universities, played a crucial role in the supply and accessibility of scientific literature and were often the only places where the literature was available. For librarianship purposes, schools or departments for librarianship at universities were founded, which is closely related to the emergence of domestic librarianship journals in most CEE countries. When it comes to information sciences in CEE countries, there is no consensus about their organization, even within individual countries. The relation between information sciences with library science still prevails, as libraries were, and remain, the primary sources for information science development. On the other hand, although a common historical background binds the CEE, each country had their individual level of openness to Western countries even before the 1990s. Indeed, the transition process after the 1990's in each CEE country followed its own dynamics, which is evident in their different scientific activity and economic development.

11 out of 15 countries involved in this research are members of the European Union, and the remaining countries are at different stages of EU accession negotiations. These countries act as an integral part of the common European space and have a significant scientific potential that could, in line with the European Research Area policy concept, mobilize knowledge, researchers, and technology towards greater internal cohesion and integration (Makkonen and Mitze 2016). Therefore, the aim of this research is to provide insight into LIS scientific activity and communication for this group of European countries, as well as to elucidate their contribution in the development of the field.

Due to the interdisciplinary nature of the LIS field, we decided to provide an analysis across five LIS subfields: information science, library science, computer science, scientometrics and communication.

Particular attention was given to the prestigious journal *Scientometrics*, as it was created and developed in Hungary. With this aim, we have set the following research goals which will be thoroughly addressed:

1. Define the contribution of the Central and Eastern European country authors to the LIS field measured by the number of published papers in LIS journals and their visibility measured through citations.
2. Evaluate whether the distributions of CEE author papers in LIS journals follow a power law distribution, and define the most influential authors.

3. Analyse the trends in authorship in LIS field in the period from 1996 to 2017 and elucidate the differences between papers published in domestic CEE journals, international journals non-CEE journals and the journal *Scientometrics*, as well as between LIS subfields.
4. Determine whether there is a significant difference in citation ratio between single-authored and co-authored papers depending on LIS subfields, as well as CEE journals, non-CEE journals and the journal *Scientometric*s.
5. Define the characteristics of co-authorship collaboration patterns: mutual collaboration CEE countries authors, collaboration with other countries, differences in co-authorship on papers published in CEE journals, non-CEE journals and in the journal *Scientometrics*.

Literature background

Monitoring LIS field development through productivity and citation research is most commonly performed through a bibliometric analysis of journal papers. One of the first studies of productivity across countries and regions was done by Bottle and Efthimiadis (1984) on the sample of 1391 LIS journals indexed in LISA and ISA databases. This study found that only 13.2% represented papers from East European countries and the USSR. Uzun (2002) investigated the representation of papers from developing and Eastern European countries in 21 SSCI, LIS journals in the period of 1980–1996. These results revealed a share of only 7.9%. Most CEE countries (from our sample) had less than ten papers in LIS journals, although Poland and Hungary were significant exceptions, with 40 and 38 papers authored, respectively. Although the author did not provide comments for these results, an explanation of the results for Hungary is likely related to papers in the journal *Scientometrics*. The research of Davarpanah and Aslekia (2008) on the geographic distribution of papers in international LIS journals, as indexed in WoS, showed that Poland was the only CEE country recognized by the productivity. Sin (2011) researched international cooperation and citation impact using a sample of six WoS LIS journals during the period of 1980–2008, and showed that among the top-ten contributing countries in 5-year intervals, only two of fifteen CEE countries, again, Poland (1980 -1984) and Hungary (1980–1984, 1985–1989, 1990–1994), were present.

Olmeda-Gómez and de Moya-Anegón (2016) investigated the publishing intensity of European countries in Scopus LIS journals during the period of 2003–2012. While the CEE countries accounted for a share of 7.3% in their sample, the compound annual growth rate was 17.4%, which is significantly higher than the growth rate in Western Europe (9.1%) and the worldwide mean. The annual growth rate is attributed to the papers of a smaller number of countries, partly due to domestic journals recently included in Scopus. Although the results of research by Juradja et al. (2017) were not directly related to the LIS field, they indicate that the post-communist countries of Central and Eastern Europe (CEE) are not present in the most systematic international comparisons of scientific publication and citation performance.

Several authors have been analysing the contributions of individual countries by measuring the number of papers published in prestigious LIS journals. Koehler (2001), for the occasion of the 50th Anniversary of the *JASIS* journal, found that the share of authors from East Europe was 0.7%, while the USA and Canada accounted for 85%. Schubert (2002) analysed 50 years of the journal *Scientometrics* and found that four

CEE countries were among the 29 most productive countries: Hungary 8.73%, Poland 0.97%, Bulgaria 0.76%, and the Czech Republic 0.69%. He and Spink (2002), in research concerning geographic authorship distribution in *JASIST* and *Journal of Documentation* from 1950 till 1999, showed that authors from Hungary, Slovenia, Poland, Croatia, Romania, and Bulgaria contributed with total of 20 papers, which is relatively a small number in comparison to papers from UK (125) or Canada (110). The research for the occasion of the 50th Anniversary of the *Information Science* journal (Merigó et al. 2018) showed that among the most cited papers, from our sample, were those with authors from Poland, the Czech Republic, Slovakia, Romania, Serbia, Hungary, and Slovenia.

A few authors from CEE countries investigated the LIS field status of individual countries. Steinerová (2003) presented information science research in Slovakia and collaborations in Central European countries. Sapa (2007) was interested in international contribution to the system of library and information science communication in Poland during the period of 2003–2005. His results showed that publications from foreign authors comprise less than 7% in Polish LIS literature. Polish LIS community absorbs global achievements and ideas, but translates them into Polish and processes the information in Poland using mainly Polish tools. Fiala and Willett (2015) conducted a bibliometric analysis of computer science publications by East European authors indexed in the Web of Science during the period of 1983–2003. Although this study investigated computer science as a hard science, it may be potentially relevant for this literature review. Their results show that the most productive country was Poland, followed by the Czech Republic, Romania, Hungary, and Slovenia. In terms of citations per paper, Hungary and Slovenia were the most influential countries. Pajić (2015) explored the pattern changes of international scientific production using a sample of 20 East European countries with a focus on social science and humanities during the 2004–2013 period. He concluded that East European social sciences, except for Hungary and Poland, still heavily relied on language, regional, and cultural proximities. This conclusion could also refer to the LIS as a social science field. Juradja et al. (2017) investigated the publication performance of CEE country authors covered by WoS in the period of 2010 to 2014. Though the LIS field did not explicitly analyse this, the results for social science show that Slovenia is the only CEE country, whose work is normalized by per capita article count in the top 25% journals, which is above the average in comparison with other countries. The ratio of quantity-quality gradients in research publishing in social sciences from Western/CEE countries were 2.88/0.52, which supports the claim that the CEE countries, excluding Slovenia, were not highly recognized in the social sciences. Based on the results of the aforementioned research, it is apparent that LIS authors from CEE countries are published in less prestigious journals and, consequently, potentially less visible on the international level. Therefore, it is not surprising that some CEE authors do not take place on the list of the most cited authors (Walters and Wilder 2016). Luukkonen and Nedeva (2010) suggested reducing fragmentation of the CEE countries, along with increasing the level of integration in common European research policy. One of the forms of integration is collaboration and international co-authorship. Research by Kozak et al. (2015) showed that international co-authorship relations with CEE countries in the period of 1990 to 2011 were smaller than expected. They claimed that most of the Eastern European countries were still subject to changes and were still awaiting their boost in scientific development, which also holds true for the LIS field. Makkonen and Mitze (2016) confirmed the gradual positive effects on collaboration and co-authorship after CEE countries enter into the EU. It is important to keep in mind that the rate of international co-authorship

in the LIS field, and its relationship with citation impact, is still not frequently measured, even on the international level (Sin 2011).

Data and methodological approach

Data collection

The sample for this research is an integral part of the database created for the project "Research activity, collaboration and orientation in social sciences in Croatia and other post-socialist European countries (RACOSS)—IP-09-2014-9351" (http://racoss.idi.hr/index_en.html). Research covered 11 EU member states: Bulgaria, Croatia, Czech Republic, Estonia, Hungary, Latvia, Lithuania, Poland, Romania, Slovakia and Slovenia, as well as four EU (potential) candidate countries: Bosnia and Herzegovina, Macedonia, Montenegro, and Serbia. The project database contains bibliographic data obtained from the Scopus database. The Scopus database, as a source for bibliometric research, has been given preference over WoS, as its coverage of social sciences is more comprehensive (de Moya-Anegón et al. 2007; Hoogendoorn 2008; Leydesdorff et al. 2010).

In order to get a relevant recall from Scopus, the search strategy included four filters: (1) authors who have listed at least one of the 15 CEE countries as Affiliation Country, (2) papers classified according to Scopus ASJC (All Science Journal Classification) code list in the "top-level" subject category Social Sciences, (3) papers published in the period of 1996–2017, and (4) papers classified as an article and review paper. Search history query was: Affiliation country (Bosnia and Herzegovina OR Bulgaria OR Croatia OR Czech Republic OR Estonia OR Hungary OR Lithuania OR Latvia OR Macedonia OR Montenegro OR Poland OR Romania OR Slovakia OR Slovenia OR Serbia) AND subject area (Social sciences) AND source title (journal) AND document type (article OR review) AND publication year (1996–2017). The search recall resulted in 120,620 papers published in 4896 journals. Each paper contained a bibliographic record with the following metadata: author(s), paper title, journal title, year, volume, pages, author(s) affiliations including country or countries, number of citations, abstract, keywords, subject area. Data was extracted in csv format and converted in excel. Description of cleaning process of obtained bibliographic data for the final project database is provided in "Appendix 1".

This research is limited to the library and information science field as one of 10 fields of social sciences classified according to modified OECD Frascati Field of Science (FOS) ("Appendix 1"). The research sample was defined by LIS subject experts based on excerpted journals from the dataset of 4896 journals obtained by above mentioned retrieval strategy. Three LIS project subject experts checked each journal and extracted those journals that belonged to the LIS area. Journals were extracted based on subject experts' knowledge about the journal, based on journals title, as well as descriptions of the journal subject issues and other relevant data available by the publisher or journal web site. After a thorough expert checking of journals, and manual checking of the document type (article or review) final dataset resulted with 3301 papers published in 160 journals. It is important to stress that this research covers only papers of authors with affiliation address from CEE countries. CEE LIS authors who conducted their research outside CEE countries, and did not register their CEE country addresses, were not included in the sample. Within the full sample, the share of LIS papers for CEE authors during the period 1996–2017 was 5.6%, and LIS journals for 3.2%.

According to the date from SCImago Journal and Country Ranking (https://www.scimagojr.com) Scopus indexed 208 LIS journals with bibliometric indicators. Olmeda-Gómez and de Moya-Anegón (2016) showed that LIS papers authored by European Union researchers in the period of 2003–2012 were published in 149 journals classified by Scopus as "Library and Information Science", while Eastern European authors published in a total of 88 journals under the same heading. Additionally, Larivière et al. (2012) stated that LIS accounts for roughly 1.5% of all WoS-indexed journals classified as Social Sciences and Humanities (SSH).

LIS subfields and journal categories

Because of interdisciplinary nature of library and information science field, as well as the assumed differences in scientific communication for some subfields and disciplines, the journals were divided into five LIS subfields: library science, information science, computer science, scientometrics, and communication. Project subject experts in this field conducted the division of journals based on their professional experience, journal title and description of the issues addressed by the journals. Waltman et al. (2011) in their research, although on the different methodological foundation, divided LIS journals into three clusters: library science, scientometrics, and general information topic journals. Aharony (2012) applied a slightly modified Zins classification scheme of information science (Zins 2007), which included ten key topics or subfields. Aharony's results showed that with the largest share of publications were those in the subfields of LIS, information science, computer sciences, and communication. Our division into five LIS subfields is based on the journal sample characteristics and is the combination of the two divisions mentioned (Table 1, and "Appendix 2").

The subfield of information science is the widest by subjects, which is visible by both, in the number of journals and the number of papers. This subfield included journals that did not fit (based on the titles and main topics they cover) into the other four categories. Because of the underlined multidisciplinary tendencies of this subfield with the diversity of journal titles and subject issues, we did not employ further divisions. More specifically, we did not provide the LIS subfield classification at the article level. Creating reliable divisions and firm boundaries between subfields and disciplines requires detailed checking of the issues and subjects the journal deals with. For example, journal *Information Science*, whose title directly refers to the LIS subfield information sciences, is, in fact, a journal

Table 1 Share of journals and papers by LIS subfields and origin of journal publishers (Central and Eastern European countries—CEE or non-CEE countries)

LIS subfield	*N* journals		*N* papers (1996–2017)	
	CEE journal's country	Non-CEE journal	CEE journals	Non-CEE journals
Information science	Hungary 1; Croatia 2	66	485	924
Library science	Croatia 1	47	273	410
Communication	Slovenia 1; Croatia 1	30	147	136
Computer science	0	9	0	608
Scientometrics	Hungary 1	1	275	43
Total	7	153	1180	2121

that deals almost exclusively with the problem of computer science. Therefore, to obtain the most reliable sample for analysis, the knowledge and experience of LIS experts were indispensable.

Classifying the journals into the subfields of library science and communication, the title of the journal explicitly contained terms related to library or communication issues. By additionally randomly checking article titles in those two subfields, the justification of our journal classification was confirmed. In the subfield of scientometrics, papers from only two, though crucial journals, *Scientometrics* and *Journal of Informetrics*, were included, with a share of approximately 10% within the LIS sample. Although other LIS prestigious journals (*Journal of the Association for Information Science and Technology (JASIST)*, *Information Processing and Management, Journal of Documentation*, etc.) publish scientometric papers, this is not their core subject matter.

The LIS journals were further divided into two groups based on the publisher criteria: CEE journals with publishers from one of the CEE country, and international or non-CEE journals. CEE LIS journals have a different paradigm of authorship and collaboration as well as subject issues in comparison to non-CEE journals. Those journals, primarily if their papers are written in the native languages of small nations, often deal with local issues and are more oriented to professional work. Therefore, much of their visibility measured by the number of citations received is lower compared to international or non-CEE journal papers. Precisely, the values of their bibliometric indicators are lower compared to international journals (Rey-Rocha and Martín-Sempere 2004; Sapa 2007). Commonly, most CEE countries have a relatively large number of domestic journals, especially in social sciences, and their papers are often published in native languages (Sivertsen 2016). Although all CEE countries have LIS domestic journals, only a small number meets the criteria for entering the Scopus database. In our sample, only seven journals, including *Scientometrics* (Table 2), are indexed by Scopus. *Scientometrics* was included in this group because Hungary is the birthplace and homeland of this journal (Schubert 2002), although it's current publisher is Springer. Because of its vital role in the LIS field, we have analysed it as a separate category in this paper. Only three out of the 15 CEE countries are represented with LIS journals indexed in Scopus: Croatia with four journals (*Informatologia, Journal of Information and Organizational Sciences*, *Medijska istraživanja* and *Vjesnik bibliotekara Hrvatsk*e) followed by Hungary—two journals (*Scientometrics* and *Informacios Tarsadalom*) and Slovenia with the journal *Javnost*. CEE journals dealing with the issue of

Table 2 Central and Eastern European (CEE) countries LIS journal papers and citations ratio

CEE journals	Journal publisher country	LIS subfield	*N* paper 1996–2017/1996–2014	Citations per paper [a]
Javnost	Slovenia	Communication science	89/67	3.52
Medijska istraživanja	Croatia	Communication science	58/39	1.36
Informacios Tarsadalom	Hungary	Information science	106/62	0.4
Informatologia	Croatia	Information science	244/195	0.7
Journal of Information and Organizational Sciences	Croatia	Information science	135/114	3.11
Scientometrics	Hungary	Scientometrics	275/207	29.62
Vjesnik bibliotekara Hrvatske	Croatia	Library science	273/168	0.71

[a]Citations per paper published in the period 1996–2014

the four LIS subfields and their papers form a share of 35%. The sample does not include any CEE peer-reviewed journals in the LIS subfield of computer science. A possible reason is that these LIS subfields emerged in the CEE countries at the end of the 20th century, after the establishment of the department and faculties, as well as the broader use of computers. It is difficult to determine whether a journal belongs exclusively to computer science (hard science) as a standalone field, or the LIS computer science subfield. In this research, the title and content related to information science, as well as a decision by subject experts determined the selection of journals in the LIS subfield of computer science.

Variables

In order to address the research questions of this research, we extracted the following variables: (1) authors productivity (2) authorship type—single-authored and co-authored papers (number of authors: 2, 3 and 4 and more), (3) publication year 1996–2017, (4) authors country (EU countries: Bulgaria, Croatia, Czech Republic, Estonia, Hungary, Latvia, Lithuania, Poland, Romania, Slovakia and Slovenia; and four ex-Yugoslav countries as current EU candidates: Serbia, Bosnia and Herzegovina, Montenegro and Macedonia), (5) journal's country of origin: CEE—domestic journal published in one of 15 CEE countries, and non-CEE or international journals, (6) LIS journals subfields: information science, library science, computer science, scientometrics, and communication; (7) Co-authorship collaboration by countries, and (8) the number of citations each paper received. Scopus citations data was collected in October 2018 and refers to the papers published in the period 1996–2014 ($N=2421$). We believe that the period of 4 years for papers published in 2014 is sufficient to be noticed and potentially cited. Ronda-Pupo and Katz (2018) in their research used roughly the same period; more precisely, they used a fixed five-year time window, which included the year of publication plus four additional years, which confirms our choice. Since this is only an initial broad study on LIS field in this group of countries, we did not engage into more complex citation analyzes.

For cross-national comparisons of LIS contribution in social science field we have computed Activity Index (AI). AI used in this research is a modification of Schubert's AI (Schubert 2002), e.g., AI = percentage share of the CEE countries LIS papers ($n=3301$)/ Percentage share of the CEE countries in social science papers ($n=58{,}512$).

When assessing author productivity, we aimed to determine whether the frequency distribution was consistent with Lotka's law. Depending on the productivity and citations ratio, the most influential CEE LIS authors were identified. The group containing the most influential authors included: authors with more than five papers, with citations above the median of the average citations by the author, and authors who published their papers in three or more LIS subfields. In order to check the justification for the selection of the most influential CEE LIS authors, we have investigated the *h*-index values for their overall scientific activity, as well as their co-author networks.

In addition to a graphical presentation of the dynamics in the trends of co-authorship over time, the collaborative coefficient was used as a measure of the degree of collaboration (Subramanyam 1983), which is defined as the ratio of the number of collaborative research papers and the total number of research papers published in the LIS subfields in the period of 1996–2017. In this paper, the co-authorship networks were processed at an admittedly superficial level in order to obtain an elementary picture of authors' collaboration and did not engage into a more detailed analysis or interpretation. Vosviewer software was used in presentation co-authorship networks.

Results

Research question 1: productivity and citation contribution

During the period of 1996–2017, authors with addresses from at least one of the 15 Central and Eastern Europe countries published 3301 papers in the 160 LIS journals. Approximately one-third ($n=1180$) of the papers were published in CEE journals and the remaining in non-CEE or international journals. When considering the distribution of these papers by years, it is noticeable that in the period of the first 10 years, between 1996 and 2005, only about 10% of papers ($n=321$) were published. In that same time span, the ratio of papers published in CEE and non-CEE journals are almost identical (Fig. 1).

The first significant increase in the number of papers within the full sample is in 2006, and can be attributed to the papers in the LIS subfield of information science. The next significant increase was observed in 2014 ($n=224$), to which all five subfields contributed, with an emphasis on papers from computer science and communication subfields. Papers published in CEE LIS journals have slightly different dynamics. The first major increase in

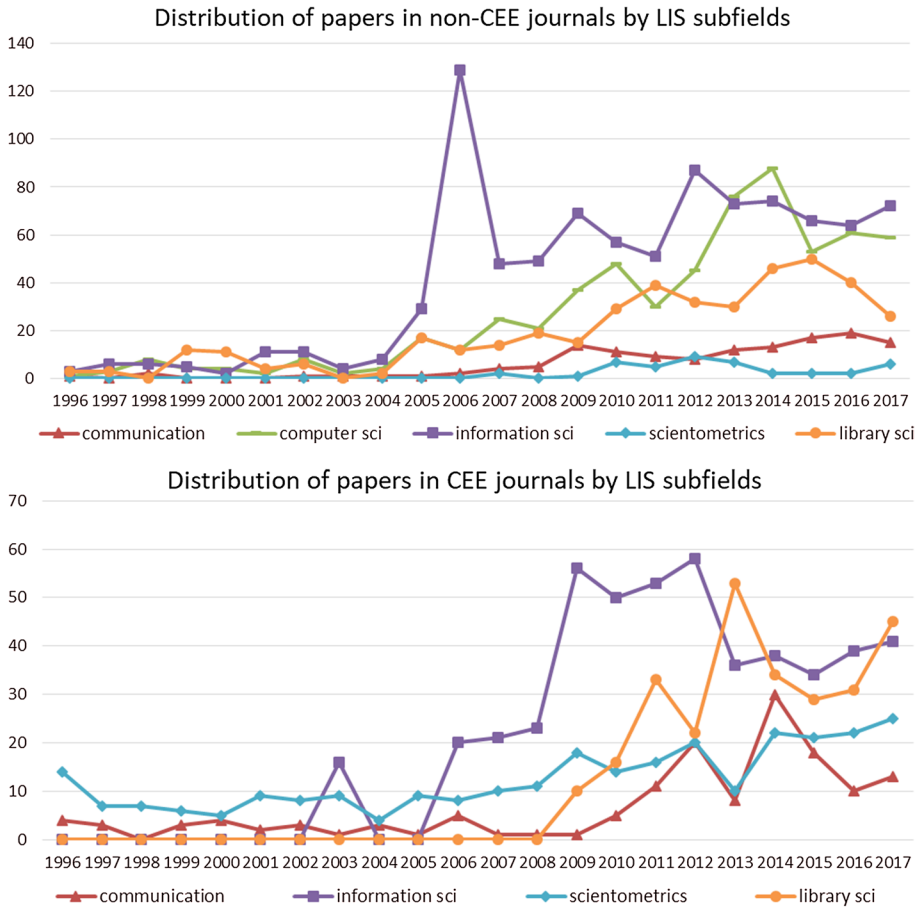

Fig. 1 Distribution of Central and Eastern European (CEE) LIS author papers in time span 1996–2017

the number of papers was observed in 2009, and the most considerable contribution was from the LIS subfield of information science. Likewise, another increase in the number of papers from CEE journals was observed in the year 2014. The characteristics of the LIS subfield scientometrics is a continuous increase in the number of papers.

It is essential to emphasize the existence of a significant difference between two subsets of journals (CEE and non-CEE) in the average number of papers per journal. In subset CEE journals (Table 1), an average of 168.6 papers were published per journal, while the average of papers per non-CEE journal was 15.8. The range of published papers in non-CEE journals was from 1 to 431 papers, with a median of 5 papers per journal. An additional feature of the CEE journal subset is the absence of journals classified into the LIS subfield computer science (Table 2).

A commonality for both journal subsets is that the most significant representation of papers was from the LIS subfield of information science (Fig. 2), resulted in a share of 42.6% ($n=1409$) for the full sample. Paper representations in the full sample by other LIS subfields were: library science 20.7%, computer science 18.4%, scientometrics 9.6% and communication 8.6%.

Recognition of CEE journal papers measured by average citations per paper showed significant differences between LIS subfields (Table 2). As expected, the most significant deviation in citation ratio referred to the journal *Scientometrics* (average citations per paper was 29.6). Although the Scientometrics was originally a Hungarian journal, it has expressed a strong international character from the beginning which promoted it to the leader in developing scientometrics as a discipline as well as in LIS subfield. Papers in CEE journals in the LIS subfields of information science and library science received one citation per paper on average (Table 2).

Differences in the citations of papers published in CEE and non-CEE journals, as well as within individual LIS subfields are listed in Table 3. In the full sample, 25.27% (612 of 2421 papers published in the period 1996–2014) papers were not cited. High frequency of non-cited papers (55.66%) corresponds to papers published in CEE journals (except the journal *Scientometrics*). The analysis of LIS subfields showed that the

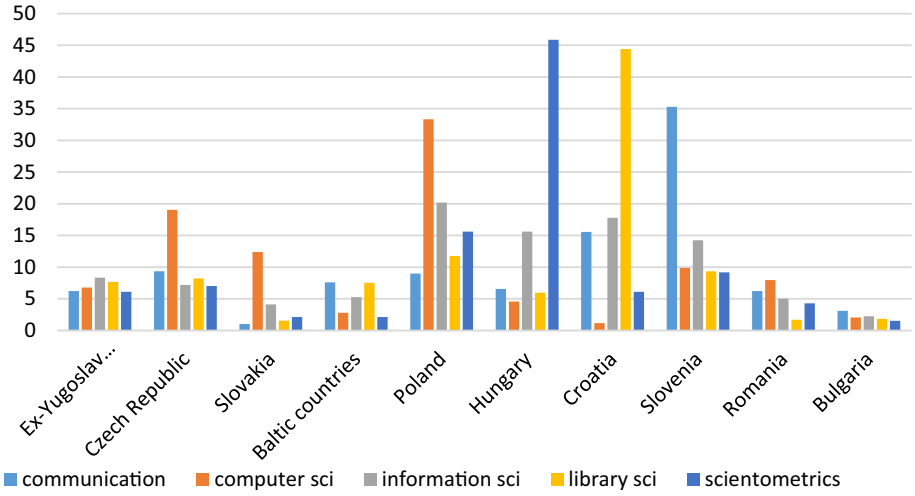

Fig. 2 Distribution of papers by five LIS subfields depending on the author's country

Table 3 LIS subfields and Central and Eastern European (CEE) and non-CEE journals citation pattern for papers published in the period 1996–2014

LIS subfield	Mean citations per paper	Median citations per paper	Highest citations per paper	Non-cited papers (%)
Communication science	5.87	2	206	27.75
Computer science	33.06	13	921	4.37
Information science	7.71	2	341	32.2
Library science	5.51	1	229	39.39
Scientometrics	28.18	15	357	2.5
CEE and non-CEE journals				
CEE journals	8.28	1	357	42.72
CEE journals (excluding *Scientometrics*)	1.43	0	42	55.66
Non-CEE journals	16.69	6	921	15.81

largest share of non-cited papers was in library science (39.4%), followed by information science (32.2%), and communication (27.75%). The LIS subfields of scientometrics and computer science had a remarkably smaller share of un-cited papers in comparison to other LIS subfields, 2.5% and 4.37%, respectively. The difference between average citations per paper published in CEE and non-CEE LIS journals is evident (Table 3). The mean citations per paper in CEE journals (without the journal *Scientometrics*) was 1.43 with the median 0, while in non-CEE journals citations per paper was 16.69 and with the median was 6. In the full sample, mean citations per paper was 13.73, with a range from 0 to 921 citations, while the median of citations per paper was 3. The journal *Scientometrics* greatly deviates from the average citations per paper (29.62).

The contribution of each CEE country or a group of related countries to the LIS field is shown in the Fig. 2. The data were normalized by the number of papers per subfield and displayed at the full sample level. Some of the CEE countries stood out for productivity in specific LIS subfields: Hungary in scientometrics, Croatia in library science, Slovenia in communication, and Poland and the Czech Republic in computer science subfield. Information science subfield characterized an almost equal number of published papers from several countries: Poland, Croatia, Hungary, and Slovenia. It is necessary to point out that almost all CEE countries, with leading Hungary, published papers in the LIS subfield of scientometrics, although this subfield represents 10% of the full sample.

A more detailed insight into productivity concerning the total and *per capita* number of published papers, their distribution in CEE or non-CEE journals, and the recognition of these papers in the relevant scientific community is shown in Table 4.

Top five countries by total productivity in absolute values are Poland, Croatia, Slovenia, Hungary and the Czech Republic, while the distribution is different concerning per capita papers (Table 4). Papers published in domestic journals had a profound influence on the status of Croatia (Table 2). Regarding Hungary and Slovenia, the impact of their domestic journals was also important, though to a lesser extent than Croatia. Analysis by number of papers published in international non-CEE journals ranking Poland as the most productive country, followed by the Czech Republic, Slovenia, Hungary, and Romania. The Activity Index (AI), which compares the share of the LIS papers within

Table 4 Central and Eastern European (CEE) countries productivity and average number of citations per paper

CEE country	*N* papers 1996–2017	*N* papers per capita	*N* papers in native country journals	*N* papers in CEE journals	*N* papers in non-CEE journals	Citations per paper published 1996–2014[a]	Citations per paper published 1996–2014 in non-CEE journals	AI (Activity Index)
Bosnia and Herzegovina	40	0.011		18	22	6.42	10.63	1.48
Bulgaria	74	0.010		8	66	9.26	9.68	1.3
Croatia	646	0.157	512	533	113	2.79	6.69	1.95
Czech Republic	342	0.032		41	301	13.55	14.47	0.69
Estonia	110	0.083		5	105	9.65	9.9	0.82
Hungary	470	0.048	239[b]	245	225	20.77	15.12	1.03
Latvia	20	0.010		1	19	2.73	2.73	0.52
Lithuania	48	0.017		4	44	4.24	3.94	0.20
Macedonia	13	0.006		1	12	9.78	9.78	0.45
Montenegro	9	0.014		5	4	6.6	14.5	0.91
Poland	681	0.017		51	630	23.16	24.46	1.08
Romania	171	0.008		15	156	16.44	16.73	0.42
Serbia	198	0.028		52	146	13.49	14.93	1.18
Slovakia	165	0.030		36	129	13.49	15.74	0.74
Slovenia	473	0.228	67	192	281	11.81	16.7	1.56

[a]Citations obtained in October 2018

[b]139 Paper published in the journal *Scientometrics*

social sciences papers for each of the individual countries, revealed a different country order. Croatia showed the most extensive AI, followed by Slovenia, Bosnia, Bulgaria, and Serbia (Table 4).

The citation ratio in the full sample for individual country papers exhibited noticeable differences concerning average citations (13.73). The most cited LIS papers were by Polish authors (23.16 citations per paper), followed by Hungarian, Romanian, Czech, Slovak, and Serbian authors. The lowest citations were from Latvia, Croatia, and Lithuania, with an average of less than 5 citations per paper. In the subset of papers published in international or non-CEE journals, the most cited papers were published by Polish authors, followed by Romanian, Slovakian, Serbian, and Czech authors. Papers with the highest average citations were in the LIS subfields of computer science and scientometrics (Table 3).

Research question 2: author productivity pattern

In the full sample among 5199 different authors, 3668 were detected as authors with CEE country addresses. Their productivity in the period of 1996–2017 ranged from one to 88 papers per author. The largest number of authors, 78.08%, published only one paper, which correlated with Lotka's law. The average number of papers per author was less than one in the period 1996–2017, or more precisely 0.89 paper. The share of authors with an average of one paper in 2 years was 0.84% (or 31). In this group of authors, the largest share was from Slovenia, Hungary, and Poland. Analysis of the LIS subfields showed that the most productive author group were represented in the subfields of information sciences and library science, followed by subfields of scientometrics, computer science, and communication. The most productive authors during the same period were not the most cited authors. This holds true particularly for authors who published in CEE LIS journals, with the exception of the journal *Scientometrics*. Out of the 3686 authors, only 1.7% ($n=64$) authors published 5 and more papers which received above the average number of citations per author (14.5). From this group of authors, less than half have published their papers in journals for one LIS field. The authors, ten in total, who had papers in journals in three of the LIS subfields, were considered as influential authors in the LIS field. These are Glänzel W. and Vinkler P. from Hungary, Mesiar R. from the Czech Republic, Doreian P., Mladenić D., Južnič P., Vehovar V. and Bartol T. from Slovenia, Ivanović D. from Serbia, and Špiranec S. from Croatia. Productivity and openness to collaboration for the most influential CEE LIS authors (Fig. 3) were visible in their co-authorship network. *H*-index values of their overall scientific activity as additional proof of their influence, were in the range of 49 to the 6, according to Scopus data.

The analysis of the co-authorship network of the most influential CEE LIS authors revealed that in the period of 1996–2017, there were no mutual co-authorship collaborations amongst the ten most influential authors, apart from two authors from Slovenia (Južnič and Bartol). Although these authors published papers in at least three LIS subfields, the co-authorship networks of the two most prestigious scientometricians, Glänzel and Vinkler particularly stood out. Glänzel showed a vast network of co-authors ($N=41$), while Vinkler exclusively published papers in a single-authored manner. Developed networks were pronounced among the authors that mainly publish their papers in journals in the computer science subfield (Mesiar, Ivanovic, and Mladenic). All other authors had collaborative networks with at least seven different co-authors.

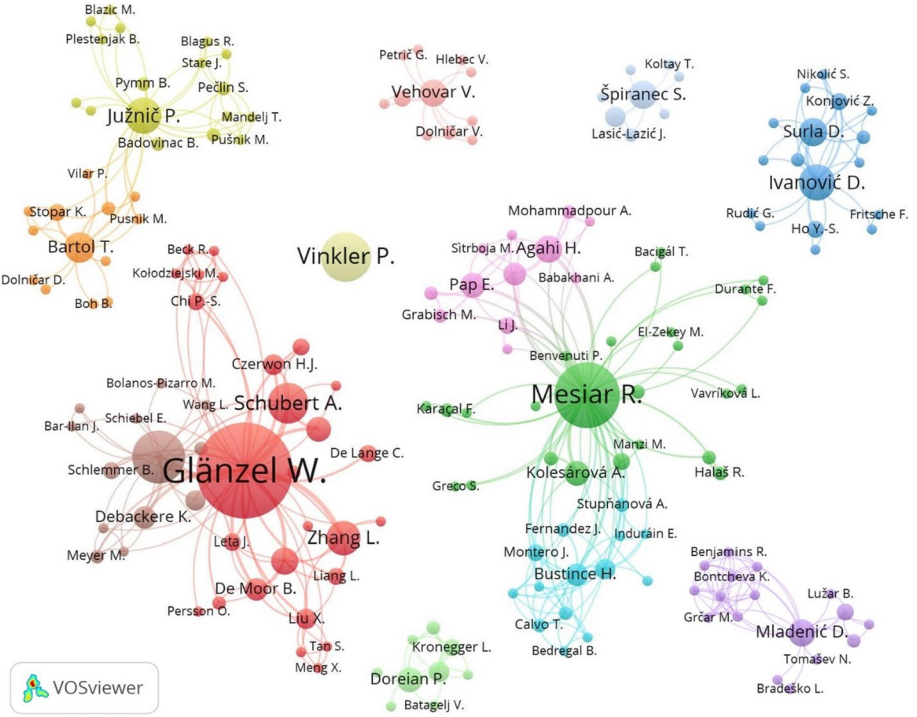

Fig. 3 The most influential Central and Eastern Europe LIS authors' networks

Research question 3: authorship trends

In the full sample, single-authored papers were the most represented with the share of 35.3% ($n = 1.166$), followed by two-authored papers with 30.8%, three-authored with 20.2%, while papers with four and more authors accounted for 13.6%. The average number of authors per paper was 2.33, with a range of 1 to 99 authors per paper. Several intervals pointed out the changes in the distribution of single-authored papers in terms of reducing their number, namely in 2004, 2007, and 2015 and onwards (Fig. 4). The distribution of two-authored papers as the most represented papers after the single-authored papers showed a significant increase in the 2010–2014 interval, followed by a significant fall. Continuous growth of three and multi-authored papers was recorded in the interval from 2008 to 2017 (Fig. 4).

The analysis of individual LIS subfields showed that the share of single-authored papers was represented mostly in library science (48.6%) and communication with (47.7%) followed by papers in the LIS subfields of scientometrics (37.4%) and information science (32.1%). The most significant deviation in the share of single-authored paper was in the LIS subfield of computer science, with a share of 20.9%.

The specificity of the information science subfield is that single-authored and two-authored papers are equally represented. Subfields of scientometrics and information science showed a proportionally equal share of papers created in co-authorship with four and more authors, 14.5% and 14.1%, respectively. The authorship distribution in the computer

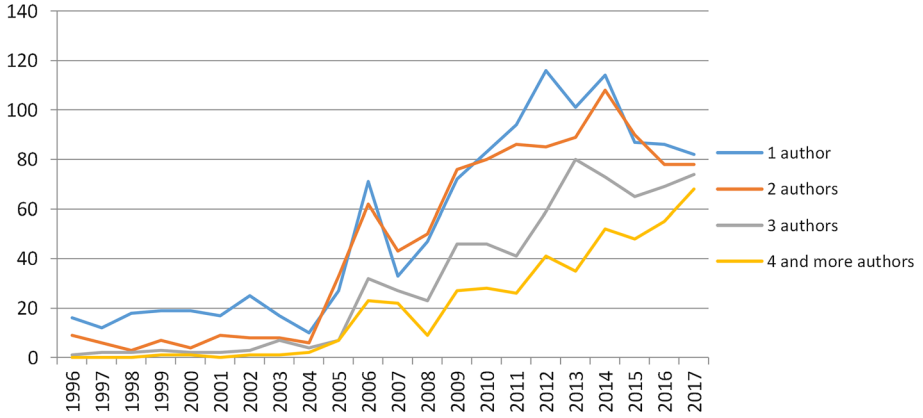

Fig. 4 Trends in authorship over the period 1996–2017

science subfield considerably differed from the other four LIS subfields and was characterized with the smallest share of single-authored papers and, proportionally, the largest share of papers with four and more authors (Fig. 5).

The assumption of the existence of differences in co-authorship pattern between papers published in CEE, non-CEE journals, and in the journal *Scientometrics*, proved to be correct as seen from trend lines in Fig. 6.

The co-authorship data by journal groups were normalized according to the proportion of co-authorship in the full sample. The average number of authors per paper in the full sample was 2.3. The highest average number of co-authorship papers form a group containing non-CEE journals, 2.5, followed by the journal *Scientometrics* 2.3, and CEE journals (without the journal *Scientometrics*) with 1.8 authors per paper. In the case of CEE journals, although there is a linear increase in co-authorship papers, this growth is slower than in non-CEE international journals (Fig. 6).

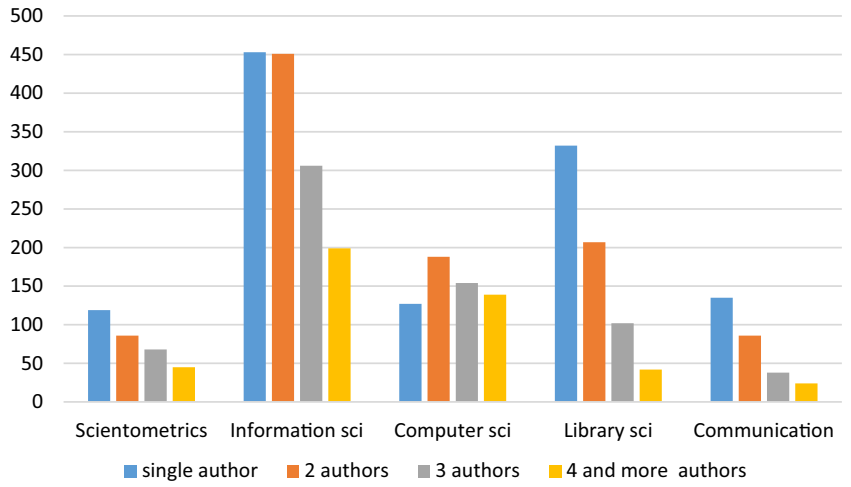

Fig. 5 Distribution of authorship by LIS subfields

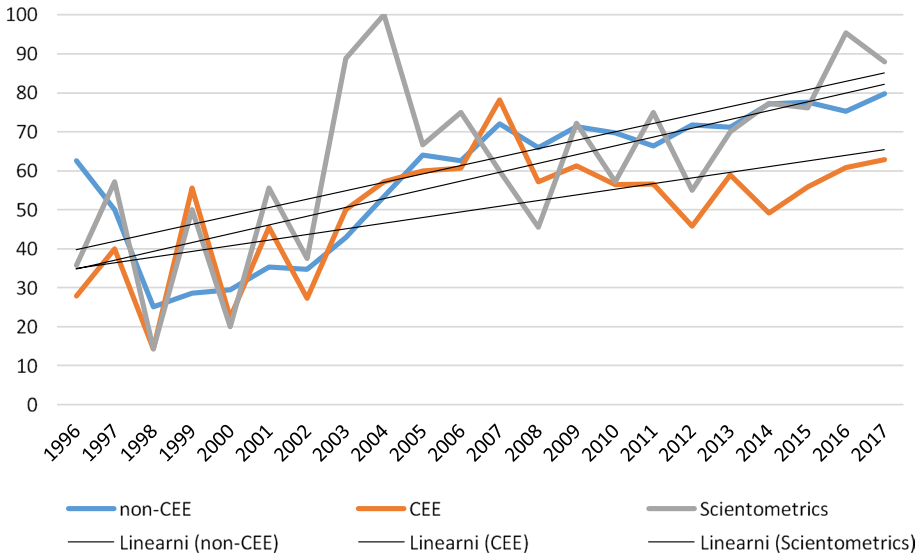

Fig. 6 Trends in co-authorship over time in the papers published in Central and Eastern Europe (CEE) journals, non-CEE journals and the journal *Scientometrics*

Research question 4: citation pattern

As previously mentioned, citations were calculated only for papers published in the period of 1996–2014 ($N = 2421$). These papers received, on average of 13.73 citations. The average citation for single-authored papers was 9.83 citations per paper and for co-authored papers, 16.09. In the full sample, the average number of citations per paper was higher if the number of authors per paper was greater: 2-author papers received 14.39, 3-authors papers 15.83, 4 to 10-authors papers 20.71 citations, multi-authored papers (with more than ten authors) received the average 58.78 citations per paper.

The difference in average citations between the single-authored and co-authored papers, according to LIS subfields, is shown in Table 5. Single-authored papers received the lowest number of citations in the communication (3.56) and library science (3.59) subfields, followed by information science (4.68). Contrarily, on average, single-author papers in the LIS subfields of scientometrics (21.54) and computer science (34.87) received more citations by a considerable amount. The co-authored papers group, taken as a category that included papers with two and more authors, showed a citations distribution for LIS subfields similar to that of single-authored papers.

The lowest values of average citation of co-authored papers were in communication (5.87), library science (7.4), and information science (9.26) subfields, contrary to scientometrics and computer science papers, with 33.44 and 32.47 citations per paper, respectively.

The difference in the average citations of single-authored and co-authored papers published in CEE, non-CEE journals, and in the journal *Scientometrics* was noteworthy. Single-authored papers published in CEE journals, on average, received 1.18 citations, non-CEE journal papers, 12.98, while single-author papers published in the journal *Scientometrics* received 23.11 citations. Co-authored papers published in CEE journals had

Table 5 Distribution of citations ratio by LIS subfields dependent on authorship pattern

LIS subfield	*N* authors	*N* articles	Total citations	Average citations
Communication	1	98	349	3.56
	2	54	168	3.11
	3	21	202	9.62
	4	7	9	1.29
	5–10	9	102	11.33
	More than 10	2	291	145.5
	All papers	191	1121	5.87
	Coauthored papers	93	772	8.3
Computer science	1	108	3766	34.87
	2	147	5161	35.11
	3	106	3107	29.31
	4	43	1536	35.72
	5–10	29	694	23.93
	More than 10	2	119	59.5
	All papers	435	14,383	33.06
	Coauthored papers	327	10,617	32.47
Information science	1	370	1733	4.68
	2	367	2946	8.03
	3	224	1966	8.78
	4	90	1164	12.93
	5–10	40	621	15.53
	More than 10	2	1	0.5
	All papers	1093	8431	7.71
	Coauthored papers	723	6698	9.26
Library science	1	229	821	3.59
	2	138	685	4.96
	3	66	340	5.15
	4	14	376	26.86
	5–10	12	206	17.17
	More than 10	3	118	39.33
	All	462	2546	5.51
	Coauthored	233	1725	7.4
Scientometrics	1	106	2283	21.54
	2	66	2151	32.59
	3	43	1666	38.74
	4	13	373	28.69
	5–10	12	291	24.25
	More than 10	0	0	0
	All papers	240	6764	28.18
	Coauthored papers	134	4481	33.44

an average citation of 1.67, in non-CEE papers and in the journal *Scientometrics*, 18.5 and 33.89 citations per papers, respectively.

Research question 5: collaboration pattern

The coefficient of collaboration as an average degree of collaboration in CEE LIS field was 0.65. Distribution by LIS subfields showed that the lowest values were in library science (0.51) and communication (0.52), and, conversely, the highest value of the degree of collaboration was in the computer science subfield (0.79), followed by the information science (0.68) and scientometrics (0.63) subfields.

In the full sample of co-authorship papers ($n=2135$), the mutual collaboration of authors from CEE countries, including co-authorship from the same country and co-authorship with other CEE countries, was 35.27% ($n=753$). Authors from all CEE countries collaborated on at least one paper. The most active mutual collaboration had authors from the Czech Republic and Slovakia, as well as authors from Slovenia and Croatia, while the countries with the most co-authorship relationship with other CEE countries were Croatia (11), Hungary and Poland (9).

The total number of countries with which the CEE LIS authors collaborated was 81.

Co-authorship networks in CEE journals, non-CEE journals, and in the journal *Scientometrics* show different pattern (Fig. 7). In the co-authorship cluster of papers published in CEE journals, Croatia is presented as the most robust node, collaborated with authors from 9 countries. On the other hand, authors from CEE countries—Bulgaria, Estonia, Lithuania, Macedonia, Poland, and Romania—who published co-authored papers in CEE journals only collaborated with colleagues from their countries.

Authors of almost all CEE countries, except for Macedonia, mutually cooperated and had joint papers published in international journals. CEE countries with the highest number of cooperation were Hungary, Slovenia, Poland, the Czech Republic, and Croatia. The most active co-authorship networks with other countries, primarily the United Kingdom and the USA, were those of Poland, Slovenia, and Hungary (Fig. 7).

The cluster of co-authored papers published in the journal *Scientometrics* showed that among 11 CEE countries that had co-authored papers, only five collaborated with Hungary as a primary node. CEE country authors' collaboration with authors from other countries showed a widely dispersed network involving authors from 21 countries. After Hungary, the most active co-authorship connections came from authors from Slovenia, Poland, and Serbia, who published most of their co-authored papers with authors from the Netherlands, the USA, and the UK.

Discussion

Research question 1: productivity and citation contribution

At the level of the full sample, productivity was almost uniformly low in the period of 1996–2005, which could be partly justified by Scopus indexing only two of the seven CEE LIS journals during this period. In that period, the most substantial contribution came from papers published in the journal *Scientometrics*. Before 2005, only a few CEE journals fulfilled the criteria for indexing in Scopus. Most of the CEE countries from our sample had remarkably low levels of productivity before 1996, as indicated by Uzun (2002). In our

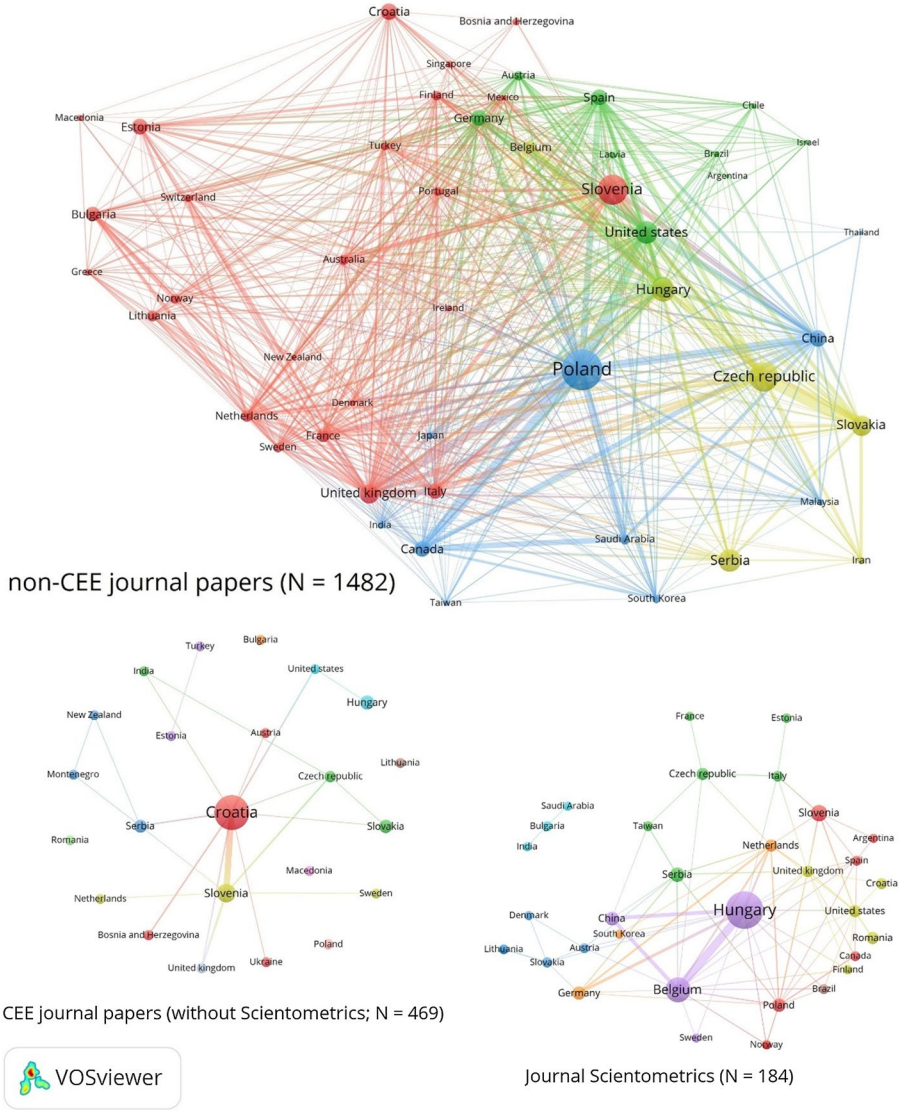

Fig. 7 Co-authorship network of papers published in Central and Eastern Europe (CEE) journals, non-CEE journals and the journal *Scientometrics*

opinion, one of the key reasons for this situation is the influence of state-specific scientific policy, transition time, and adaptation to the openness of publishing papers in international journals. According to Mali (2010), in the past, political factors in CEE countries pushed social scientists into intellectual isolationism and parochialism, which is still visible in some social science fields today.

The increase in the number of published papers since 2006 has been partly influenced by the increase in the number of CEE journals indexed in Scopus (Fig. 1), as well as the fact that most of CEE countries becoming EU member states. As EU member states,

they accepted some of the elements of the European Commission's scientific policy and incorporated it into their national science policies, which included more intensive publication in international journals. One confirmation of this thesis is that the compound annual growth rate in the period of 2005–2017 was 20.57, which, compared to Olmeda-Gómez and de Moya-Anegón (2016), indicated a progress.

The comparison of countries according to the Activity Index (AI) indicator, which measures productivity in the LIS field with all papers published in the social sciences field, places Croatia, and other countries of the former Yugoslavia (Slovenia, Bosnia, Serbia) at the leading positions (Table 4). In the case of Croatia, that status is based on its LIS journals indexed in Scopus (Table 1). The more objective status of the visibility and potential importance of these papers is their citations ratio (Table 2), which is below the average values (Table 4). The possible reasons for the low citation ratio could be a language barrier (the majority of papers in Croatian LIS journals were written in Croatian language) and paper subject issues. Concerning the other CEE countries, Poland and Hungary have AI above the median, while the average citation ratio for these two countries was also the highest. The explanation of these results is related to the extremely high productivity of Polish authors in the LIS subfield of computer science, and for Hungarian authors, in the subfield of scientometrics, as the two most cited LIS subfields.

The productivity of individual countries, according to LIS subfields (Fig. 2), shows that in addition to the leading role of Hungarian authors in the subfield of scientometrics, almost all CEE countries have authors dealing with this issue. A possible reason is to explore scientific activity within each country, but also an aspect of increasing application of bibliometric indicators in scientist promotions, as well as an international evaluation of research institutions and universities.

The division of the journals into the CEE and the non-CEE group displayed significant differences in recognition of papers measured by citations received (Table 2). The results obtained justify the thesis that CEE LIS journals, even when publishing papers in the English language, are less noted and cited in relation to similar papers published in international journals. The above situation could be caused by multiple factors. One of them was addressed by Olmeda-Gómez and de Moya-Anegon (2016) showing that the lack of stimulus for excellence in national journals affects the indicators for the scientific communities and their publication.

At first glance, a pronounced characteristics of CEE author production in non-CEE journals is the dispersal of papers in a relatively large number of journals, and shows characteristics of power-law distribution; only 8.6% of the papers were published in 54% non-CEE journals. On the other hand, over 60% of CEE authors articles were published in a less than 10% non-CEE journals, suggesting a concentration of research issues relevant to the international scientific community. The largest number of these journals were classified to the LIS subfields of computer science and information science, which was expected as these two subfields had the largest number of papers.

The classification of the LIS field in subfields, albeit far from the ideal, has been justified in this research through visibility by citations received. The citation analysis of the full sample shows that one quarter of the papers in the LIS field were not cited, which strikingly less when compared to the results is obtained by Davarpanah and Asleki (2008). The smaller share of uncited papers may be owed to the fact that about two-thirds of papers were published in international non-CEE journals. The results similar to ours were given by Cronin and Shaw (1999). They claim that papers with a first author outside the North Atlantic countries were found to be more uncited than papers with North Atlantic authors.

Differences in shares of cited and uncited papers in particular LIS subfields are quite obvious (Table 3). The library science and information science subfields show the highest number of uncited papers, which can be partly justified by the relatively large number of papers written in native languages (Table 2), as well as more local issues or in the case of information science subfield to broad multidisciplinary journal scope. Contrarily, as expected, scientometrics and computer science are LIS subfields with an extremely meagre share of uncited papers because of papers written in English language, published in prestigious international journals, and obviously dealt with trendy issues. The obtained differences directly point to the absence of homogeneity within the LIS field, which should be taken into account when discussing scientific communication paradigms in the LIS field as a whole, or the evaluation of scientific work in the LIS field.

Differences by individual CEE countries in the productivity as well as the distinctiveness of visibility of papers measured by citations received were expected. The results depended on the research issues, as well as of journals in which papers were published.

Research question 2: author productivity pattern

According to most literature findings (Schubert 2002; Liu 2003; Davarpanah and Asleki 2008; Walters and Wilder 2016; Suresh Kumar 2017), the productivity of the LIS author was distributed according to Lotka's law, as also evidenced by our results. Although Lotka's distribution of productivity worth as an accepted norm in science, however, the fact that less than one percent of the authors published an average of one paper in 2 years is an indicator of scientific activity in LIS fields in CEE countries. Also, the most influential authors (0.3%), when compared with similar studies, had a significantly lower average of productivity. Davarpanah's and Aslekia's (2008) findings show that 0.88% of the most prolific contributors published on average one to two papers per year, while Walters and Wilder (2016) results show that the top 0.4% authors published two papers per year on average.

Possible explanations for Slovenian authors as the most influential CEE authors could be their stimulating science policy compared to other CEE countries. An important factor is that Slovenia was the leading country in ex-Yugoslavia in the LIS field, which undoubtedly contributed to the present status. The expected leading position in the LIS subfield of scientometrics correspond to Hungarian authors, who are the most responsible for the development of the subfield.

H-index values for overall scientific activity, the top 10 authors, as a group of influential LIS CEE authors, are an additional indicator of their impact on the discipline. Although the range of the h-index is broad, from 49 to 6, it should be noted that h-index values depend on the length of scientific activity, total productivity, and LIS subfields. For comparison, the top-ranking British information scientist, Peter Willett, had an *h*-index of 31 (Oppenheim 2007), but according to Scopus data at the beginning of May 2019, P. Willet had an *h*-index of 68.

Research question 3: authorship trends

When discussing our results in regard to similar studies, we limited ourselves to only recent research. A more comprehensive overview of previous research on the trends in authorship over the time in the LIS field was given by Chang (2015). Our results on the shares of single-authored or co-authored papers were closest or nearly identical to those obtained by Sin

(2011), Erfanmanesh and Hosseini (2015), and Ronda-Pupo and Katz (2018). Concerning the share of co-author papers with two authors, our results were similar to Suresh Kumar (2017), Aharony (2012) Naqvi (2005) and Liu (2003). Based on the aforementioned, the expected results for an average number of authors per paper did not significantly differ from the related studies by Sin (2011), Larivière et al. (2012), and Thavamani (2014).

The analysis of co-authorship on the papers published in CEE, non-CEE, and the journal *Scientometrics*, showed significant differences justifying our division of the journals (Fig. 6). A notable difference in favour of increasing the average number of authors per paper in non-CEE journals was expected. Namely, multi-authored papers are mainly a reflection of teamwork, more demanding topics, or methodological approaches, which potentially provide a greater chance of being published in international journals compared to single-authored papers. Our results for the average number of authors per article in the journal *Scientometrics* significantly differed from the results of Schubert (2002), Hou et al. (2008), which confirms Schubert's claim on the tendency of growing collaboration.

The analysis of the frequency of single-authored and co-authored papers by LIS subfields shows the similarity of the LIS subfields of library science and communication, and, respectively, scientometrics and information science. The expected significant deviation shows the subfield of computer science to have the lowest average value of a single-authored paper.

In order to gain a clearer picture of our results, we presented comparisons with related research. Bharvi et al. (2003) shows a share of 53.4% single-authored papers for the subfield of scientometrics, which, when compared to our results (37.42%), is in favour of intensifying development of collaboration in this subfield. The differences within the LIS subfields authorship also confirm the study by Chang (2018). These results show differences in the share of single-authored papers in library science (27.1%) and information science (18.4%). However, Chang (2015) stressed that the percentage of single-authored articles by one librarian was greater than that of articles authored by one researcher.

Although the share of single-authored and two-authored papers in the full sample was gradually reduced since 2014, there are significant differences in authorship within individual LIS subfields. They represent a reflection of many factors but are also an indicator of the dynamics and orientation of research.

Research question 4: citation pattern

Although some authors, e.g., Ronda-Pupo and Katz (2018), emphasize that there are doubts as to whether multi-authored LIS papers attract more citations than single-authored papers, their results speak in favour of multi-authored papers. We as well as Levitt and Thelwall (2016), Levitt (2015), Merigó et al. (2018) came to the same conclusion. In Ronda-Pupo and Katz results multi-authored papers accounted for 77% of the total citations, which is close to our result.

Albeit at the level of the full sample the average citations for single-authored papers was 9.83, an analysis by LIS subfields showed significant differences. The citations of single-authored papers below the average had library science, communication, and information science subfields. Without more detailed analysis it is difficult to determine the possible causes of such a state at this level of analysis. On the other hand, single-authored papers in the scientometrics and computer science subfields received two or three times more citations than an average paper (Table 5). For the subfield of scientometrics, a possible explanation would be a large number of papers published by the most prominent

scientometricians. For the subfield of computer science, which on the other hand represent almost half of the multi-authored papers, the highly cited single-authored papers deserve a more detailed analysis.

The differences in the average citations of single-authored papers as well as co-authored papers published in CEE, non-CEE, and journals in the journal *Scientometrics* although expected, were still surprising (Table 5). The low average citations of articles published in CEE journals, both single-authored and co-authored papers, could be influenced by a language barrier, relevance of the topic, as well as the methodology used. Even if all the previous conditions were met, the titles of the journal in national languages could hardly attract international authors who will cite them. This assertion could be verified by more detailed analysis like co-citations analysis or qualitative methods.

Research question 5: collaboration pattern

Although the values of the degree of collaboration by LIS subfields are different, the co-authorship at the level of the LIS field is on the rise. Our values for the collaboration coefficient in the LIS field are almost identical to similar research (Thavamani 2014). It is interesting to emphasize that all CEE countries collaborated with each other but with different levels of intensity, which was expected. Countries that are historically, geographically, and linguistically closer showed more intensive collaboration, e.g., the Czech Republic and Slovakia or Slovenia and Croatia. CEE authors collaboration networks with authors from other countries were scattered on a relatively large number of countries.

The co-authorship network clusters greatly vary depending on whether the papers are published in CEE, non-CEE journals, or in the journal *Scientometrics*. In the cluster of co-authored papers from CEE journals, Croatia is expected to be the central node because it has the largest number of journals and papers. In Croatian journals, the highest number of co-authored papers, which was also expected, were from ex-Yugoslav countries (Slovenia, Bosnia and Herzegovina, Serbia).

The specificity of the cluster of co-authored papers published in international, non-CEE journals is dispersed co-authorship networks, with the preference of collaboration with authors from the UK and the USA. These collaborations are realized by authors from Poland, Slovenia, and Hungary, which also points to the leading CEE countries in the LIS field.

As expected, Hungary is the central node in the co-authored papers in the cluster of papers published in the journal *Scientometrics*. The scientometricians with the largest collaboration contribution is Wolfgang Glänzel, which is evident from his co-authorship networks (Fig. 3). The reasoning behind the link between Hungary and Belgium is that Glänzel has two registered addresses, one in Hungary and another one in Belgium.

Conclusions

The contribution of LIS authors from Central and Eastern Europe (CEE) countries measured by number of published papers in the period from 1996 to 2017, clearly shows a difference before and after the year 2005 (Fig. 1). This is the year when most of the CEE countries became EU member states, thus accepting the rules of the European Commission's scientific policy and incorporated it into their national science policy, including more intensive publishing in international journals.

The most productive countries in absolute values are Poland, Croatia, Slovenia, and Hungary, but when assessing papers per capita, Slovenia, Croatia and Estonia were the leading countries (Table 4). Croatia's position among the most productive countries relies on indexing its domestic journals in Scopus. The Hungarian contribution is particularly pronounced in the papers published in the journal *Scientometrics*, while the papers of Polish and Slovenian authors are oriented to international journals. Productivity per individual LIS subfields highlights (Fig. 2) Poland, the Czech Republic, and Slovenia in the computer science LIS subfield, Hungary in the scientometrics subfield, while Croatia is leading in librarianship.

Although productivity of the CEE LIS authors is distributed according to Lotka's law, less than one percent of the authors published an average one paper in 2 years, which is significantly lower in comparison with other relevant research. The most influential ten authors had a significantly lower average of productivity compared with similar studies, with the exception of Glänzel W. and Mesnier R. The analysis of the co-authorship network of the most influential authors shows an almost entire absence of cooperation on joint papers (Fig. 3).

Results obtained by this research concerning authorship trends over the time, show pronounced similarity with related published research. Unlike the results on the full sample, the analysis of co-authorship of the papers published in CEE, non-CEE, and the journal *Scientometrics*, shows significant differences (Fig. 6). Specificities in authorship pattern (Fig. 5) show some similarities in the LIS subfields of library science and communication, and, respectively, scientometrics and information science. The computer science LIS subfield has a prominent co-authored collaboration similar to a stand-alone field computer science.

As it was expected, the visibility of papers CEE LIS authors measured by citations shows significant differences between the papers published in the domestic CEE journals, international non-CEE journals, and the journal *Scientometrics* (Table 3). An average low citations of articles published in CEE journals, among other factors could be influenced by language barrier, relevance of the topic, as well as the methodology used.

Although the values of the degree of collaboration by LIS subfields are different, the co-authorship at the level of the LIS field is on the rise. Mutual collaboration of authors from CEE countries exists but is not yet intensive, except some countries with more similar historically, geographically, and linguistically background. The most expressed collaboration of CEE authors are with authors from the USA, the UK, China, Spain and Germany. The co-authorship network greatly varies depending on whether the papers are published in CEE, non-CEE journals, or in the journal *Scientometrics* (Fig. 7).

This unique study analyses library and information science field in the group of 15 Central and Eastern European countries of similar post-socialistic background, with the most important aim to present an overview of the basic indicators of the scientific contribution and activity in this filed. Due to the complexity of the study issue and in order to obtain a more comprehensive picture, additional detailed quantitative and qualitative methods are required.

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Appendix 1: Description of data preparing process for the project database

If the obtained dataset was used as the sample for bibliometric analysis, without any additional checks and cleaning, the results of the analysis would certainly be different. First, Scopus, as well as WoS, provide a classification system at the level of journals, and both allow journals to have multidisciplinary classifications (Wang and Waltman 2016). Second, there is the problem of the diversity of classification systems of science, specifically the social sciences. By comparing Scopus ASJC (All Science Journal Classification) list of Social Sciences with the modified OECD Frascati Field of Science (FOS) Social Sciences (https://www.oecd.org/science/inno/38235147.pdf) revealed significant differences. In the case of Scopus, these differences are related to the involvement of several fields of the humanities and some fields dominated by issues of technology and engineering, which, due to differences in scientific communication, could have a significant impact on the results. Within the obtained sample, an example of a drastic impact on our results in social sciences analysis was the finding of inclusion journals and papers that deal almost exclusively with the issues of natural sciences or biomedicine (Nature, Science, Proceedings of the National Academy of Sciences of the United States of America, Fuzzy Sets and Systems, etc.). By checking each paper, we have excluded the possibility that such papers that dealt with the issues of natural sciences or biomedicine, were misclassified as to social sciences. Papers published in such journals represented a share of 2%, but they accounted for 36% of the total number of citations (Lazić et al. 2017). Additionally, almost all of those papers were multi-authored, with more than n authors per paper, which is uncommon in social sciences. This confirms Wang's and Waltman's (2016) thesis that journal classification systems play an essential role in the accuracy of bibliometric analyses. An additional reason to check the reliability of the obtained search results is that Scopus has an unreliable classification of documents per document type, i.e., article or review. Moreover, Scopus sometimes classifies documents with one or two pages, without references or abstract, in the document type category "article or review". Also, conference proceedings are sometimes classified as peer review journals under the category source type "journal".

To solve the problem with sample unreliability, we have chosen an expert-based approach. Namely, the project subject experts in each social science fields (sociology, political science, psychology, educational science, law, economics and library and information science) examined each of the 4896 journals that were initially obtained from Scopus. Subject experts classified journals based on their journal knowledge and journal title (usually, journal titles are indicative). Questionable journals which could not be classified in specific fields were analyzed in detail through journal or publisher webpage, and decision were subjected to a consensus. A thorough expert checks-up yielded in a final dataset containing 2724 journals with 58,512 bibliographic records categorized in social sciences ten subject categories according to modified OECD Frascati Fields of Science (FOS): economics and business, educational science, information and library science, law, political science, psychology, sociology, and three multidisciplinary fields (social sciences, social sciences and humanities, and social sciences and other fields). The modified OECD classification was applied due to the fact that it is widely used by CEE countries.

Appendix 2: List of journals by five LIS subfields

LIS subfield	Journal title	Number of papers
Communication	Catalan Journal of Communication and Cultural Studies	2
	Chinese Journal of Communication	1
	Communication Monographs	1
	Communications	7
	Comunicacion y Sociedad	1
	Comunicar	7
	Convergence	7
	Emerging Communication: Studies in New Technologies and Practices in Communication	1
	Feminist Media Studies	5
	Global Media Journal	1
	IEEE Transactions on Professional Communication	1
	Informing Science	10
	International Communication Gazette	2
	International Journal of Advanced Media and Communication	4
	International Journal of Communication	25
	International Journal of Digital Multimedia Broadcasting	11
	International Journal of Web Based Communities	7
	Javnost	89
	JMM International Journal on Media Management	1
	Journal of Communication	2
	Journal of Communication Management	4
	Journalism	9
	Journalism and Mass Communication Quarterly	1
	Journalism Studies	9
	Media International Australia	2
	Medijska Istrazivanja	58
	New Review of Film and Television Studies	4
	Nordicom Review	3
	Northern Lights	2
	Observatorio	3
	Radio Journal	2
	Review of Communication	1
Computer science	IFIP Advances in Information and Communication Technology	49
	Industrial Management and Data Systems	61
	Information Sciences	431
	Information Systems Journal	1
	Journal of Cheminformatics	43
	Journal of Computer Information Systems	16
	Journal of Organizational and End User Computing	1
	Journal of Strategic Information Systems	3
	Progress in Informatics	3

LIS subfield	Journal title	Number of papers
Information science	Aslib Proceedings: New Information Perspectives	10
	Bulletin of the American Society for Information Science	1
	Common Knowledge	1
	Computers and the Humanities	3
	Cybermetrics	1
	Data and Knowledge Engineering	8
	European Science Editing	3
	First Monday	9
	Gazette	1
	Global Media and Communication	2
	IEEE Transactions on Information Theory	79
	IFIP International Federation for Information Processing	92
	Informacios Tarsadalom	106
	Information	6
	Information and Management	5
	Information Development	9
	Information Processing and Management	34
	Information Research	33
	Information Retrieval	5
	Information Society	12
	Information-Wissenschaft und Praxis	4
	Informatologia	244
	Interdisciplinary Journal of Information, Knowledge, and Management	16
	International Journal of Enterprise Information Systems	9
	International Journal of Information and Management Sciences	6
	International Journal of Information Management	28
	International Journal of Information Processing and Management	1
	International Journal of Information System Modeling and Design	2
	International Journal of Information Technology and Management	1
	International Journal of Knowledge Management Studies	3
	International Journal of Organizational Diversity	3
	International Journal of the Inclusive Museum	7
	Journal of Digital Information	2
	Journal of Digital Information Management	14
	Journal of Documentation	28
	Journal of Global Information Management	3
	Journal of Information and Knowledge Management	8
	Journal of Information and Organizational Sciences	135
	Journal of Information Science	19
	Journal of Information Science and Engineering	5
	Journal of Information Technology	1
	Journal of Information Technology Education:Research	1
	Journal of Knowledge Management	14
	Journal of Network and Systems Management	7
	Journal of Research and Practice in Information Technology	4
	Journal of the American Society for Information Science and Technology	18

LIS subfield	Journal title	Number of papers
	Knowledge and Process Management	2
	Knowledge Management	3
	Knowledge Management and E-Learning	6
	Knowledge Management Research and Practice	15
	Knowledge Organization	14
	Knowledge-Based Systems	96
	Learned Publishing	14
	Lecture Notes in Control and Information Sciences	116
	Malaysian Journal of Library and Information Science	8
	Museum Management and Curatorship	5
	New Media and Society	10
	New Review of Information Networking	3
	Nordic Journal of Digital Literacy	1
	Online Information Review	12
	Proceedings of the ASIS Annual Meeting	1
	Proceedings of the ASIST Annual Meeting	1
	Proceedings of the European Conference on Knowledge Management, ECKM	63
	Profesional de la Informacion	5
	Prometheus	3
	Publishing Research Quarterly	10
	Research Evaluation	11
	Science and Technology Studies	1
	Webology	6
Library science	Archival Science	3
	Bilgi Dunyasi	1
	Bulletin of the John Rylands University Library of Manchester	1
	Cataloging and Classification Quarterly	22
	Collection Building	3
	D-Lib Magazine	7
	Electronic Library	26
	European Journal of Communication	26
	Evidence Based Library and Information Practice	1
	Grey Journal	30
	IFLA Journal	4
	Information Technology and Libraries	4
	Interlending and Document Supply	4
	International Information and Library Review	6
	International Journal of Lexicography	20
	International Journal of the Book	4
	International Journal on Digital Libraries	8
	Journal of Academic Librarianship	11
	Journal of Archival Organization	1
	Journal of Classification	10
	Journal of Interlibrary Loan, Document Delivery and Electronic Reserve	2
	Journal of Librarianship and Information Science	9
	Journal of the Medical Library Association	2

LIS subfield	Journal title	Number of papers
	Journal of the Society of Archivists	1
	LIBER Quarterly	17
	Library and Information Science Research	6
	Library Collections, Acquisition and Technical Services	3
	Library Hi Tech	11
	Library Hi Tech News	2
	Library Journal	1
	Library Leadership and Management	1
	Library Management	19
	Library Philosophy and Practice	2
	Library Resources and Technical Services	2
	Library Review	15
	Library Trends	19
	Libres	1
	Libri	19
	New Library World	29
	OCLC Systems and Services	4
	Portal	2
	Program	27
	Reference and User Services Quarterly	1
	Science and Technology Libraries	1
	Serials Librarian	1
	Slavic and East European Information Resources	19
	VINE	2
	Vjesnik Bibliotekara Hrvatske	273
Scientometrics	Journal of Informetrics	43
	Scientometrics	275

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