УДК 001.8:004:316.472.4
https://doi.org/10.20913/1815-3186-2022-3-101-122

A Scientometric Analysis of the Literature on the Topic "Academic Social Networks"

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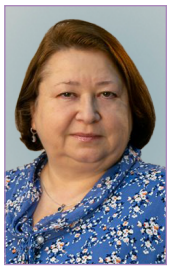

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Abstract. In the past few decades, scientific communication has become widespread through academic social networks (ASNs). The purpose of this article is to consider ASNs both as a research tool and as an object of study in scientific publications. The scientometric analysis of literature on ASNs was carried out. The literature set consisted of 1,216 records retrieved from the Web of Science (WoS) database. The set included the documents where the ASNs were the scientific research objects or those where the ASNs were only mentioned as a bibliographic data source for systematic reviews or meta-analyses (predominantly in medicine) or as an experimental data repository. It was found that documents on ASNs started to appear in the WoS after 2005. The USA, the University of Wolverhampton (United Kingdom), and M. Thelwall are the country, organization, and author leading in the number of documents on ASNs in the set. The journals published the documents presented by the following subject areas: Computer Science; Computer Science and Librarianship; Mechanical Engineering; Engineering and Technology. Four out of the first ten highly cited documents are devoted to altmetrics in ASNs. The authors used document co-citation analysis via free scientometric analytical software CiteSpace and discovered research fronts. It was found that when the number of publications on ASNs started to rise, scholars began to discuss the community recommendation, professional indexing/folksonomy, and cold-start problem. Later, the altmetrics used in the ASNs became the main subject in the researches of ASNs. The last statement is confirmed by co-word analysis via CiteSpace. It is shown that the most frequent keywords of the studied document set are altmetrics, impact, and citation.

Keywords: scientometrics, academic social network, research fronts, Web of Science, altmetrics, document co-citation analysis, co-word analysis, CiteSpace

Citation: Busygina T. V., Yuklyaevskaya A. V. A Scientometric Analysis of the Literature on the Topic "Academic Social Networks". Bibliosphere. 2022. № 3. P. 101–122. https://doi.org/10.20913/1815-3186-2022-3-101-122.

Received 18.02.2022
Revised 21.06.2022
Accepted 29.06.2022

Наукометрический анализ литературы по теме «научные социальные сети»

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Аннотация. В последние несколько десятилетий научная коммуникация все шире осуществляется посредством академических социальных сетей. Целью статьи является рассмотрение академических социальных сетей как инструмента исследования и как объекта изучения в научных публикациях. Проведено наукометрическое исследование документопотока по проблеме «научные социальные сети» (НСС), представленного в Web of Science (1216 документов). Установлено, что исследуемый информационный массив содержит не только публикации, в которых НСС являются объектом исследования, но и статьи, в которых НСС указываются как источники библиографических данных для проведения систематического обзора или метаанализа (преимущественно в медицине); либо как репозиторий экспериментальных данных. Показано, что публикации в БД WoS появляются с 2005 г. США, Вуллвертонский университет (Великобритания) и Телволл М. – страна, организация и автор – лидирующие по числу публикаций по проблеме НСС. Журналы, в которых опубликованы документы исследуемого массива, отнесены к областям: Информатика; Информатика и библиотечное дело; Машиностроение; Инженерия и технологии. Четыре из 10 наиболее часто цитируемых публикаций по НСС посвящены альтметрикам. Анализ коцитирования документов, выполненный с использованием программы для наукометрических исследований свободного доступа CiteSpace, позволил выявить основные исследовательские фронты: на заре появления НСС в информационном пространстве ученые обсуждали «рекомендации сообщества», соотношение «профессиональное индексирование контента/фольксономия» и «проблему холодного старта». По мере развития НСС основным предметом научных исследований стали альтернативные метрики, применяемые в НСС. Последнее утверждение подтверждается анализом сочетаемости слов, также выполненным с использованием CiteSpace. Показано, что наиболее частотными ключевыми словами исследуемого документопотока являются «альтметрики», «влияние» и «цитирование».

Ключевые слова: наукометрия, академическая социальная сеть, направления исследований, Web of Science, альтметрия, анализ совместного цитирования документов, ко-ворд-анализ, CiteSpace

Для цитирования: Бусыгина Т. В., Юкляевская А. В. Наукометрический анализ литературы по теме «научные социальные сети» // Библиосфера. 2022. № 3. С. 101–122. https://doi.org/10.20913/1815-3186-2022-3-101-122.

Статья поступила в редакцию 18.02.2022
Получена после доработки 21.06.2022
Принята для публикации 29.06.2022

Introduction

Academic social network. The concept. Text messengers, wikis, social networks, and social bookmarking tools are Web 2.0 applications. Since the development of Web 2.0 technologies (O'Reilly, 2005) in 2005, scientists, like other categories of Internet users, have become engaged in the Global (Facebook, Twitter, YouTube, Flickr, MySpace) and professional (LinkedIn) social networks (Boyd, Ellison, 2007). Scientists used Global social networks for scientific purposes (e.g., search for scientific literature or scientific collaboration, results discussions, etc.) and educational purposes (Jordan, 2014). Social networks explicitly targeting scholars have emerged rapidly (Nentwich, König, 2012; Ortega, 2016). They meet the needs of scientists for information exchange, cooperation, and self-organization and are called academic social networks (ASNs) (or scientific social networks, scholarly social networks, etc.).

A Web 2.0 application can be considered as a social network on the Internet if it meets the Jordan following conditions: a place to create a personal profile, a list of connections with other users, the ability to track the actions of those who appear on the list, and the ability to establish new connections (Boyd, Ellison, 2007). According to these conditions, ASNs are the well-known *CiteULike, Mendeley, Academia.edu, ResearchGate,*

Connotea[1], *Zotero*. A data repository *myExperiment* is positioned as an ASN also (Guler et al., 2016a; Guler et al., 2016b).

Academic social network. Literature review. Scientists studied ASNs actively. The experience of these studies is communicated in books (Carrigan, 2019; Neal, 2012; Ortega, 2016). In particular, significant attention in the scientific literature was paid to altmetrics. Altmetrics is a discipline whose subject is the creation and research of new metrics (alternative metrics) evaluating the functioning of a scientific product (article, book, presentation, statement, and discussion on the topic of scientific research, computer program, etc.) within the virtual space of the Internet (the number of discussions on social networks, downloads, and views times in scientific repositories, bibliographic managers, etc.). Altmetrics are also a way to evaluate a researcher's activities based on their presence, mention, and use of the Internet, but not on the number of documents' citations in scientific journals. The presence of a researcher in social networks is associated with the level of citation and, as a result, their academic success (Mazurek et al., 2020). Such altmetrics are actively included in ASNs services. For example, in a researcher's profile in such ASNs as ResearchGate and Mendeley, it is possible to assess the scientific activity of the particular researcher according to altmetrics (Li et al., 2012; Thelwall, Kousha, 2015).

Despite the availability of traditional review publications on the topic ASNs, nobody has comprehensively assessed the publications on the issue based on scientometric analysis yet. At the same time, the scientometric study can give interesting additional information about some scientific topic. It can take a look at the issue from another angle of vision.

Scientometrics. Today, scientometrics is a set of methods to analyze scientific documents (books, articles, and other publications) using scientific publications' metadata taken from scientometric databases. Web of Sciences and Scopus are the most popular and meaningful nowadays. The databases platforms' tools provide for free several parameters for descriptive statistics based on bibliographic and metadata for documents to assess performance and other parameters that provide additional knowledge about the dataset under investigation. A knowledge domain is knowledge of a specific, specialized discipline or field, in contrast to general (or domain-independent) knowledge. When retrieving a complete and relevant set of documents on a specific topic, we can discuss it as a specific knowledge domain and carry out a scientometric analysis of a particular field of knowledge. The scientometric analysis includes the data on the documents set size (number of records), publication dynamics, documents that have generated the most significant interest in the scientific community (highly cited articles), authors, institutions leading for the number of investigations in the scientific area, etc. Scientometric analysis can be done on the global level when datasets are retrieved for the Whole World (Singh, Pandita, 2018) or on the local level when datasets are retrieved for the particular region of the World (Demaine, 2018; Lee, 2020; Nishavathi, Jeyshankar, 2020; Pattanashetti, Harinarayana, 2017; Yang, Lee, 2018).

Knowledge domain visualization. Additional opportunity appears when using software to visualize knowledge domains. Data visualization tools provide an accessible way to see and understand trends, outliers, and patterns in data.

The CiteSpace is one of the software programs (Cobo et al., 2011) developed for science mapping. The program combines bibliometric analysis, information visualization, and data extraction algorithms (Chen, Song, 2019). Among the types of analysis, the CiteSpace provides documents (references) co-citation analysis (DCA), and co-occurrence analysis of words or phrases (concepts) taken from the document titles, controlled terms of WoS, and paper abstracts (the co-word analysis – CWA).

The DCA is one of the ways to determine the relationship between various documents in a specific knowledge domain. If two papers are co-cited in the third, then with a high degree of probability they belong to the same research area (Маршакова-Шайкевич, 1973; Small, 1973). CiteSpace builds a network with references as nodes. The link between two nodes is the co-citation of two documents in a third document. A set of parameters characterizes the networks. The number of nodes and co-citation links is the first of them. Moreover, when building a document co-citation network using CiteSpace, several parameters of nodes are calculated. Two of them are: (1) the document co-citation number of the node, which is proportional to the node diameter; (2) "betweenness centrality," (BC) revealing the node importance in the network. Two node types can have a high BC value: nodes with multiple links to other nodes within the same node group (cluster) (like a hub) and nodes located between different node groups. The latter is of greater interest because they are interpreted as initiators (progenitors) of new scientific direction (pivot point). The DCA with CiteSpace provides network clustering and automatic cluster labeling with terms extracted from titles, abstracts, and controlled terms (WoS) of the citing documents. The clusters symbolize research fronts in the analyzed scientific field and represent a map of the scientific area in its development, arranged in chronological order by the average year of the cluster documents.

[1] Connotea stopped its service on March 12, 2013.

The CWA in CiteSpace determines the patterns of words or phrases (concepts) co-occurrence in a document set to identify primary research fronts within a scientific field under investigation.

The objectives of our work aimed for a comprehensive scientometric analysis of the topic "ASNs" to assess the number of publications on the issue, the documents publication dynamics, to reveal leading countries, institutions, and authors for the number of documents, journals where the documents are published, most cited publications. The CiteSpace software was used to reveal and visualize the main research fronts in the topic *ASNs*.

The results of the scientometric analysis should be helpful for researchers in the field of studying state of art and perspectives of modern scientific communications. Scientists who actively use the Internet space to interact with colleagues will find helpful information for themselves.

1. Materials and Methods

1.1. Materials

The search for documents on ASNs in the WoS database was performed according to the following request: TS[2]=("social scientific network*[3]" or "academic social network*" or "social research network*" or "scholar* social network*" or "academic social site*" or "social media for academics" or Mendeley or CiteULike or "Academia.edu" or ResearchGate or "Research Gate" or MyExperiment or "Scientific Social Community" or Connotea or Zotero). Terms that are phrases are in quotes ("social scientific network*"). In addition to the phrases "social science network*", "academic social network*", "social research network*", the query lists the names of the well-known social science networks.

The set of 1216 documents was found from 2005 to 2020 (18 June 2020). The search was carried out in the following WoS citation indexes: Science Citation Index Expanded (SCI-EXPANDED) from 1975 to present; Social Sciences Citation Index (SSCI) from 1975 to present; Arts & Humanities Citation Index (A & HCI) from 1975 to present; Conference Proceedings Citation Index-Science (CPCI-S) from 1990 to present; Conference Proceedings Citation Index-Social Science & Humanities (CPCI-SSH) from 1990 to present; Book Citation Index-Science (BKCI-S) from 2005 to present; Book Citation Index-Social Sciences & Humanities (BKCI-SSH) from 2005 to present; Emerging Sources Citation Index (ESCI) from 2015 to present.

When searching, we faced the problem of articles separating. The problem was that documents mentioned ASNs for different purposes: first – as a source of bibliographic information for simple review, systematic review, meta-analysis, the others – as a place to store data, and the third ones – as a place to discuss particular professional issues. However, we were interested only in papers in which ASNs were the object of scientific research. We tried to exclude articles out of our interest using the Boolean operator «NOT» and listing addresses (for example, "not TS = (https://data.mendeley.com OR" Mendeley Data "OR" https://www.researchgate.net "OR myexperiment.org). However, this method did not help us: when browsing the set with exceptions, we continued to find documents out of our interest (for example, articles where the ASN ResearchGate listed as a source of bibliographic information). That is why we examined the whole document set we obtained initially. The set of documents we have retrieved is relevant and sufficiently representative for the scientometric investigation of the ASNs topic.

1.2. Methods

WoS. The WoS tool *Results Analysis* was used to obtain descriptive statistics data about document set on ASNs. The following parameters were analyzed: the documents publishing dynamics per year; type-specific structure of the document set; leading authors and organizations by the number of documents; thematic categories to which the records in the set are assigned, the distribution of documents by countries; types of editions (journals, monographs, etc.) in the set; the most frequently cited documents.

CiteSpace. Mapping of the research field "ASNs". We exported the bibliometric data of the documents retrieved from the WoS database into CiteSpace 5.6.R1 software and conducted DCA and CWA.

2. Results and discussion

2.1. Document types and languages

According to the WoS tool *Results Analysis*, most of the documents in the set on ASNs are scientific articles in journals (54.4 % of documents), conference proceedings (23.8 % of documents), and reviews (18.2 %) (Table 1). About 95 % of the documents found here are published in English. It is no surprise and natural because the WoS database is English-language, and the central part of its content is presented with scientific journal articles.

2.2. The dynamics of documents publication

The number of documents on ASNs in the WoS database has started growing since 2005, which indicates a significant increase in the interest of scientists in ASNs (Fig. 1). Tim O'Reilly, in the article titled "What Is Web 2.0" introduced the concept of "Web 2.0" to denote services (platforms, projects, networks) that users can fill with their content themselves, precisely in 2005 (O'Reilly, 2005).

[2] TS is the WoS code that provides search in bibliographic record fields: title; essay; author's keywords; keywords plus WoS, upon request.

[3] The truncation character asterisk (*) represents any character group, including no character (for example, network* matches networks and network).

Table 1. Document types of the documents on ASNs in the WoS database

Таблица 1. Типовидовой состав документопотока по НСС в базе данных WoS

Document types	Number of documents in WoS	%
Article	661	54.4
Proceedings Paper	290	23.8
Review	222	18.3
Data Paper	55	4.5
Editorial Material	29	2.4
Early Access	28	2.3
Book Chapter	21	1.7
Letter	8	0.7
Meeting Abstract	7	0.6
Book Review	5	0.4
News Item	4	0.3
Database Review	3	0.2
Software Review	2	0.2

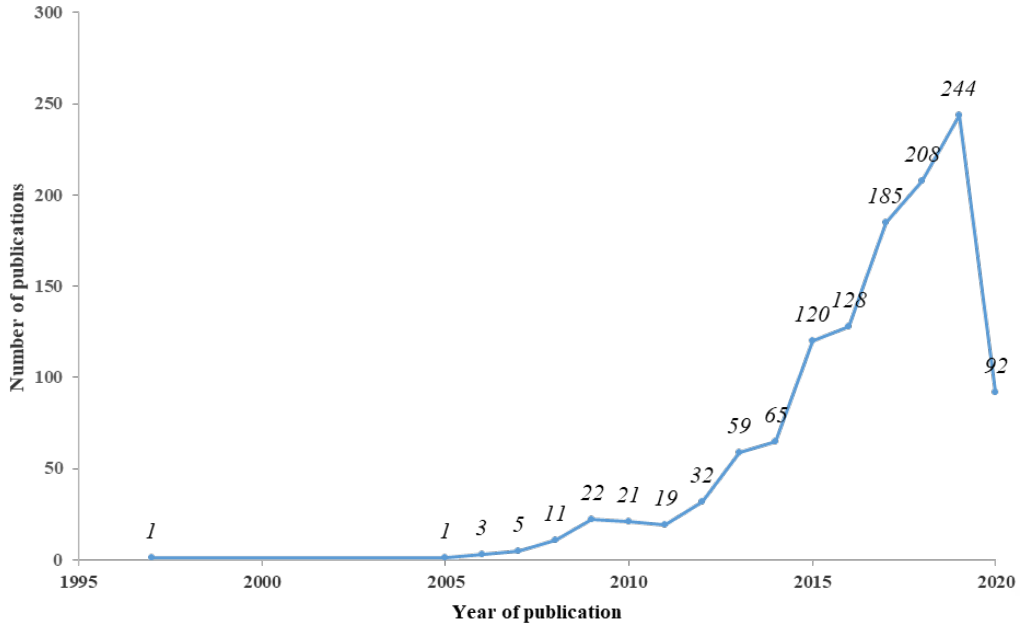

Fig. 1. The dynamics of publication of the documents on ASNs. The year 2020 is not indicative: the document set on ASNs for this year was not complete because the latest downloading of information took place in the middle of the year (18 June 2020)

Рис. 1. Динамика публикации документов по НСС. 2020 год не является показательным: состав документов по НСС на этот год не является полным, поскольку выгрузка документов для исследования была произведена в середине года (18 июня 2020 г.)

2.3. Funding of ASNs research

Five hundred eighty-one agencies supported studies on ASNs. When analyzing the statistics for the parameter, it is found that 834 bibliographic records of the set (68.6 % of 1216) do not contain data on funding support. Therefore, only about 30 % of the researches have been carried out with the help of a financial grant. Table 2 presents the most common funders. Most of the studies supported Chinese funds: the National Natural Science Foundation of China (NSFC) and Fundamental Research Funds for the Central Universities. It follows that much attention is paid to the research of communication through ASNs (Sun et al., 2020) and using these networks as a bibliographic source for the review literature (Sun et al., 2020) in China. Financial Funds from other countries (European Union, Brazil, USA) supported studies of research and use ASNs.

Table 2. ASNs Research Funding Agencies

Таблица 2. Организации, финансирующие исследования по НСС

Funding agencies	Country	The number of documents indicating the organization	%
National Natural Science Foundation of China (NSFC)	China	53	4.4
European Commission (EC)	European Union	14	1.2
National Council for scientific and technological development CNPQ	Brazil	12	1.0
Coordenadoria de Aperfeiçoamento de Pessoal de Nível Superior CAPES	Brazil	11	0.9
Fundamental Research Funds for the Central Universities	China	10	0.8
National Science Foundation (NSF)	USA	10	0.8

2.4. Journals that published articles on ASNs most frequently

Articles examining ASNs are published in more than 600 editions, which indicates the scattering of information. The most productive journals are *Scientometrics* (68 entries), *Data in brief* (54 entries), *Journal of the association for information science and technology* (27 entries), *Journal of informetrics*, and *Lecture notes in computer science* (25 entries each), *Proceedings of the International Conference on Scientometrics and Informetrics* (22 entries) (Table 3).

According to the WoS database thematic classifier *Web of Science Categories*, the journals with articles on ASNs are assigned to 171 categories. *Informatics and librarianship* (350 documents – 28.8 %), *Informatics and information systems* (196 documents – 16.1 %), *Interdisciplinary research in the field of computer technology* (158 documents – 12.9 %) (Table 4) are the categories in which the percentage exceeds 10 % of the total number of records.

In the journals (Scientometrics, Journal of informetrics, for example) related to the categories Informatics and librarianship, Informatics and information systems, metrics that assess the activity of scientists in ASNs (altmetrics *Mendeley readers, RG score*) (Bornmann, 2014, 2015) are discussed. In the journal Data in brief (WoS Category – Multidisciplinary Sciences), mainly those studies are published in which there is a reference to Mendeley Data, since Mendeley until recently combined a scientific social network, a bibliographic manager, a scientific data repository[4].

Conferences discussing ASNs topic

A bit less than a quarter (24 %) of the documents on ASNs are presented in the proceedings of 222 conferences. The main ones are:

– «14th International Society of Scientometrics and Informetrics Conference ISSI», 2013 and «21st International Conference on Science and Technology Indicators STI Peripheries Frontiers and Beyond», 2016 (8 documents);

Table 3. The sources of the documents on ASNs

Таблица 3. Источники документов по НСС

Journal	Number of documents	%
Scientometrics	72	5.6
Data in brief	58	4.4
Journal of the association for information science and technology	27	2.2
Journal of informetrics	25	2.1
Professional de la informacion	16	2.1
Online information review	16	1.8
Journal of ethnopharmacology	13	1.3
PlosOne	12	1.2
Learned publishing	10	1.1
Aslib Journal of Information Management	9	1.0

[4] Mendeley Data currently exist as a standalone application.

Table 4. WoS database categories assigned to journals in which the documents on ASNs were published

Таблица 4. Тематические категории журналов базы данных WoS, в которых были опубликованы документы по НСС

Web of Science categories	Number of documents	%
Information science library science	350	28.8
Computer science information systems	196	16.1
Computer science interdisciplinary applications	158	13.0
Computer science theory methods	100	8.2
Multidisciplinary sciences	84	6.9
Engineering electrical electronic	70	5.8
Computer science artificial intelligence	62	5.1
Education educational research	55	4.5
Pharmacology pharmacy	39	3.2
Computer science software engineering	38	3.1
Management	28	2.3
Social sciences interdisciplinary	28	2.3
Communication	27	2.2
Surgery	24	2.0
Chemistry medicinal	20	1.6

– «15th International Conference of the International Society for Scientometrics and Informetrics ISSI», 2015 and «17th International Conference of the International Society for Scientometrics and Informetrics ISSI», 2019 (7 documents);

– «IEEE ACM International Conference on Advances in Social Networks Analysis and Mining ASONAM», 2013, 2014, 2015, 2018, 2019 and «Internoise ASME 2012 Noise Control and Acoustics Division Conference», 2012 (5 documents).

2.5. Countries and organizations leading in ASNs research

ASNs have been studied in 101 countries, with the most considerable amount of researches being conducted in the USA (17.5 %), United Kingdom (12.2 %), China (11.6 %), Spain (8.6 %), Germany (6, 3 %), Canada (5.7 %), India (5 %) (Table 5).

The authors of documents on ASNs are affiliated with 1482 organizations. The institutions that deal with these issues are: University of Wolverhampton (UK) (44 documents), Leiden University (Netherlands) (20 documents), University of Manchester (UK) (18 documents), University of Pittsburgh (USA) (16 documents), University of Wuhan (China) (15 entries), Max Planck Society for Scientific Research (Institute for Solid State Research) (Germany) (13 documents), University of Granada (Spain) (13 documents), University of British Columbia (Canada) (12 documents), Malay University (Malaysia) (11 documents), as well as the Russian Academy of Sciences (Russia), South China Pedagogical University (China) documents and the University of Southampton (UK) – 10 documents per organization (Table 6).

2.6. Researchers Leading in ASNs investigations

In the set of documents, 3367 authors were identified who studied ASNs. The most significant number of publications belong to Thelwall M. (44), Bornmann L. (16), Haunschild R. (13), Costas R., Tang Y. (11), Kousha K. (10) (Table 7).

2.7. Most frequently cited documents on the topic of ASNs

Ten most frequently cited articles (Table 8) on the ASNs published from 2009 to 2015 are in the journals *Nucleic acids research*, *Scientometrics*, *Proceedings of the national academy of sciences of the United States of America*, *Journal of Informetrics*, *Journal of the association for information science and technology*. The articles are cited from 11 to 38 times per year on average. The total number of the articles' citations is between 105 and 305.

The total citation score for the set of documents in July 2020 was 5813. The average citation score per article was 6.8, and the Hirsch index was 35.

The article (Wolstencroft et al., 2013) performed at the School of Computer Science, University of Manchester, has been most frequently cited. The investigation is devoted to the Taverna platform that is the tool for processing bioinformatics research data. The data gathered and processed here are transported to *myExperiment, an ASN, and a* repository for the working materials of the biological studies

Table 5. Countries undertaking ASNs researches

Таблица 5. Страны, проводящие исследования НСС

Country	Number of documents	%	Country	Number of documents	%
USA	213	17.5	Iran	35	2.9
United Kingdom	148	12.2	Pakistan	29	2.4
Peoples R China	141	11.6	Poland	28	2.3
Spain	105	8.6	France	27	2.2
Germany	77	6.3	South Africa	27	2.2
Canada	70	5.8	Austria	24	2.0
India	62	5.1	Finland	22	1.8
Italy	60	4.9	Malaysia	22	1.8
Netherlands	54	4.4	Switzerland	21	1.7
Australia	48	3.9	South Korea	18	1.5
Brazil	46	3.8	Belgium	17	1.4
Russia	45	3.7	Saudi Arabia	16	1.3

Table 6. Leading scientific institutions by the number of papers on ASNs

Таблица 6. Научные учреждения-лидеры по количеству статей по НСС

Organizations	Country	Number of documents	%
University of Wolverhampton	UK	44	1.8
Leiden university	Netherlands	20	1.8
Manchester university	UK	18	1.6
University of Pittsburgh	USA	16	1.5
Wuhan university	China	15	1.3
Max Planck Society (Division Science & Innovation Studies)	Germany	13	1.2
Max Planck Institute of Solid State Research	Germany	13	1.1
University of Granada	Spain	13	1.1
University of British Columbia	Canada	12	1.1
University of Malaya	Malaysia	11	1.0
Russian Academy of Science	Russia	10	0.9
South China normal university	China	10	0.8
University of Southampton	UK	10	0.8

(workflows). A frequently cited article by C. A. Goble and co-authors is dedicated to ASN *myExperiment* also (Goble et al., 2010).

Noteworthy is that among ten highly cited documents, six are devoted to academic reputation online, and altmetrics (Bornmann, 2014; Haustein et al., 2014; Li et al., 2012; Mohammadi, Thelwall, 2014; Thelwall, Kousha, 2015; Zahedi et al., 2014) (social importance, social impact – are highlighted in blue in Table 8). The articles (Li et al., 2012), (Thelwall, Kousha, 2015) analyze the possibilities of social networks for assessing academics' influence (scholarly impact measurement).

Two from the list of actively cited articles are devoted to ResearchGate and Academia.edu, respectively (Thelwall, Kousha, 2014, 2015). Mohammadi and Thelwall (Mohammadi et al., 2015) discuss the peculiarities of the altmetric *Mendeley readership* for the social sciences and humanities.

Ahmed and Xing's article (Ahmed, Xing, 2009) is another frequently cited paper. It develops a machine learning method for modeling the dynamic network's behavior of different nature (gene networks, the network of interaction of US Senators). ASNs are considered in the paper also as a dynamic system. The authors modeled

Table 7. Leading authors by the number of documents on ASNs

Таблица 7. Авторы-лидеры по количеству документов по НСС

Authors	Organizations	Number of documents	%
Thelwall, Mike	University of Wolverhampton, Wolverhampton, United Kingdom	44	3.5
Bornmann, Lutz	Administrative Headquarters of the Max Planck Society, Munich, Germany	16	1.3
Haunschild, Robin	Max Planck Institute for Solid State Research, Stuttgart, Germany	13	1.1
Costas, Rodrigo	Leiden University, Leiden, Netherlands	11	0.9
Tang, Yong	South China Normal University, Guangzhou, China	11	0.9
Kousha, Kayvan	University of Wolverhampton, Wolverhampton, United Kingdom	10	0.8
Abramov, Valery M.	Russian State Hydrometeorological University, Saint Petersburg, Russia	9	0.7
Ortega, Jose-Luis	Consejo Superior de Investigaciones Cientificas (CSIC)	9	0.7
Zahedi, Zohreh	Leiden University, Leiden, Netherlands	9	0.7
De Roure, David	University of Oxford, Oxford, United Kingdom; University of Southampton, Southampton, United Kingdom	8	0.7
Haustein, Stefanie	Université du Québec à Montréal, Montreal, Canada; University of Ottawa, Ottawa, Canada	8	0.7
Goble, Carole Anne	University of Manchester, Manchester, United Kingdom	7	0.6
Gogoberidze, George G.	Russian State Hydrometeorological University, Saint Petersburg, Russia	7	0.6
He, Daqing	University of Pittsburgh, Pittsburgh, PA, USA	7	0.6
Herman, Eti	University of Haifa, Haifa, Israel	7	0.6
Nicholas, David	Tomsk State University, Tomsk, Russia; CIBER Res Ltd, Berks, United Kingdom	7	0.6
Shiri R.	Finnish Institute of Occupational Health, Finland	7	0.6

semantic transformations of some scientific concepts (author's keywords) within the articles taken from some ASN.

Thus, the top 10 highly cited articles indicate that ASNs are of interest for the scientific community as tools for assessing academic activity on Internet, as objects for analyzing their structure, as repositories for placing scientific data, as objects for developing algorithms for analyzing ASNs (including computer modeling of processes).

2.8. The thematic focus of research on ASNs

In total, the studies on ASNs are classified in 118 subject areas. The most quantitatively filled with them are presented in Table 9. ASNs investigated in the following main thematic areas: Informatics – 411 documents (33.8 %), Informatics and librarianship – 350 documents (28.8 %), Mechanical engineering and technology – 105 documents (8.6 %), Science and technology – 88 documents (7.2 %), education – 63 documents (5.2 %). Physicians and biologists use ASNs (ResearchGate, Mendeley) to select literature for a review, systematic review, and meta-analyses (Agrawal et al., 2020; Bajwa et al., 2017; Simmons et al., 2020; Weldegebreal, Worku, 2019). It is for this reason that the sample contains medical publications. The analyzed set of 1216 documents includes about 140 documents containing terms (review and "systematic literature search" or "systematic review*" or meta-analysis) in the title, abstract or indexed terms, referred to the areas of Pharmacology Pharmacy Public, Surgery, Neurosciences Neurology, General internal medicine, Environmental Occupational Health, Medicine General Internal, Clinical Neurology, Dentistry Oral Surgery Medicine, etc., in the overwhelming majority of cases, medical, research areas.

The Subject areas and Web of Science Categories give us some ideas of the problems investigated in the knowledge domain "ASNs" in general. Nevertheless, they are insufficient for the main

Table 8. Top 10 Most Cited WoS's documents on ASNs

Таблица 8. Топ-10 публикаций по НСС с высоким значение цитирования в WoS

Reference	Article title	Year of publication	Number of citations
(Wolstencroft et al., 2013)	The Taverna workflow suite: designing and executing workflows of Web Services on the desktop, web or in the cloud	2013	305
(Zahedi et al., 2014)	How well developed are altmetrics? A cross-disciplinary analysis of the presence of 'alternative metrics' in scientific publications	2014	165
(Bornmann, 2014)	Do altmetrics point to the broader impact of research? An overview of benefits and disadvantages of altmetrics	2014	149
(Li et al., 2012)	Validating online reference managers for scholarly impact measurement	2012	146
(Goble et al., 2010)	myExperiment: a repository and social network for the sharing of bioinformatics workflows	2010	135
(Ahmed, Xing, 2009)	Recovering time-varying networks of dependencies in social and biological studies	2009	135
(Haustein et al., 2014)	Coverage and adoption of altmetrics sources in the bibliometric community	2014	124
(Mohammadi, Thelwall, 2014)	Mendeley readership altmetrics for the social sciences and humanities: Research evaluation and knowledge flows	2014	121
(Thelwall, Kousha, 2015)	Disseminating, communicating, and measuring Scholarship?	2015	116
(Thelwall, Kousha, 2014)	Academia.edu: Social network or Academic Network?	2014	105

Table 9. Distribution of documents on ASNs according to WoS Subject Areas

Таблица 9. Распределение документов по НСС в соответствии с тематическими областями WoS

Research Areas	Number of documents	%
Computer Science	411	33.8
Information Science Library Science	350	28.8
Engineering	105	8.6
Science Technology Other Topics	88	7.2
Education Educational Research	63	5.2
Pharmacology Pharmacy	42	3.5
Business Economics	35	2.9
Social Sciences Other Topics	32	2.6
Communication	27	2.2
Surgery	24	2.0
Neurosciences Neurology	23	1.9
General internal medicine	22	1.6
Chemistry	19	1.6
Public environmental Occupational health	19	1.6
Plant sciences	18	1.5
Psychology	18	1.5
Telecommunications	18	1.5
Dentistry oral surgery medicine	17	1.4
Integrative complementary medicine	17	1.4
Physics	16	1.3

trends (research fronts) of the topic understanding. For a more detailed investigation of the topic's thematic structure, we used the program to visualize scientific literature trends and patterns, the CiteSpace. Main research fronts of the knowledge domain "ASNs" were revealed with the CiteSpace use are visualized, positioned in chronological order, and discussed in the article.

2.9. Mapping the research field "ASNs" based on the DCA and with the help of CiteSpace

Six hundred sixty-two nodes were identified (Fig. 2, 3). 2943 co-citation links network them. The color of the link denotes the year when the document was first co-cited. The number of co-citations of a given document specifies the size of a node. Table 10 presents the first 11 most frequently cited articles. In Figure 2 they are represented by the first author's name and the year of publication.

The DCA revealed 112 clusters, 8 of which are visually presented in Figure 3, 4. For automatic marking of clusters (Figs. 3 and 4), terms from the titles of citing documents (citers) selected by the CiteSpace program and ranked by an algorithm using LLR (log-likelihood ratio test) (Chen, Song 2019) empowered by scientometric and visual analytic techniques, offer opportunities to improve the timeliness, accessibility, and reproducibility of conventional systematic reviews. While increasingly accessible science mapping tools enable end users to visualize the structure and dynamics of a research field, a common bottleneck in the current practice is the construction of a collection of scholarly publications as the input of the subsequent scientometric analysis and visualization. End users often have to face a dilemma in the preparation process: the more they know about a knowledge domain, the easier it is for them to find the relevant data to meet their needs adequately; the little they know, the harder the problem is. What can we do to avoid missing something valuable but beyond our initial description? In this article, we introduce a flexible and generic methodology, cascading citation expansion, to increase the quality of constructing a bibliographic dataset for systematic reviews. Furthermore, the methodology simplifies the conceptualization of globalism and localism in science mapping and unifies them on a consistent and continuous spectrum. We demonstrate an application of the methodology to the research of literature-based discovery and compare five datasets constructed based on three use scenarios, namely a conventional keyword-based search (one dataset. In Table 11 clusters are labeled with three or four terms. Indeed, CiteSpace identifies 100 terms, ranked in descending order of value of the applied algorithm (LLR) (but not all of them are shown).

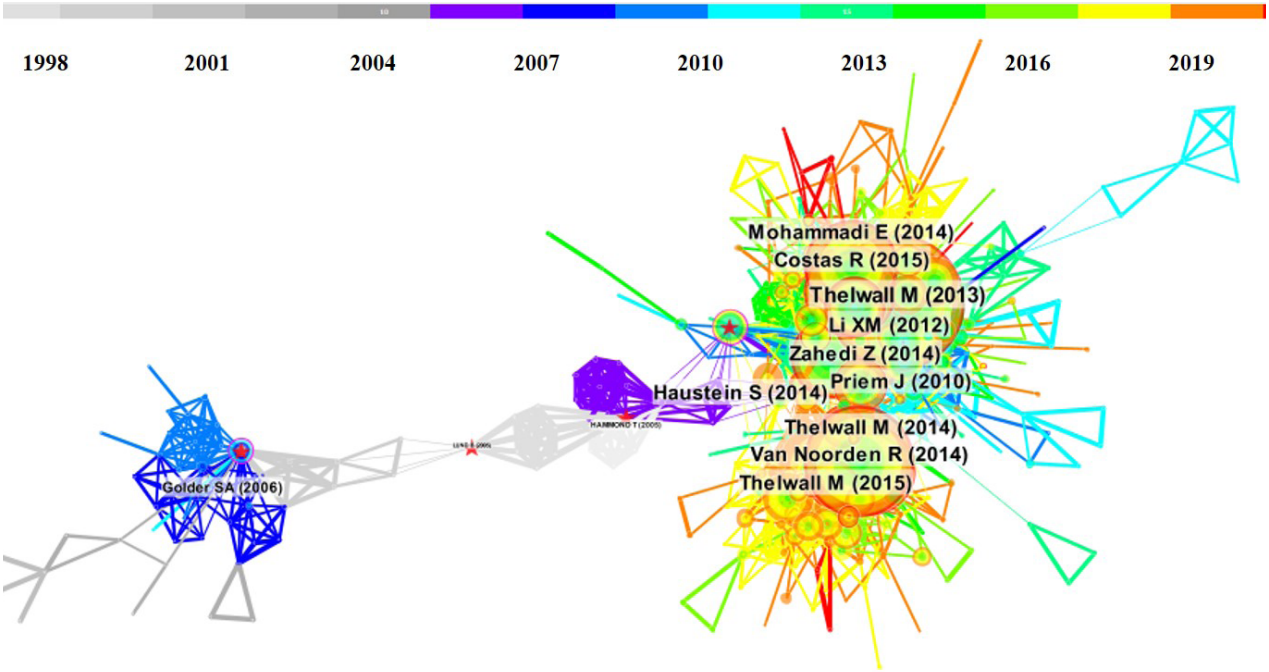

Fig. 2. Documents co-citation network for the ASNs document set. Built on the base of 36626 valid references of 1216 documents. Retrospective from 2005 to 2020. DCA in CiteSpace identified 666 nodes linked by 2870 co-citations. The palette starts with a grey shade (2005), turning into a rainbow spectrum (until 2020), selected to represent the citation year. The references with a high value of betweenness centrality are marked with asterisks and a purple ring and signed with the first author's name and the year of publication. The references with a high citation (at least 58) also signed with the first author's name and the year of publication (Table 10)

Рис. 2. Сеть коцитирования документов (ссылок) для документального массива по НСС. Построена на основе 36626 пристатейных ссылках. Ретроспектива – с 2005 по 2020 г. При анализе коцитирования документов было выявлено 666. Для временной шкалы была выбрана палитра, начинающаяся с оттенков серого (2005), далее переходит в палитру спектра радуги (2020) узлов, объединенных 2870 связями коцитирования. Ссылки с высокими значениями центральности по посредничеству выделены звездочками. Ссылки с высокими значениями коцитирования (не менее 58 цитирований) обозначены фамилией первого автора и годом публикации (Таблица 10)

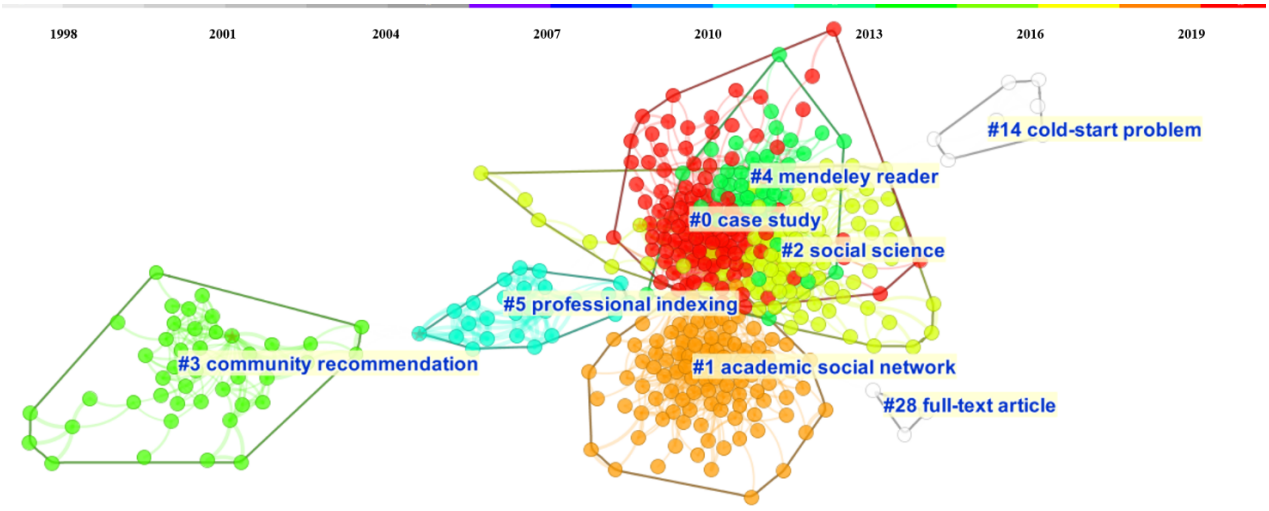

Fig. 3. Clusters of the document co-citation network for the document set on ASNs
Рис. 3. Кластеры сети коцитирования документов для документального массива по НСС

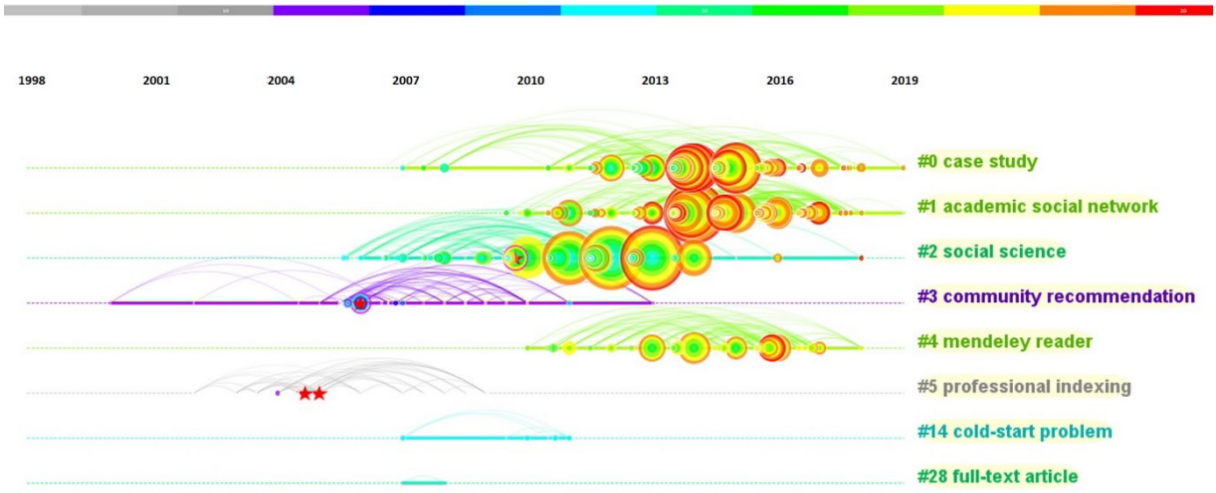

Fig. 4. A timeline view of clusters of the document co-citation network for the documents on ASNs
Рис. 4. Расположение кластеров сети коцитирования документов для документального массива НСС на временной шкале

The "oldest" are clusters #5, #3, and #28. The average year for publishing the references, the clusters include, are 2005 and 2007 (Table 11). The documents of clusters #5 and #3 are the intellectual basis of the research fronts "professional indexing" and "social tagging", "Community recommendation".

The problem of content systematization was being solved at the initial stages of the ASNs formation (cluster #5). Social network developers followed the path that has already been tested to create document repositories and digital libraries: labeling content with descriptors (descriptive terms), also called keywords or tags. The ASN user could use a filter or tag search. The creators of the resources (repository, digital library) carried out by tagging using the data provided by the document's author in the case of a repository and digital library. In the case of social networks, the function of content indexing has been provided to users. It took the form of social tagging (collaborative tagging, social classification, social indexing), which is also called Volksonomy (folksonomy = folk taxonomy) (Hotho et al., 2006; Rawashdeh et al., 2013). Notably, the intellectual basis of the "professional tagging" cluster consists of two publications with high BC (see Methods) values (Hammond et al., 2005; Lund et al., 2005) (Fig. 2, Table 12). They are devoted to *Social Bookmarking Tools* and discuss content organization using collaborative tagging. In the article (Kipp, 2011), which is the main citer of the cluster (it cites ten times the documents of cluster #10, which has 25 documents), the scientist performs a comparative analysis of thematic indexing of scientific articles by the social tagging method (CiteULike) and the professional indexing method (PubMed) (Table 11).

The ASNs' services recommending their content to users based on social tags *(Community recommendations)* have appeared later (cluster #3, 2007). Golder and Huberman (2006) discusses collaborative tagging in social bookmarking web service Del.icio.us. The CiteULike and Connotea (ASNs and bibliography management systems simultaneously) are given as examples of ASNs, in which social tagging is applied for the systematization of scientific papers. Notably that the article by Golder and Huberman (2006) highlighted in the document co-citation network as the pivotal one (BC = 0.10) (Fig. 2, Table 12). The authors suggested that the proliferation of sites that support collaborative tagging would continue. These sites would provide fertile ground for studying computer-mediated collaborative systems and provide users with new ways to share and recommend the content. Cluster #3 reflects the problem of *Community recommendations in ASNs discussed in the set of documents under investigation.*

The next in chronological order is cluster #28. Cluster #28 reflects the research problems on scientists' behavior in the exchange of scientific articles full texts on the platforms of scientific social networks (Jamali, Nabavi, 2015). It highlights the analysis of full-text sources in the Google Scholar search engine as a separate topic. ASN ResearchGate is the most abundant source of full texts among the individual sites in this system. The sources of the full texts in ASNs were actively investigated in many articles (Borrego, 2017). However, the problem of access to full texts of scientific publications through ASNs has many other, no less important aspects. The high visibility that ASNs have achieved has not come without controversy during the platforms' rise to prominence. One factor in its popularity was the large volume of full-text PDF (portable document

Table 10. References ranked by the number of citations in the ASNs document co-citation network (highlighted in Figure 3)

Таблица 10. Ссылки, ранжированные по количеству цитирований в сети коцитирования документов ASNs (выделены на рисунке 3)

Reference co-citation	Year of publication	Reference	Article title	Cluster
106	2013	(Thelwall et al., 2013)	Do altmetrics work? Twitter and ten other social web services	2
91	2012	(Li et al., 2012)	Validating online reference managers for scholarly impact measurement	2
88	2014	(Van Noorden, 2014)	Online collaboration: scientists and the social network	1
74	2015	(Costas et al., 2015)	Do “altmetrics” correlate with citations? Extensive comparison of altmetric indicators with citations from a multidisciplinary perspective	0
73	2015	(Thelwall, Kousha, 2015)	ResearchGate: disseminating, communicating, and measuring scholarship?	1
72	2014	(Thelwall, Kousha, 2014)	Academia.edu: social network or academic network?	1
71	2014	(Mohammadi, Thelwall, 2014)	Mendeley readership altmetrics for the social sciences and humanities: research evaluation and knowledge flows	0
71	2014	(Zahedi et al., 2014)	How well developed are altmetrics? A cross-disciplinary analysis of the presence of ‘alternative metrics’ in scientific publications	0
64	2014	(Haustein et al., 2014)	Coverage and adoption of altmetrics sources in the bibliometric community	0
63	2010	(Priem et al., 2010)	Altmetrics: A manifesto	2
58	2011	(Eysenbach, 2011)	Can tweets predict citations? Metrics of social impact based on Twitter and correlation with traditional metrics of scientific impact	2

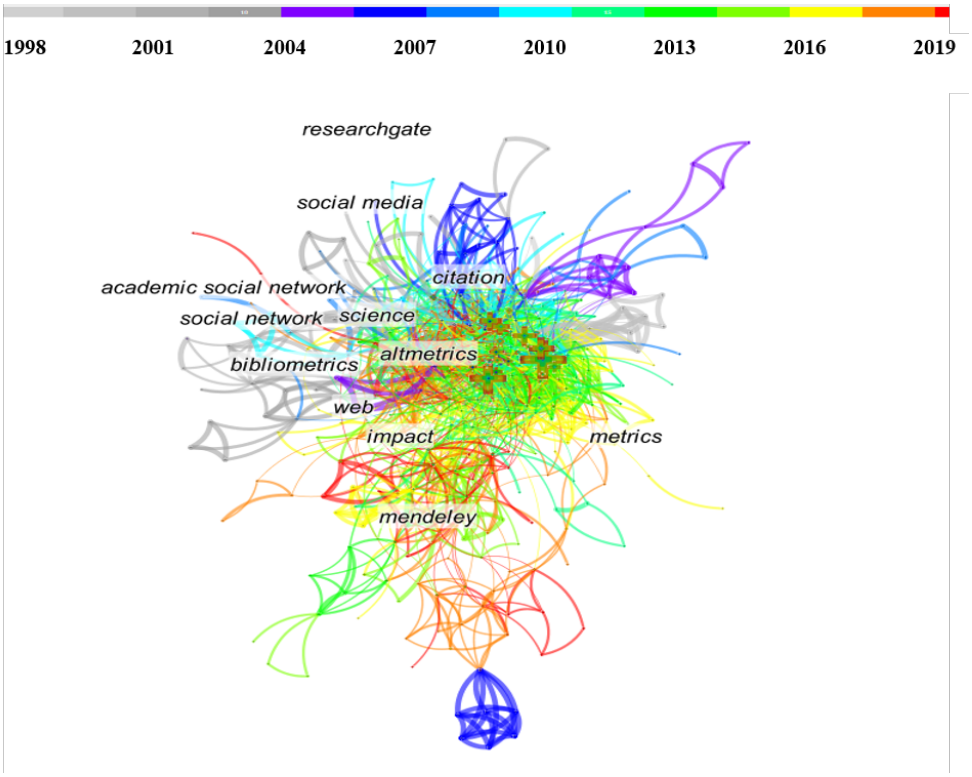

Fig 5. CiteSpace keywords co-occurrence analysis of the documents on ASNs from the WoS database
Рис. 5. Анализ в CiteSpace совместной встречаемости ключевых слов в документах по НСС из базы данных WoS

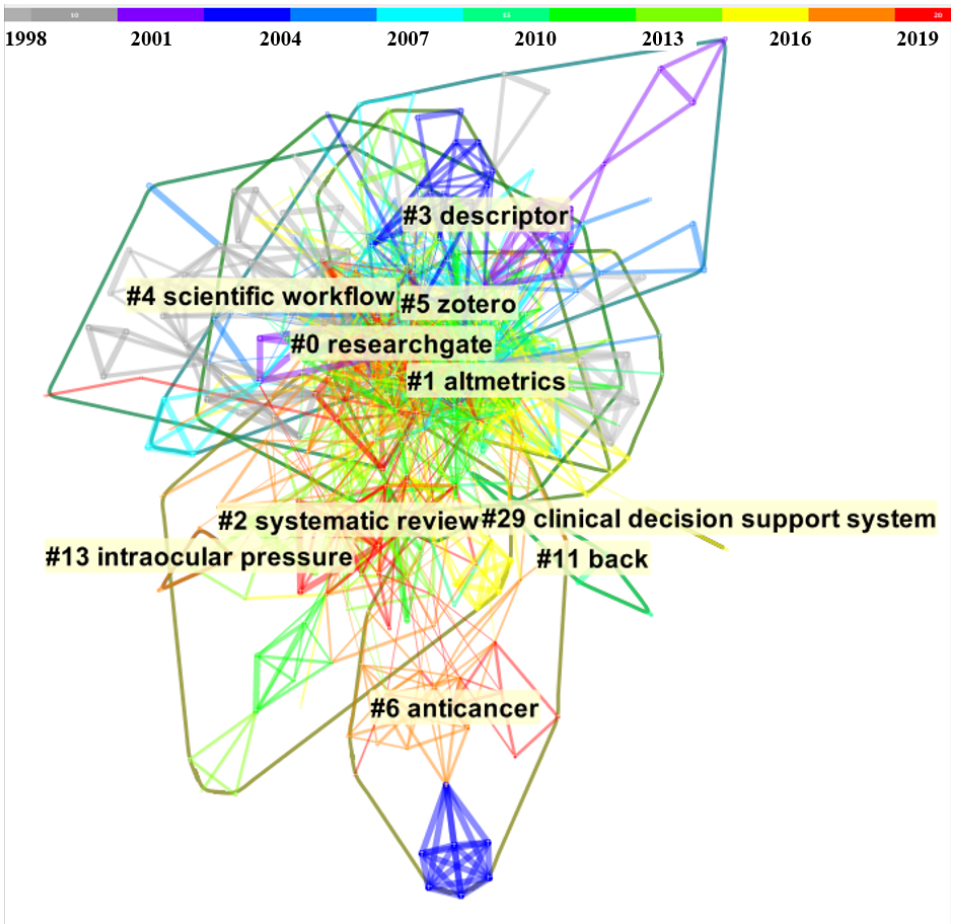

Fig. 6. CWA network clusters are plotted in CiteSpace
Рис. 6. Кластеры сети совместной встречаемости слов, выявленные при помощи CiteSpace при анализе документального массива по НСС

Table 11. Clusters of the document co-citation network for the document set on ASNs

Таблица 11. Кластеры сети коцитирования документов для документального массива по НСС

Cluster ID	Cluster size	Cluster silhouette*	Mean year of publication	LLR (*log-likelihood ratio* tests)	Cluster issue interpretation; references to citing articles, from the titles, abstracts, keywords of which labels for clusters
#5	25	0.972	2005	***Professional indexing*** (15.67, 1.0E-4); tagging practice (15.67, 1.0E-4); academic social network (0.1, 1.0);	There are significant differences in indexing (bookmarking in CiteULike) by article authors, social network users who bookmark pages with the article, and professional indexing by information workers (librarians-organizers) (Kipp, 2011)
#3	43	0.977	2007	***Community recommendation*** (51.49, 1.0E-4); exploring social tagging (51.49, 1.0E-4); social tag (42.81, 1.0E-4);	Exploring social tagging for personalized community recommendations (Ke, Chen, 2012; Kim, Saddik, 2013)
#28	3	1	2007	***Full-text article*** (13.94, 0.001); different subject field (13.94, 0.001); Google Scholar (6.04, 0.05);	ResearchGate was the top single website providing full-text files (10.5 % of full-text articles) for Google Scholar (Jamali, Nabavi, 2015)
#14	7	0.989	2010	***Cold-start problem*** (14.62, 0.001); effective recommender algorithm (14.62, 0.001); academic social network (3.69, 0.1);	An Effective Recommender Algorithm for Cold-Start Problem in Academic Social Networks (Rohani et al., 2014)
#2	85	0.88	2011	***Social science*** (91.39, 1.0E-4); altmetrics source (68.44, 1.0E-4); bibliometric community (68.44, 1.0E-4); humanities research (64.45, 1.0E-4);	Mendeley reader data could be a useful supplementary measure to remedy some limitations of citation analysis across the social sciences and humanities (Mohammadi, Thelwall, 2014)
#0	102	0.813	2014	***Case study*** (83.95, 1.0E-4); **altmetrics** data provider (80.86, 1.0E-4); meta-analysis review (80.86, 1.0E-4);	Case studies and meta-analysis reviews of altmetrics data providers (particularly Mendeley, CiteULike and others) (Bornmann, 2015; Ortega, 2020)
#4	41	0.915	2014	***Mendeley reader*** (178.49, 1.0E-4); early citation (85.72, 1.0E-4); citation count (68.31, 1.0E-4); multidisciplinary comparison (68.31, 1.0E-4);	Series of studies of ASN/bibliographic manager Mendeley (metrics "Mendeley reader", structures of the scientific community Mendeley, etc.) and some other ASN (ResearchGate) (Thelwall, 2017; Thelwall, Kousha, 2017)
#1	100	0.934	2015	***Academic social network*** (126.49, 1.0E-4); research universities (101.34, 1.0E-4); academic social networking site (96.81, 1.0E-4);	User, disciplinary structure of ASN, other aspects of functioning, comparative analysis of ASNs (Bhardwaj, 2017)

* The silhouette value of a cluster measures the quality of a clustering configuration. Its value ranges between –1 and 1, with 1 representing a perfect solution.

format) articles present in many researcher profiles. These full-text PDFs were easily discoverable in web searches, making ASNs a popular source for article sharing. This fact has been brought to the attention of some publishers and has given rise to a concerted effort to tackle this problem. In 2017 a group of publishers, including such prominent firms as ACS Publications and Elsevier, formed the Coalition for Responsible Sharing to pressure ResearchGate to take measures against distributing copyright-protected material on its platform (O'Brien, 2019).

Cluster #14 (the average year of publication of cluster documents – 2010) denotes research on recommendation systems for ASNs developing. Recommendation systems are designed to predict what objects (films, music, books, news, and websites) will interest the user, based on the specific information on the user's profile. When creating recommendation systems, the "cold-start problem" comes first. The "cold start problem" has also been solved to develop recommendation systems for ASNs. The problem is what the ASN should offer to a new user of the web and whom to offer new content (Rohani et al., 2014).

Further, in terms of chronology and localization in the network, clusters (#2, #0, and #4) are marked as *Social science*, *Case study*, *Mendeley reader*. The clusters highlight the various aspects of studying the altmetrics: "Mendeley reader" as altmetric for social sciences (Mohammadi, Thelwall, 2014); the case studies and meta-analysis reviews of altmetrics data providers (particularly Mendeley, CiteULike, and others) (Bornmann, 2015; Ortega, 2020); series of studies of ASN/bibliographic manager Mendeley (metrics "Mendeley reader," structures of the scientific community Mendeley, etc.) and some other ASN (ResearchGate) (Thelwall, 2017; Thelwall, Kousha, 2017) (Table 11). It is no coincidence that among the co-cited articles located in the document co-citation network (Fig. 2, Table 12, BC=0.16) on the path to these clusters is the pivotal publication (Priem, Hemminger, 2010). In 2010, a group of four experts (Jason Priem (University of North Carolina-Chapel Hill), Dario Taraborelli (Wikimedia Foundation), Paul Groth (University of Amsterdam), Cameron Neylon (Science and Technology Facilities Council)) made a proposal using alternative metrics (alt-metrics, altmetrics). The essence of their proposals is reflected in the Altmetry Manifesto (Priem et al., 2010).

Almost the most numerous cluster #1 symbolizes the research front that studies various aspects of ASNs: users composition, disciplinary structure of the ASNs, comparative ASNs research (Table 11).

The fact that alternative metrics of the ASNs are actively studied in the scientific literature is confirmed by our data received using CWA in the CiteSpace program. The terms most frequently encountered in this set are "altmetrics", "impact", "citation" (Table 13).

The CWA (Fig. 5) network clustering analysis results were remarkable (Fig. 6): the CWA has revealed some other thematic areas than DCA did. These areas are not connected with the study of the ASNs but deal with their use as a source of a bibliography for performing a review, systematic review, or meta-analysis (CWA, clusters #11, #2, #29, #13; see Table 14). All of them are related to the analysis of medical literature. Cluster #4, which symbolizes the research front defined by the group of terms as Scientific workflows, Bioinformatics, etc. (Table 14), should be referred to the same series. The terms are selected by the LLR values (Table 14). Taverna Workflow Management System (http://www.taverna.org.uk) is a bioinformatics tool for managing workflows and experiments. Two articles devoted to this platform are frequently cited articles (Wolstencroft et al., 2013) (Table 8). This tool (Taverna) has come into our field of vision because it is compatible with the repository of workflows (workflows repositories) myExperiments, which positions itself as a scientific social network.

The research topics of such authors as V. M. Abramov and G. G. Gogoberidze (Russian State Hydrometeorological University, Saint Petersburg, Russia) are not explicitly reflected in the research fronts identified by CiteSpace. Both authors are among the authors with many publications in the studied document set (Table 7). The studies of these scientists are classified in the WoS database as "Geosciences Multidisciplinary"; "Water Resources"; "Computer Science Interdisciplinary Applications," etc. The work of the scientists is included in our table since the summaries of all their publications contain a link (https://www.researchgate.net/profile/Valery_Abramov2/) to V. Abramov's profile in ResearchGate. "The platform gave excellent opportunities for preliminary discussion and data exchange in the frame of these researches," writes V. Abramov. Thus, in this study, these works form the research front of cluster #0 (Table 14).

Conclusion

ASNs are a type of scientific communication implemented in the Internet media based on Web 2.0 technologies and belong to Science 2.0 online-based tools. The specialized ASNs were developed to meet scholars' needs after the formation of Global social networks. As a phenomenon of social communication, global social and academic social networks are the object of study for scientists. In this work, we carried out a multidimensional scientometric analysis of the document set on ASNs retrieved from the WoS database on 18 June 2020. Countries, organizations, and scientists investigating the modern form of communication between scientists are identified. It is shown that research on ASNs started in 2005. The leading are the following countries: USA, China, United Kingdom, and Spain.

Table 12. Articles in the document co-citation network with the betweenness centrality value exceeding 0.1

Таблица 12. Статьи в сети коцитирования документов со значением центральности по посредничеству (Betweenness centrality), превышающим 0,1

Co-citation	Betweenness centrality	Publication year	Article
4	0.19	2005	(Hammond et al., 2005)
27	0.16	2010	(Priem, Hemminger, 2010)
2	0.15	2005	(Lund et al., 2005)
19	0.10	2006	(Golder, Huberman, 2006)

Table 13. The frequency of keywords co-occurrence of the document set on ASNs in the network built via CiteSpace

Таблица 13. Частота совместной встречаемости ключевых слов документального массива по НСС в сети, построенной при помощи CiteSpace

Co-occurrence frequency	Year of publication of the article with the first mention of the term	Keyword
151	2013	altmetrics
124	2012	impact
96	2008	citation
93	2012	social media
87	2013	Mendeley
76	2014	ResearchGate
59	2012	science
56	2010	academic social network
54	2011	bibliometrics
49	2014	metrics
45	2009	social network
43	2012	web
42	2015	indicator
40	2012	journal
38	2014	Twitter
38	2014	Google Scholar
37	2008	citation analysis
36	2008	information
31	2008	open access
30	2016	media
28	2016	article
25	2015	Scopus
25	2010	network
23	2007	CiteUlike
21	2013	academiaedu
21	2015	publication
21	2015	model

Note. 27 out of 484 keywords are given; the inclusion threshold is the occurrence of at least 20.

Table 14. Clusters of the network built in CiteSpace during CWA of the documents on ASNs (Fig. 6).

Таблица 14. Кластеры сети совместной встречаемости слов, выявленные при помощи CiteSpace при анализе документального массива по НСС (рис. 6)

Cluster ID	Cluster size	Cluster silhouette	Mean year of publication	Terms selected by LLR (*log-likelihood ratio* tests) for clusters labeling
4	42	0.841	2011	scientific workflow (16.18, 1.0E-4); bioinformatics (10.75, 0.005); semantic web (7.07, 0.01); training planning (5.49, 0.05)
3	45	0.884	2011	descriptor (11.93, 0.001); title keyword (11.93, 0.001); tagging (11.93, 0.001); CiteULike (11.43, 0.001)
1	86	0.77	2014	altmetrics (13.64, 0.001); citation analysis (12.43, 0.001); webometrics (10.14, 0.005); citation counts (7.6, 0.01)
0	89	0.69	2014	ResearchGate (15.86, 1.0E-4); academic social network (11.12, 0.001); social media (9.72, 0.005); social networking sites (6.68, 0.01); f1000 (5.54, 0.05)
11	4	0.976	2015	back (10.53, 0.005); physical fitness (10.53, 0.005); pelvis (10.53, 0.005); hamstring stretching (10.53, 0.005)
5	32	0.809	2016	Zotero (20.02, 1.0E-4); innovation (14.97, 0.001); author-based metrics (9.96, 0.005); feminist research (9.96, 0.005)
6	29	0.928	2017	anticancer (16.83, 1.0E-4); anti-inflammatory (16.83, 1.0E-4); antioxidant (11.18, 0.001); phytochemistry (7.49, 0.01)
2	68	0.817	2017	systematic review (10.05, 0.005); obesity (10.05, 0.005); meta-analysis (6.69, 0.01); prevalence (6.69, 0.01)
29	2	0.994	2018	clinical decision support system (?, 1.0); usage statistics (?, 1.0); academic librarians (?, 1.0); accuracy (?, 1.0)
13	3	0.997	2019	intraocular pressure (11.03, 0.001); physical activity (11.03, 0.001); glaucoma (11.03, 0.001); exercise (8.27, 0.005)

At present, the main issues discussed in connection with the ASNs are alternative metrics designed to reflect the activity of scientists online. It is shown that among the most frequently cited publications under investigation, there are many articles on altmetrics in ASNs. CiteSpace revealed the main research fronts in the literature on ASNs from 2005 to 2019. Social tagging, professional indexing problems, and "cold access" were discussed when ASNs started to rise. Subsequently, in some ASNs (ResearchGate, Mendeley), systems for assessing scientific activity in the web environment (altmetrics) were developed. Also, the questions of how various ASNs were organized, the behavior of their members, etc., are studied. However, altmetrics in ASNs are the primary research trend.

In our document set retrieved from the WoS database, along with articles that directly analyze ASNs, there are articles in which ASNs are referred to as scientific data repositories (e.g., Mendeley, myExperiment). There are articles with high citation rates (Wolstencroft et al., 2013; Goble et al., 2010). All this indicates that the document flow we are analyzing reflects that ASNs are the object of scientific research and that ASNs have entered directly into scientists' lives.

ASNs continue to change instantly. For example, there are reports about the termination of some of them (CiteULike, Connotea). While this article was being written, a message came at the end of December 2020 that Mendeley would be removing social media features such as Mendeley Feed and Public Groups; Mendeley Profiles; Mendeley Funding. That is, Mendeley will cease to function as an ASN. A new Mendeley Reference Manager will be operational and improved based on users' feedback.

It is believed that the Web 2.0 paradigm ("Science 2.0") has exhausted itself. The Web 2.0 technology made it possible to quickly and practically free of charge using a significant number of vital Internet services with high consumer qualities, which led to the emergence of a vast number of monotonous resources, resulting in the depreciation of most of them. Apparently, for this reason, having lost the competition, ASNs self-destruct one after another (CiteULike, Connotea, Mendeley). The next wave would

be web 3.0 ("Science 3.0") (Teif, 2013). Web 3.0 is a concept for developing Internet technologies, formulated by the head of Netscape.com, Jason Calacanis, to continue the idea of Web 2.0 Tim O'Reilly. Its essence is that Web 2.0 is only a technological platform, and Web 3.0 will allow professionals to create high-quality content and services on its basis (Calacanis, 2007). The methods of DCA and CWA we used for revealing the trends in the literature on ASNs have their limitations. They did not allow us to identify the latest trends in the development of ASNs. The trends are associated with the next stage in the evolution of the Internet – an idea of Web 3.0 technology. However, the trends in the development and use of ASNs, which we could identify and visualize, are also of interest.

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