A BIBLIOMETRIC ANALYSIS OF THE USE OF OPEN SOURCE SOFTWARE IN EDUCATIONAL CONTEXTS

Orfa Nidia Patiño Toro, Yesenia Acevedo Correa
University institution ESCOLME, Colombia
E-mail: cies4@escolme.edu.co, yacevedoc@ucn.edu.co

Alejandro Valencia-Arias, Martha Benjumea-Arias
Metropolitan Institute of Technology, Colombia
E-mail: jhoanyvalencia@itm.edu.co, marthabenjumea@itm.edu.co

Abstract

Open source software has now become a significant alternative in meeting different needs in business, government and academic environments, such as needs related to economics, management, learning and innovation, among others. The purpose of this research was to examine the research trends and evolution of the field of open source software adoption between 2001 and 2019. The methodology used involved bibliometric analysis of 289 documents obtained through a Scopus extracted search equation, generating indicators of quantity and quality and analyzing the emerging themes in said field of knowledge. The findings of the research include the existence of a strong trend towards research and dissemination regarding open source software, particularly in countries such as the United States, whose institutions and authors demonstrate high levels of productivity and dissemination. There was also evidence of an interest in reducing barriers and encouraging the adoption and implementation of the software in other sectors where its use is still lagging behind. The main conclusion of the research is that the research of open source software adoption focuses on the following topics: innovation, Linux, FLOSS, engineering requirements, risk management, open innovation, the public sector, social network analysis and total cost of ownership.
Keywords: *bibliometric analysis, information technology, open source software, research trends, technology adoption.*

Introduction

The adoption of open source software (OSS) is recognized as an alternative for accessing platforms for content creation, management and learning, free of charge and in a range of contexts. As a result, software of this type can be "freely used, copied, studied, modified and redistributed" by any individual (González, 2006). This has led to the creation of a free software movement that works through partnerships to develop programming projects. These communities are characterized by having members who are highly trained and motivated to meet the proposed objectives (Clavero, Formentí, & Prieto, 2008).

Prior Research

Open Source Software (OSS) has been extended in recent years, focusing strong attention and becoming one of the main driving forces of the business ecosystem (Silic & Back, 2016; Velázquez-Juárez, Valencia-Pérez, & Peña-Aguilar, 2016); however, companies and individuals

counterbalance difficulties and challenges to achieve an appropriate adoption of OSS; since not only challenges derived from the technological components must be solved but also from the changes in the organizational culture and transformation of the mentality in the decision makers of IT (Méndez, 2016; Londoño-Patiño & Acevedo-Álvarez, 2018).

The use of OSS arises as a strategic action for both public and private institutions, and through which tools from the information and communication technologies (ICTs) can be employed critically and creatively in order to address specific needs at low cost (Valverde, 2005). Research has been conducted that has focused its efforts on determining variables or advantages that drive organizations and users towards the adoption of Open Source Software, which, despite its strengths, is still sparsely used compared to licensed software (Kagiri, He, & Henglin, 2013).

In this context, the progress of ICT has influenced settings that have enabled content transformation processes to be stimulated, generating new ways of educating and new areas for employability related to the creation of new technological and virtual environments (Serrano & Narváez, 2010). It is here that the use intention of OSS begins to be consolidated, not only in order to bring about technical breakthroughs, but also for a social purpose, given the existing ethical and political need to favor this community (Alonso & D'Antoio, 2015).

Among the latest trends in the ICT community is an appreciation for the integration of open source software (Taha, Abbood, Razzaq, & Al-Bahri, 2018), which has gained popularity as a highly valuable tool in modern organizational contexts around the world (Kramer, 2014). In that sense, it should be noted that demand for OSS has increased considerably, strengthening its adoption and having a significant impact on the software development industry as a result of its functionality and the trust generated by the multiplicity of options and communities that provide online support (Koloniaris, Kousiouris, & Nikolaidou, 2018).

There has also been evidence of a upsurge in the adoption of OSS by both governmental and private entities, with the medium acting as an alternative to traditional proprietary software (Goode, 2014; Sarrab & Rehman, 2014). In addition, it is important to mention that developing countries show a significant delay in the adoption of OSS especially by end users. In these contexts, most users do not buy proprietary software, but benefit from it through the reuse of licenses, so the tendency to piracy is a common practice (Kamau and Sanders, 2013).

Research Problem

Despite the clear progress made by OSS, limitations to adoption by some sectors still exist. It is therefore important to raise awareness of the contribution made by incorporating such software (Moreno-Agudelo & Valencia-Arias, 2017; Taha et al., 2018), given the still prevalent belief in the centralized innovation model of private software, where only those who possess the source code are authorized to improve it (González-Barahona, 2008).

Linked to this, despite the increasing worldwide popularity of the adoption of Open Source Software (Mijinyawa & Abdulwahab, 2014), in the literature there is a gap in research related to this topic (Lakka, Stamati, & Michalakelis, 2014), so the adoption and use of OSS are not well understood yet (Mahapatra, Manzar, & Bhadauria, 2015). Due to this need for more research on the subject, there are many organizations and people who are reluctant or skeptical to adopt OSS, so it is considered relevant to carry out new research in order to provide supportive frameworks to formulate new adoption strategies from OSS (Mijinyawa & Abdulwahab, 2014).

The growth dynamic of research by various authors is immediately apparent in the documents reviewed and the relevant factors over time in the process of users adopting and using these tools, as are an orientation towards specific elements and the search to improve acceptance. This is despite the barriers and potential resistance that persist in some settings. According to these circumstances, the research seeks to answer the question What are the research trends and developments in the acceptance and use of open source software?

116

For this reason, this research aimed to examine the research trends and evolution of the acceptance and use of open source software. Although the open software initiative (OSI) was created in 1988 by E. Raymond and B. Perens, only until 2001 was the first research registered in Scopus directly related to the adoption of free software (Wang, & Wang, 2001). Therefore, this bibliometric analysis has taken as a period of analysis the documents reported from 2001 to June 2019.

Research Methodology

General Background

It should be noted that this research provides a quantitative approach that enables the data collected to be calculated (Vega-Malagón et al., 2014), while also offering a descriptive scope in order to record and present in detail the data found regarding the evolution of the variables observed over a specific timeframe, which is an important foundation in the generation of scientific knowledge (Sánchez, Blas, & Tujague, 2011). The research also sets out the primary objective of reviewing the current situation and trends demonstrated by experts in their research into the adoption process of open source software (OSS), taking into account the most noteworthy characteristics of the research processes carried out between 2001 and 2019.

Tools and Procedures

The research methodology was based on consulting literature references through bibliometric analysis, supported by information drawn from the Scopus database, which was selected taking into account the ease of navigation, access and analysis of a large number of citations and summaries of specialized scientific texts (peer reviewed), recognized for the quality of the sources; and especially, for being a repository and valuable tool in the performance of bibliometric analysis and validation of scientific productions (de Granda-Orive, Alonso-Arroyo, & Roig-Vázquez, 2011; Martín-Ravelo & Carbonell-de la Fe, 2015). This analysis was used as a basis to describe bibliometric indicators related to quantity, quality and structure, which are significant aspects in achieving the results of the research.

Quantitative techniques based on statistical calculations were used for this bibliometric review, including mathematical and statistical components that are normally used to measure academic output in different knowledge areas.

The above is significant, given the interest in obtaining the results that are characterized by scientific accuracy and relevance, which contributes to the presentation of indicators through methodologies systematized and generalized by the researchers, promoting the verification of similarities or differences between the indicators used (Bordons & Zulueta, 1999; Camps, 2008). These techniques contributed to a review of numerous scientific publications that demonstrate revealing derivations as well as the progress made on the subject, and enabled contrasts to be drawn between the variables mentioned in the research, such as publication type and aspects of the authors, institutions and the countries where the publications were produced.

A variety of terms and synonyms associated with the topic in question were considered in the creation of the search equation, including *open source, software, OSS, adoption* and *acceptance*. Additionally, other aspects vital to obtaining advanced and specific information (such as title, key words, summary and logical operators) were considered. The Scopus database was selected due to it being the most extensive source of accessible, reliable information of high academic validity and quality (with indexed journals containing summaries, research results and citations from peer-reviewed publications) and a global benchmark for research (Villa, Ruiz, Valencia, & Picón, 2018). The following structure was defined as the search equation

Orfa Nidia PATIÑO TORO, Yesenia ACEVEDO CORREA, Alejandro VALENCIA-ARIAS, Martha BENJUMEA-ARIAS. A bibliometric analysis of the use of open source software in educational contexts

PROBLEMS
OF EDUCATION
IN THE 21st CENTURY
Vol. 78, No. 1, 2020

117

for the procedure: *((TITLE (("Open source" W/1 software) OR oss) AND TITLE (adoption OR acceptance))) OR ((KEY (("Open source" W/1 software) OR oss) AND KEY (adoption OR acceptance)))*. According to the database reports, as of June 2019 the equation showed a total of 289 records as a result.

Data Analysis

The most significant derivations provided data related to publications, such as quantity indicators highlighting the main journals and the productivity levels of authors, institutions and countries. Indicators linked to quality were also presented, measuring the impact created by the number of citations achieved by each author and the journal's number of publications. Finally, the structure indicators were presented.

The above was carried out in order to identify the topics related to the processes of open source software adoption, weighing up those publications related to the subject under research and those themes with a greater chance of development, based particularly on the publications and fostered by the links described above as the combination of terms included in the search (*open source, software, OSS, adoption, acceptance*).

Research Results

About the indicators mentioned in the methodology section, the results generated for the construction of the bibliometric analysis are shown below.

Quantity and Quality Indicators – Annual Journal Productivity

In terms of the number of publications (annual productivity), Figure 1 demonstrates the existence of a high rate of growth in the interest in studies involving processes of ***open source software adoption*** in recent years. Despite this, the period that showed the biggest increase in article publication was between 2004 and 2018, with the most productive year being 2013 with 30 publications.

Figure 1
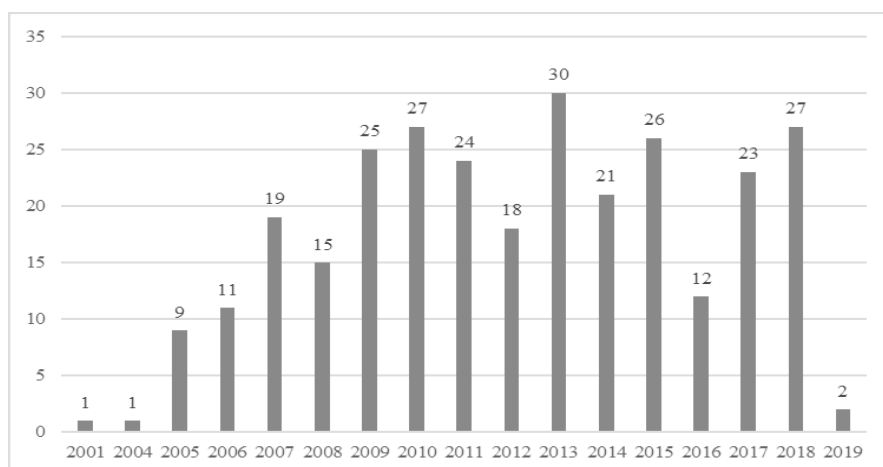*Number of publications per year*

118

Figure 2 displays the results for the 10 most important journals according to the number of publications concerning the topics. 'IFIP Advances in Information and Communication Technology' has occupied first place in the ranking with 20 publications, followed some way behind by 'Lecture Notes in Computer Science, including Subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics' with 9. In third place was 'IFIP International Federation for Information Processing' with 8 publications, ahead of the 'International Journal of Open Source Software and Processes' and 'ACM International Conference Proceeding Series' with 7 and 6 publications respectively. 'Ceur Workshop Proceedings' and the 'Journal of Systems and Software' reported 4 results each, and the ranking is completed by 'Decision Support Systems', 'Information Systems Research' and the 'Journal of Database Management', with each having three publications to their credit. This information is of great value in the process of measuring and confirming potential gaps or particularities concerning the publications of the various journals.

Figure 2
Number of publications and citations per journal
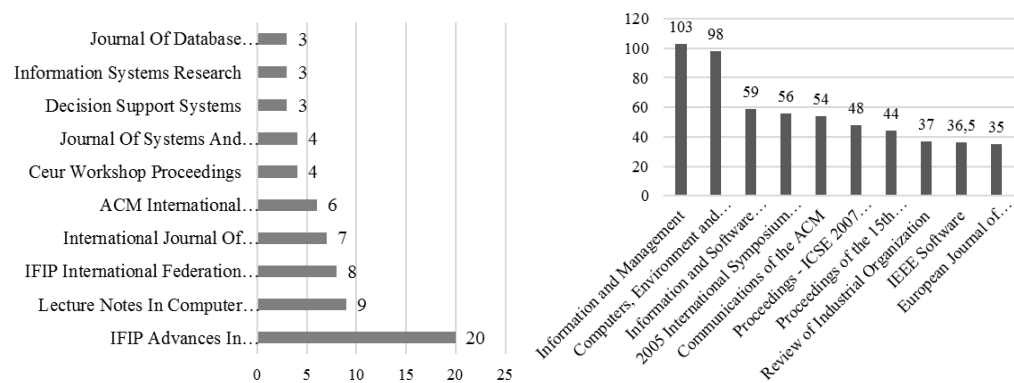
In Figure 2, the journals with the highest citation rates per publication related to the topic analyzed can be seen. 'Information and Management' was the most cited journal with a total of 103 citations, followed by 'Computers, Environment and Urban Systems' with 98 citations per publication. 'Information and Software Technology', the '2005 International Symposium on Empirical Software Engineering (ISESE)', 'Communications of the ACM' and 'Proceedings-ICSE 2007 Workshops: Fourth International Workshop on Mining Software Repositories (MSR 2007)' were next in the ranking with 59, 56, 54 and 48 mentions respectively. The list was completed by 'Proceedings of the 15th European Conference on Information Systems (ECIS 2007)' the 'Review of Industrial Organization', 'IEEE Software' and the 'European Journal of Information Systems, which generated 44, 37, 36.5 and 35 citations in their respective order of appearance.

Figure 3 shows the results of the analysis of the most productive authors. It shows that in first place was Kris Ven with 13 publications. Jan Verelst was second in the list with 11, followed by Xavier Franch, Lidia López and Dolors Costal, with an output of 10, 9 and 8 articles respectively. Next, Yan Li, Angelo Susi and Chuan Hoo Tan all produced 7 publications each and, finally, 6 articles each were attributed to María Carmela Annosi and Maha Shaikh.

Furthermore, the indicators related to the impact generated by the authors can be seen in Figure 3, which shows the researchers who boast the highest number of mentions of their work on the topic at hand. However, it is important to mention that impact factors can give rise to differences of opinion among experts, as they do not precisely validate the quality

of a publication with regard to the information provided. Nevertheless, impact factors do demonstrate the impact of an article in the scientific context, given that the differentiation of the variables that affect and influence indicators of this type is binding.

Authors Productivity

Figure 3
Publications and citations of the top ten authors
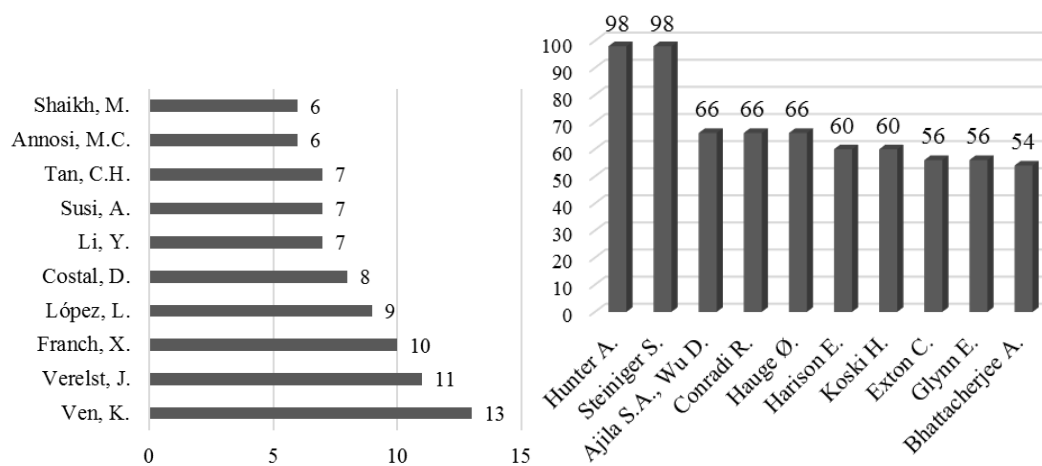
In line with the above, the indicators articulated in this research prove to be relevant when acknowledging the impact forged by the various authors, coupled with the possibility of identifying the benchmarks for measuring the data collected. The most citations per author were received by Andrew Hunter and Stefan Steiniger with 98 each, followed by Samuel Ajila, Di Wu, Conradi Reidar and Øyvind Hauge with 66 mentions each. Elad Harison and Heli Koski were next with 60 citations, ahead of Chris Exton and Eugene Glynn with 56 citations and Anol Bhattacherjee with 54 citations (see Figure 3).

Regarding or about the above classification, no correlation is revealed between the most productive author and the suggested quality of the publications, according to the number of articles and the number of citations received.

Additionally, in accordance with the productivity and the type of publications concerning the adoption of open source software, it is worth mentioning that 55% of the publications arose from conferences and 40% came from articles, making them relevant tools for the exchange of knowledge between experts. The progress and relevance of the subject was also evident, representing a determining factor in generating interest and discussion in the scientific community and promoting the increased importance and validity of the subject in academic contexts.

Productivity of Institutions and Countries

About the productivity of institutions, Figure 4 shows that the publications were produced by 160 different institutions, of which 94 universities (58.75% of the total) produced 80.12% of the articles, meaning that this specific situation did not conform to the Pareto principle. Thus, in this case the universities were divided into quartiles according to their level of importance, reflecting the fact that 25.6% of the publications originate from 7.5% of meaning that this

120

specific situation did not conform to the Pareto principle in the institutions. Similarly, the statistics indicated that 24.38% of the universities produced 50% of the output, while 50.63% were responsible for 75.30% of the work published. Additionally, 78.13% of the universities were found to provide 2 or fewer publications, which correspond to 52.4%, demonstrating a wide spread of knowledge on the topic investigated.

Similarly, it is highlighted that 22.89% of the articles were attributed to universities positioned in the top 10. The Polytechnical University of Catalonia published the most with 14 articles, University of Antwerp got second place with 13. These were followed by the ESSEC Business School, Free University of Bozen-Bolzano, National University of Singapore and Fondazione Bruno Kessler, which produced 7 publications each. The list was completed by the University of Warwick with 6 articles and HEC Montréal, North Carolina State University and Youngstown State University with 5 publications each.

Figure 4
Productivity of Institutions and Countries
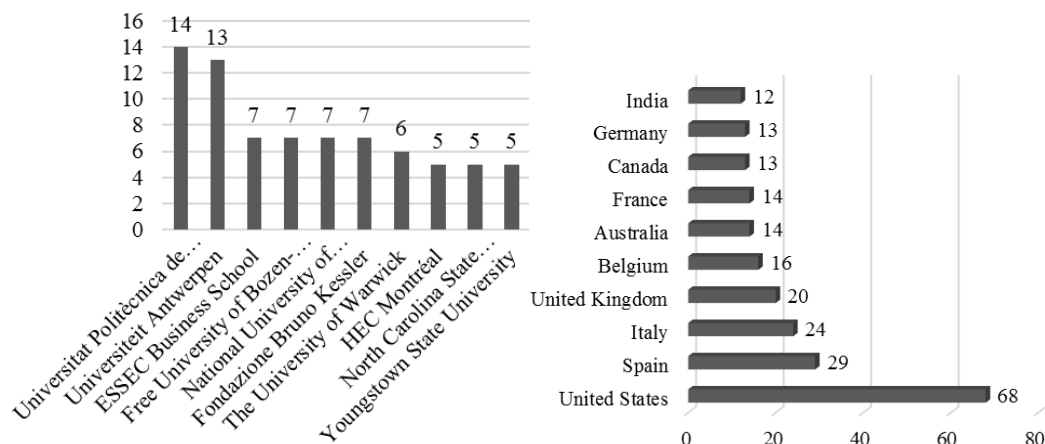
With regard to the countries that had done the most progress in the generation and dissemination of scientific knowledge in the field, a total of 62 countries was found, of which 30.65% produced 75% of all the publications. Figure 4 shows that the most influential country is the United States with 68 articles, followed by Spain with 29, Italy with 24, the United Kingdom with 20 and Belgium with 16. Australia and France appeared with 14 publications each, and the ranking was completed by Canada and Germany with 13 publications each. Similarly, 57.47% of the publications were attributed to the 10 most prevalent countries, while 40 countries (equivalent to 64.52% of the sample) produced 2 or fewer articles per year.

Discussion

The aim of the research was to examine the research trends and evolution of the field of adoption of open source software between 2001 and 2019. The results of the inquiry provided important details of the strong trend in the development of research and publications around the adoption of free software, which highlights countries such as the United States, as their institutions and researchers who exhibited higher levels of productivity and product circulation around the topic, this was due to the number of researchers and publications from this country. Also, there was an interest in reducing gaps and promoting the adoption and use of this tool in sectors where it has not yet achieved great reception.

Keyword analysis is used to identify the subjects of specific areas of knowledge that are generating significant impact on processes of scientific dissemination by driving trends in research activities. In this sense, the standardized keyword dynamics is presented below, this was carried out through a search for the key terms used by researchers in their studies, the agreement of similar meanings, and the relationship of the keywords obtained in the research.

The keywords are compiled in order to confirm which appear most frequently in the research. An examination of these terminologies is a definitive tool to describe the themes outlined by the researchers in the publications and represents an important source of information.

In this regard, the subjects that feature most frequently in the period studied include innovation, which had the highest number of results, demonstrating the importance the topic has acquired on the global scientific stage. Along the same line, innovation is related to the integration of open source software by organizations, through the adoption and use of a variety of platforms (online service platforms, open source hardware platforms, free and reduced-cost 3D design tools and collective collaboration tools) whose integration is motivated by factors associated with high reliability, low cost and the possibility of receiving external assistance. This drives ecosystems of innovation by bringing together a range of actors and platforms in order to establish effective collaborative relationships (Bloemen, Amrit, Kuhlmann, & Ordóñez-Matamoros, 2014; Kwak, Kim, & Park, 2018; Ven & Verelst, 2006).

The keyword that has the second-highest number of mentions in the research is survey. This research reveals a growing interest in and use of this information gathering technique, as well as different factors associated with the implications of adopting open source software for companies. These implications include the need to have and invest in competent human talent in addition to the benefits to organizational learning processes. (Li, Tan, & Yang, 2013). Additionally, numerous studies are carried out in order to determine the perception of the commercial value and the actual contribution of the organizational consolidation of OSS (Marsan, Paré, & Beaudry, 2012), and innovative strategies regarding the commercialization and economic aspects of OSS provision are analyzed (Harison & Koski, 2010).

About the term *Linux* (recognized as an open-source operating system) a range of inquiries are associated with barriers to the adoption of OSS and potential solutions to the situation. This is because, despite high growth in use by users in the market, challenges also exist that are caused by the practices employed by distributors of proprietary software, who use dissuasive strategies (uncertainty, fear and doubt) to reduce the potential adoption of open source software (Nagy, Yassin, & Bhattacherjee, 2010). The researchers also indicate that Linux is a tool that has been institutionalized by organizations at the different phases of their development and processes, considering the characteristic elements of each company as predictors of its constant adoption (Xiao, 2006).

In terms of free and open source software, also known as *FLOSS*, different studies are used to demonstrate the process of introduction of this technology in different settings and institutions, the impediments to its adoption and the position taken by the different stakeholders involved. According to experts, there is a clear difference between OSS adoption in public sector entities and private institutions. The same is true of the usage gaps between large companies and small and medium-sized enterprises (SMEs), revealing barriers related to security guarantees (the trustworthiness and legality of transactions), intellectual property rights and challenges to managerial, technological, productive and competitive capacities (Machado, & Van Leeuwen, 2006; Tosi, Lavazza, Morasca, & Chiappa, 2015).

In addition to the above, by becoming a strategic asset, it is also necessary to consider the importance of the dynamics of participants in the incorporation of FLOSS, as well as the management risks of the tool given its introduction in companies (Kenett, Franch, Susi, & Galanis, 2014). As such, an interest arises in reflecting on the developmental trajectory of the adoption of open source software in the various sectors and organizations (Squire, 2017).

122

Furthermore, analysis of the research reveals that in compliance with requirements engineering, barriers in the usage techniques and development of OSS among communities can be seen (ecosystem users). In this sense, experimentation takes place in the design of strategies, models and new techniques that will enhance experiences and the perception of usability (ease of use) (Costal, López, & Franch, 2015; Llerena, Rodríguez, Castro, & Acuña, 2017).

In addition to the importance acquired by the use of OSS in business activities, the research also expresses the concerns over the numerous risks in management (risk management), due to significant flaws in terms of the quality, timeframe and cost of delivery. One of the main shortcomings is the inadequate management of these risks when implementing solutions based on open source software. In turn, these risks are sought to be reduced through an understanding of the behavior and dynamics shown by the communities responsible for offering the software components (Franch et al., 2015).

The need to appropriately manage the different risks when seamlessly incorporating this tool in processes is therefore evaluated, ensuring that the activity is effectively managed and has continuity over time. This is achieved through platforms such as RISCOSS, based on data modeling and easy to configure, promoting the personalization of numerous types of settings. It adopts two differentiated forms of work due to its ability to measure the impact of decisions before they are made, and constantly examines the variables associated with risk and potential deviations from commercial targets, which can be constantly supervised and fed back to decision makers (Franch et al., 2015). Understanding, managing and mitigating the numerous risks associated with the adoption of OSS is therefore crucial in protecting against adverse impacts that have great potential to affect companies (Ranch et al., 2013).

Furthermore, open innovation has been a key element of the processes of OSS development, adoption and implementation since its emergence in 2003. In these processes, it is necessary to consider changes to work roles, individual predisposition and the adoption of the development of commercial OSS. At the same time, personal incentives should be evaluated depending on performance and the distinctive features of each institution (Alexy & Henkel, 2007; Munir & Runeson, 2015).

Main Topics in the Research Agenda

Figure 5 shows the research fields that display the highest growth or have tended to decrease on the global stage, in terms of the adoption of open source software. This information is supported by the dynamic over time of the keywords, thus facilitating the identification of the principal trends for the most prevalent themes in the studies, such as those that present innovative topics that generate interest in the field of knowledge under research.

Figure 5
Growing topics
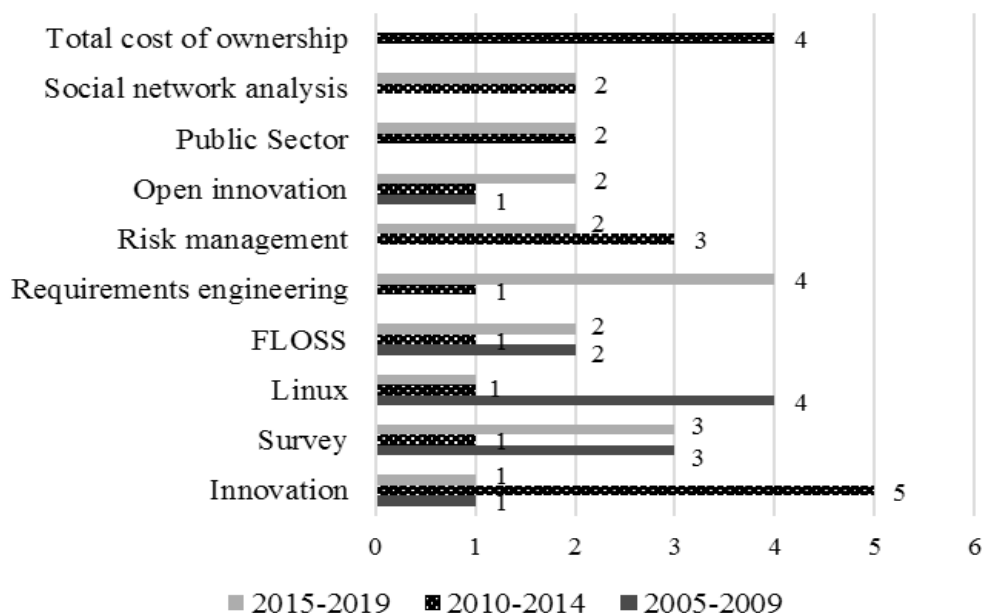
Taking the chosen search as a reference, in Figure 5, the topics developed with greatest interest by the authors, or those that show highest growth, are those related to requirements engineering, surveys, FLOSS and open innovation. These results focused on the identification of the defining aspects of the evolution of open source software adoption as a vital tool in organizational performance. Figure 5 also reveals the importance of meeting quality, reliability and security standards in the development of open source software, enabling it to be implemented effectively by users. Furthermore, experts have also promoted the carrying out of different investigations that are based on consulting different sectors regarding their perceptions of the usefulness and effectiveness of using OSS. Similarly, an interest in integrating open innovation strategies is promoted as a source of growth for communities and progress in the incorporation of OSS.

The fields that show a downward trend include the keywords "Total cost of ownership" and "innovation", and the authors of this article believe that the decreased use of these words could fundamentally be due to the topic having evolved over time towards other perspectives or fields of knowledge. As such, the researchers analyzed the focus of their studies on other areas.

Conclusions and Implications

The research concludes that examination into the evolution of open source software is increasing significantly in various settings across the world, where it is developed, distributed and incorporated in order to improve process efficiency and competitiveness in the industries and institutions that use it. At present, the research is being carried out that focuses on establishing frames of reference for OSS implementation in the government and private sector that will facilitate automation, the integration of security models and growth in innovation ecosystems; in academic contexts, this research aims to improve learning strategies. This research also explores the need to identify those factors that affect the adoption of OSS and to rethink the processes of acceptance of new technologies.

124

With regard to the growing interest of some sectors in adopting open source software, this is seen to be influenced by the rise of information technologies and the ease of access to devices, which emerge as a determining factor in the decisions of users. The use of surveys in the studies is also apparent, as a means of obtaining significant information on factors related to the acceptance, use and innovation of open source software by different organizations.

Additionally, the information regarding the progress of open source software that was collected through the research is noteworthy, given that it provides a statistical basis of the relevance of OSS and its importance in business and academic activities. Analysis is also performed of the importance of improving management of compliance with technical quality specifications and differentiation in the times and costs involved in delivering the product to users. The research also analyzes the protection of intellectual property rights in a way that will enhance experiences (accessibility and usability) and drive the adoption of OSS to a greater extent.

Furthermore, the literature review indicates that open innovation is vital in communities involved in the development of these tools, as an alternative in the market in response to the barriers to access and the possibility of absorbing the results of efficient collaboration and integration in all environments, as a strategic focus in organizational forms, technological growth and increasing the capacity for business innovation, particularly in so-called developing countries, in order to expand opportunities and attain competitiveness.

In the results generated from the bibliometric analysis, the evolution of the subject has passed through various perspectives, from the evaluation and classification of the organizational adoption of OSS to the measurement of the factors affecting adoption. Examples of the latter include the level of trust and acceptance, in addition to the notable use of Linux; management capacities; the effect on learning processes; and the potential benefits of the development and subsequent commercialization and implementation of open innovation in the routine activities and processes of different sectors of society. This indicates a strong increasing trend as a result of the initiatives from the public and private sectors (for employees) that extend access to new technologies to most of the population, and the interest of users in obtaining free tools that facilitate their learning and adequate performance in all contexts.

Finally, this research manages to identify the need to direct efforts towards future studies that will promote the possibility of envisaging the potential of incorporating open source software in small and medium-sized enterprises in developing countries, and of seeking to devise new strategies for the implementation of OSS in organizational and educational contexts, finding its substantiation in the processes of knowledge and information management that permeate organizational cultures to increase acceptance in the adoption of software of this type.

References

Alexy, O., & Henkel, J. (2007). Promoting the penguin: Who is advocating open source software in commercial settings? *Academic of Management Proceeding*, *2007*(1), 1–9. https://doi.org/10.5465/ambpp.2007.26530011

Alonso, A. & D'Antonio, S. (2015). El software libre y el open knowledge como comunidades de conocimiento paradigmáticas. [Free software and Open Knowledge as paradigmatic knowledge communities]. *Utopía y Praxis Latinoamericana, 20* (Abril-Junio). http://www.redalyc.org/articulo.oa?id=27942241007

Bloemen, R., Amrit, C., Kuhlmann, S., & Ordóñez-Matamoros, G. (2014). Innovation diffusion in open source software: Preliminary analysis of dependency changes in the Gentoo portage package database. In *11th International Working Conference on Mining Software Repositories, MSR 2014* (pp. 316–319). Hyderabad, India. https://doi.org/10.1145/2597073.2597079

Bordons, M., & Zulueta, M. A. (1999). Evaluación de la actividad científica a través de indicadores bibliométricos. [Evaluation of scientific activity through bibliometric indicators]. *Revista Española de Cardiologia*, *52*(10), 790–800. https://doi.org/10.1016/S0300-8932(99)75008-6

Costal, D., López, L., & Franch, X. (2015). Using roles for OSS adoption strategy models. In *8th International i*Workshop, iStar 2015 - In conjunction with the 23rd International Requirements Engineering Conference, RE 2015* (pp. 19–24). Ottawa; Canada. https://www.scopus.com/record/display.uri?eid=2-s2.0-84943373547&origin=inward&txGid=a6428450a3166e568e47fd99f96fbef0

de Granda-Orive, J. I., Alonso-Arroyo, A., & Roig-Vázquez, F. (2011). Which database should we use for our literature analysis? Web of Science versus SCOPUS. *Archivos de Bronconeumología*, *47*(4), 2013. https://doi.org/10.1016/j.arbres.2010.10.007

Dhir, S., & Dhir, S. (2017). Adoption of open-source software versus proprietary software: An exploratory study. *Strategic Change*, *26*(4), 363–371. https://doi.org/10.1002/jsc.2137

Franch, X., Kenett, R., Mancinelli, F., Susi, A., Ameller, D., Annosi, M. C., … Oriol, M., Siena, A. (2015). The RISCOSS platform for risk management in open source software adoption. In *11th IFIP WG 2.13 International Conference on Open Source Systems, OSS 2015* (pp. 124–133). Florence; Italy. https://doi.org/10.1007/978-3-319-17837-0_12

Franch, X., Kenett, R. S., Susi, A., Galanis, N., Glott, R., & Mancinelli, F. (2015). Community Data for OSS adoption risk management. In *the Art and Science of Analyzing Software Data* (pp. 377–409). Elsevier. https://doi.org/10.1016/B978-0-12-411519-4.00014-8

Glynn, E., Fitzgerald, B., & Exton, C. (2005). Commercial adoption of open source software: An empirical study. In *2005 International Symposium on Empirical Software Engineering, ISESE 2005* (pp. 225–234). Queensland; Australia. https://doi.org/10.1109/ISESE.2005.1541831

González, J. C. (2006). B-Learning utilizando software libre, una alternativa viable en Educación Superior. (B-Learning using free software, a viable alternative in Higher Education). *Revista Complutense de Educación, 17*(1), 121-133. https://revistas.ucm.es/index.php/RCED/article/view/16745

González-Barahona, J. M. (2008). Las ventajas de la apertura. [The advantages of opening]. *El profesional de la información, 17*(1), 5-7. https://doi.org/10.3145/epi.2008.ene.01

Goode, S. (2014). Exploring organizational information sharing in adopters and non-adopters of open source software: Evidence from six case studies. *Knowledge and Process Management*, *21*(1), 78–89. https://doi.org/10.1002/kpm.1430

Harison, E., & Koski, H. (2010). Applying open innovation in business strategies: Evidence from Finnish software firms. *Research Policy*, *39*(3), 351–359. https://doi.org/10.1016/j.respol.2010.01.008

Kagiri, T. M., He, Y., & Henglin, S. (2013). Factors limiting OSS adoption. *Oulun, Finland: University of OULU*. Working Paper N° 01.

Kamau, J. W., & Sanders, I. D. (2013). An Empirical Investigation into the Effect of Usability on Adoption of Desktop Open Source Software by University Students in Kenya. *Computer and Information Science, 6*(3), 108-125.

Kenett, R. S., Franch, X., Susi, A., & Galanis, N. (2014). Adoption of Free Libre Open Source Software (FLOSS): A risk management perspective. In *38th Annual IEEE Computer Software and Applications Conference, COMPSAC 2014* (pp. 171–180). Vasteras; Sweden. https://doi.org/10.1109/COMPSAC.2014.25

Koloniaris, S., Kousiouris, G., & Nikolaidou, M. (2018). Possibilities of use of free and open source software in the greek local authorities. *IFIP Advances in Information and Communication Technology*, *525*, 128–143. https://doi.org/10.1007/978-3-319-92375-8_11

Kramer, F. (2014). On the advantages, perils and pitfalls of using cloud computing and open source software in small and medium-sized businesses. The case of a german entrepreneurial company. In *20th Americas Conference on Information Systems, AMCIS 2014*. Savannah, GA; United States: Association for Information Systems. https://www.scopus.com/record/display.uri?eid=2-s2.0-84905987557&origin=inward&txGid=1719568f0f089c60c8e5c867144881ab

Kwak, K., Kim, W., & Park, K. (2018). Complementary multi-platforms in the growing innovation ecosystem: Evidence from 3D printing technology. *Technological Forecasting and Social Change*, *136*, 192–207. https://doi.org/10.1016/j.techfore.2017.06.022

Lakka, S., Stamati, T., & Michalakelis, C. (2014, October). Cross country comparison on the factors determining OSS diffusion. In *Proceedings of the 18th Panhellenic Conference on Informatics* (pp. 1-6). ACM.

Li, Y., Tan, C.-H., & Yang, X. (2013). OSS adoption: Organizational investment in internal human capital. *Journal of Computer Information Systems*, *54*(1), 42–52. https://doi.org/10.1080/08874417.2013.11645670

Llerena, L., Rodríguez, N., Castro, J. W., & Acuña, S. T. (2017). Adoption of the focus groups technique in the open source software development process. In *Lecture Notes in Computer Science (including subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics), 10271,* (pp. 325–340). https://doi.org/10.1007/978-3-319-58071-5_25

Londoño-Patiño, J. A., & Acevedo-Álvarez, C. A. (2018). El aprendizaje organizacional (AO) y el desempeño empresarial bajo el enfoque de las capacidades dinámicas de aprendizaje. *Revista CEA, 4*(7), 103-118. https://doi.org/10.22430/24223182.762

Machado, M. J., & Van Leeuwen, M. (2006). Barriers to FLOSS in SMEs: The lack of knowledge and skills. In *1a Conferencia Iberica de Sistemas e Tecnologias de Informacao, CISTI 2006 - 1st Iberian Conference on Information Systems and Technologies, CISTI 2006, 1,* (pp. 143–155). Ofir; Portugal. https://www.scopus.com/record/display.uri?eid=2-s2.0-84923867270&origin=inward&txGid=3623c1ddbbf1060c11c66732be883685

Mahapatra, R. K., Manzar, R., & Bhadauria, V. S. (2015). Adoption and use of open source infrastructure software by large corporations: The case of MySQL. *Journal of Database Management*, *26*(4), 1–17. https://doi.org/10.4018/JDM.2015100101

Marsan, J., Paré, G., & Beaudry, A. (2012). Adoption of open source software in organizations: A socio-cognitive perspective. *Journal of Strategic Information Systems*, *21*(4), 257–273. https://doi.org/10.1016/j.jsis.2012.05.004

Martín-Ravelo, A., & Carbonell- de la Fe, S. (2015). The scientific production on Artificial Intelligence: first-quartile journals indexed by Scopus Sciverse. *Revista Cubana de Ciencias Informáticas*, *9*(4), 72–88. http://scielo.sld.cu/pdf/rcci/v9n4/rcci06415.pdf

Méndez, L. (2016). Towards a Reference Framework for Open Source Software Adoption. *Proceedings of CAiSE 2016 Doctoral Consortium.* Ljubljana, Slovenia.

Mijinyawa, M. K., & Abdulwahab, L. (2014). An extended framework for evaluation of open source software adoption in small businesses. *Research Journal of Information Technology, 6*(4), 248-269.

Moreno-Agudelo, J. A., & Valencia-Arias, J. A. (2017). Factores implicados en la adopción de software libre en las Pyme de Medellín. *Revista CEA, 3*(6), 55-75. https://doi.org/10.22430/24223182.673

Munir, H., & Runeson, P. (2015). Software testing in open innovation: An exploratory case study of the acceptance test harness for Jenkins. In *International Conference on Software and Systems Process, ICSSP 2015* (pp. 187–191). Tallinn; Estonia. https://doi.org/10.1145/2785592.2795365

Nagy, D., Yassin, A. M., & Bhattacherjee, A. (2010). Organizational adoption of open source software: Barriers and remedies. *Communications of the ACM*, *53*(1), 148–151. https://doi.org/10.1145/1666420.1666457

Ranch, X., Susi, A., Annosi, M. C., Ayala, C., Glott, R., Gross, D., … Siena, A. (2013). Managing risk in open source software adoption. In *8th International Joint conference on Software Technologies, ICSOFT 2013* (pp. 258–264). Reykjavik; Iceland. https://www.scopus.com/record/display.uri?eid=2-s2.0-84887052413&origin=inward&txGid=4105149499807129379cffcb952eec42

Sánchez, M. J., Blas, H., & Tujague, M. P. (2011). El análisis descriptivo como recurso necesario en Ciencias Sociales y Humanas. [Descriptive analysis as a necessary resource in Social and Human Sciences]. *Fundamentos en Humanidades*, *XI* (22), 103–116. https://www.redalyc.org/html/184/18419812007/

Sarrab, M., & Rehman, O. M. H. (2014). Empirical study of open source software selection for adoption, based on software quality characteristics. *Advances in Engineering Software*, *69*, 1–11. https://doi.org/10.1016/j.advengsoft.2013.12.001

Serrano, J. E., & Narváez, P. S. (2010). Uso de software libre para el desarrollo de contenidos Educativos. [Use of Free Software for the Development of Educational Contents]. *Formación Universitaria, 3(6)*, 41-50. https://doi.org/10.4067/S0718-50062010000600006

Silic, M., & Back, A. (2016). The influence of risk factors in decision-making process for open source software adoption. *International Journal of Information Technology & Decision Making, 15*(01), 151-185.

Squire, M. (2017). The lives and deaths of open source code forges. In *13th International Symposium on Open Collaboration, OpenSym 2017,* (15), 1-8. Galway; Ireland. https://doi.org/10.1145/3125433.3125468

Taha, A. M., Abbood, A. A., Razzaq, A. A., & Al-Bahri, A. S. (2018). Identifying the affecting factors for adoption of open source software in it community. *Journal of Engineering and Applied Sciences*, *13*(14), 5771–5780. https://doi.org/10.3923/jeasci.2018.5771.5780

Tosi, D., Lavazza, L., Morasca, S., & Chiappa, M. (2015). Surveying the adoption of FLOSS by public administration local organizations. In *11th IFIP WG 2.13 International Conference on Open Source Systems, OSS 2015* (pp. 114–123). Florence; Italy. https://doi.org/10.1007/978-3-319-17837-0_11

Valverde, J. (2005). Software libre, alternativa tecnológica para la educación. [Free software, technological alternative for education]. *Revista Electrónica "Actualidades Investigativas en Educación"*, 5 (julio-diciembre). https://www.redalyc.org/html/447/44750220/

Vega-Malagón, G., Ávila-Morales, J., Vega-Malagón, A. J., Camacho-Calderón, N., Becerril-Santos, A., & Leo-Amador, G. E. (2014). Paradigmas en la investigación. Enfoque cuantitativo y cualitativo. [Paradigms in research. Quantitative and qualitative approach]. *European Scientific Journal*, *10*(15), 523–528. http://www.eujournal.org/index.php/esj/article/viewFile/3477/3240

Velázquez-Juárez, J. A., Valencia-Pérez, L. R., & Peña-Aguilar, J. M. (2016). El papel del modelo de la triple hélice como sistema de innovación para aumentar la rentabilidad en una Pyme comercializadora. *Revista CEA, 2*(3), 101-112. https://doi.org/10.22430/24223182.268

Ven, K., & Verelst, J. (2006). The organizational adoption of open source server software by Belgian organizations. *IFIP International Federation for Information Processing*, *203*, 111–122. https://doi.org/10.1007/0-387-34226-5_11

Villa, E., Ruiz, L., Valencia, A., & Picón, E. (2018). Electronic Commerce: Factors Involved in its adoption from a bibliometric analysis. *Journal of Theoretical and Applied Electronic Commerce Research*, *13*(1), 39–70. http://dx.doi.org/10.4067/S0718-18762018000100104

Wang, H., & Wang, C. (2001). Open source software adoption: A status report. *IEEE Software, 18*(2), 90-95.

Xiao, B. (2006). Organization adoption of linux: An institutional perspective. In *12th Americas Conference on Information Systems, AMCIS 2006* (pp. 1053–1056). Acapulco, Mexico.

Zulueta, M. A., Cabrero, A., & Bordons, M. (1999). Identificación y estudio de grupos de investigación a través de indicadores bibliométricos. [Identification and study of research groups through bibliometric indicators]. *Revista Española de Documentación Científica*, *22*(3), 333–347. https://doi.org/10.3989/redc.1999.v22.i3.341%09

Orfa Nidia Patiño Toro (Corresponding author)	Master in Management of Technological Innovation, Cooperation and Regional Development, Professor, [Institución Universitaria Escolme], University Institution Escolme, Calle 50 #40-39, Medellín – Colombia, 050013. E-mail: cies4@escolme.edu.co ORCID: https://orcid.org/0000-0001-8729-2138
Yesenia Acevedo Correa	Master (c) in Sociology, Professor, Fundación Universitaria Católica del Norte, Calle 33 # 74 E – 51, Medellín – Colombia, 050013. E-mail: yacevedoc@ucn.edu.co ORCID: https://orcid.org/0000-0003-2557-2809
Alejandro Valencia-Arias	PhD. in Engineering. MSc. Systems Engineering, Professor, [Instituto Tecnológico Metropolitano] Metropolitan Technological Institute, calle 54 A #30- 01, Barrio Boston, Medellín – Colombia, 050013. E-mail: jhoanyvalencia@itm.edu.co ORCID: http://orcid.org/0000-0001-9434-6923
Martha Luz Benjumea-Arias	MSc. Management Engineering, Professor, [Instituto Tecnológico Metropolitano] Metropolitan Technological Institute, calle 54 A #30- 01, Barrio Boston, Medellín – Colombia, 050013. E-mail: marthabenjumea@itm.edu.co ORCID: https://orcid.org/0000-0002-6776-3892