Full Length Research Paper

Development of bibliometrics in Colombia

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The literature on bibliometrics published by Colombian and foreign authors who selected Colombian academic journals or events held in the country to communicate their findings is analyzed. The publications by Colombian researchers published abroad were also collected and analyzed. The type of documents used by researchers, the journals most used, and the languages used for communicating their findings were also studied. The growth of the literature, the network of co-authorships, the more productive authors, and scientific fields most researched were also analyzed. It was found 255 papers were published in academic journals, most of them in Spanish language; 77% of authors have published just one document, while 23% of them made between 2 and 24 contributions. The production of this kind of literature is concentrated in the last decade as well as the collabortion behavior of authors. The literature is growing in an exponential form at a rate of 20% per year and doubling in size every 4 years. Network analysis identified six research groups in the country.

Key words: Bibliometrics, scientometrics, informetrics, Colombia, co-authorship.

INTRODUCTION

The publication of a document is the materialization of the results of a research carried out by an individual or group of individuals in a given field of knowledge. The publication of a document allows a researcher's work be read, criticized and then cited by other scientists in the same field or associated areas. Before the publication of a document, a scientist may choose to present the results of his/her research in a national or international event looking for criticisms and comments from colleagues. These comments and criticisms can often help him/her to enrich some aspects of the paper (Fox, 1983), since scientific events (roundtables, seminars, meetings,

conferences) represent valuable opportunities to "share ideas and discoveries where the presentation of the progress of the research to the academic community of pairs follow the rigor expected for the legitimization of the form and content of scientific research findings" (Chan et al., 2007). Thus, scientific communication is a social process that allows the dissemination and exchange of information among scientists, since a scientist must submit his/her document to a review process by "blind peers". This is the mechanism for evaluating documents for publication, adopted by academic journals.

Castro et al. (2009) suggest that "scientific publications

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play a role in the different stages of the research activity; they are the starting point of any inquiry, therefore, show the state of knowledge in a given subject, and are the preferred channels that announce the results of researches completed. It also helps spread knowledge, which will be the basis for further research of other scientists, so that the contributions of successive generations of researchers make possible the cumulative growth of science and, ultimately, scientific progress". Consequently, researchers through their publications directly contribute to development of a discipline in theoretical, practical and methodological aspects; therefore, for bibliometrics, publications have become the object of study (Mueller, 2007; Fox, 1983).

The idea of using published scientific literature as an object of study dates back to the mid-1930s when Wilson and Fred (1935) claimed that a census of publications in a given field could give valuable information to interpret past production and enough basis for predicting future trends. Hence data collected of the literature have been used as conventional tools for strategic planning, performance evaluations, and trends of scientific fields. This analysis is done through bibliometric techniques, an area of information science that was introduced in the scientific world in the early twentieth century, to study the published scientific literature and create productive performance indicators of a scientist. It is interested in knowing, with the use of mathematical models and applying descriptive and inferential statistics, what and how to publish, and how to characterize trends of the behavior of the scientific output of a field of knowledge (Mueller, 2007). Thus, it has become a technique that is applied not only by library information science professionals, but by psychologists, physicists, accountants, managers, etc. who are interested in measuring "levels of scientific production of a country, an institution, an author, or journal" (Ríos et al., 2011, p. 304), to find thematic trends, most productive authors, basic core of scientific journals, etc.

Bibliometrics is a discipline that is also being developed and applied in Colombia. For example, in 1999 the Colombian Observatory of Science and Technology was created with the purpose of reaching "the production of statistics and indicators, support strategic planning and decision-making processes through a comprehensive understanding of the dynamics of science, technology, and innovation -CTI- in the country, and its place at the regional and global levels" (Colombian Observatory of Science and Technology, 2012). Since its inception it has made extensive use of bibliometric techniques for technology monitoring and measuring the bibliographical productivity of Colombian scientists. The Colombian Observatory of Science and Technology institution annually publishes a text titled "Science and Technology Indicators" that includes various aspects of bibliographical production, investment in science, technology and innovation, and industrial property rights, among others. There are also professionals from various fields who

have studied and applied bibliometric techniques in different disciplines, but as far as it is known by the authors of this paper there is no research that have studied the development of bibliometrics, scientometrics, and informetrics field in Colombia, neither the application of these techniques in the country. For that reason, the purpose of this paper is to analyze the development of bibliometrics in Colombia, following up national or foreign authors who have made publications in journals and at national events, and to Colombian authors who have made publications in foreign journals or events using bibliometric techniques, i. e. the study of scientific production on Colombian bibliometrics. To date, this monitoring is absent in the applied sciences, pure sciences, social sciences and the humanities. This paper aims to fill up this void and open space for future exploration on this issue, especially by the importance that it has to characterize the national scientific production identifying trends on more productive authors, more productive journals and by this way contribute to understand the evolution and development of science in Colombia. For that reason, this article will describe and analyze the literature produced on bibliometrics in Colombia trying to answer the following questions:

What kind of document predominates in this production? What are the most often used journals to communicate the results of research? What are the languages chosen to disseminate the results of researches? What are the areas of knowledge where Colombian scientists are using bibliometric techniques? Who are the authors who are applying bibliometric techniques in the country? Who are the more productive authors? Do these authors collaborate with each other and are they forming networks? What are the more representative groups? What is the form of growth of this literature?

This paper seeks to answer these questions. To achieve this goal it is organized as follows: the first section gives a brief introduction to the research problem and asks the questions to be answered. In the second part we review the literature relevant to the issue. Then, we describe the methodology, the units of analysis, the form of data collection and form of measurement of data. Subsequently we provided the results and discuss their findings. Finally conclusions are presented and the literature reviewed in the writing of this paper is listed.

LITERATURE REVIEW

Bibliometrics is a research line of library and information science which plays an important role in the analysis of scientific production in different areas of knowledge of a country. For example, its evolution and development in Brazil has been studied by Urbizagástegui (1984). Its incorporation as a research line at graduate programs in Brazil was analyzed by Araújo and Alvarenga (2011). The subjects studied and communicated through five Brazilian

academic journals in the field of information science covering the period from 1990 to 2005 and including geographical and chronological distribution were examined by Machado (2007). Also a historical analysis of the evolution and structure of bibliometrics can be read in Urbizagástegui (2007).

In Mexico no studies were found that specifically analyze the published literature on the application of bibliometric techniques, but there are studies that analyze the scientific production using these techniques in the fields of hydraulic engineering (Sola et al., 2011), psychology (Díaz et al., 2010; García et al., 2010), in agricultural sciences (Bravo et al., 2008), hypertension (Carrasco-Rico et al., 2004), and solid state physics (Ferreira et al., 1978).

Also in Peru some research has been done tracing the development of bibliometric applications in information science and librarianship by Chiroque Solano (2007), who show that between 2003 and 2007 there were only 13 documents. Similarly, Romaní et al. (2011) examined the literature produced as lines of research in the biomedical science and they found only 21 papers published by Peruvian researchers. Recently Urbizagástegui (2012) conducted a more detailed research and found 124 research papers in different fields of science in general. These are examples of bibliometric applications in some countries of Latin America.

No studies that specifically analyze the literature on Bibliometrics, scientometrics or informetrics produced in Colombia were identified. However, several studies analyzes special areas of knowledge. For example, Guerrero (2007) analyzed the structure and dynamics of the articles published in the Colombian Journal of Sociology. González et al. (2011) studied articles published in the area of veterinary medicine and animal husbandry. The scientific production of infectious diseases was analyzed by Ríos et al. (2011); the Latin American scientific production in physical therapy by Vernaza-Pinzón and Álvarez-Bravo (2011); the scientific literature in clinical research and audiology by Hernández-Jaramillo, et al. (2010); the academic production in the field of Colombian psychology by López López et al. (2010). Analysis of work on multidisciplinary engineering was indexed in the database Web of Science by Rojas-Solas and San-Antonio-Gómez (2010). The impact of bibliographic production in science, technology and innovation was done between 1996 and 2005, by Castro et al. (2009). Reviews of the impact factor and its use in Colombia were done by Leon et al. (2007). Analysis of thesis programs and behavior modification therapy was conducted at universities in Bogotá by Rey and Santos (2005).

METHODOLOGY

As units of analysis were taken papers published in academic journals, papers were presented at congresses to address some of the aspects of bibliometrics or applying these techniques in any discipline or particular subfield. We excluded books, theses, monographs and gray literature mainly because these types of documents are not indexed in bibliographic databases and are not made available on the internet. We searched for documents published as articles, book chapters and papers presented at conferences or events, held in Colombia by Colombian or foreign authors. Likewise, we searched for publications of the same type (articles, book chapters and papers presented at conferences or events) by Colombian authors abroad. These documents were retrieved through text mining techniques on the web, using keywords such as Colombia, bibliometrics, informetrics, sciento-metrics, Lotka's law, Bradford's law, Zipf's law, Price index, Pratts' index, co-citation, citation analysis, social networks, h-index, visibility, growth of literature, impact factor, bibliographic coupling, immediacy factor, invisible colleges, epidemic theory, Goffman's transition point, Goffman's law, obsolescence of literature, half-life, elitism and research front, technological monitoring, evaluation of science, etc. in their multiple combinations. We also searched the catalog of the Library System of the University of Antioquia (Medellín, Colombia), since in this library are indexed national academic journals. Likewise, regional repositories as SciELO Brazil, SciELO Mexico, SciELO Venezuela, SciELO Colombia, SciELO Chile, SciELO Argentina, SciELO Bolivia, and Redalyc were searched. Also databases such as Web of Science, Scopus, Academic Search Complete, Springer, Agris, HAPI, Library Literature and Information Science Full Text, LISTA Library, Information Science and Technology Abstracts, and well as Google Scholar were searched.

To ensure a stable and manageable data collection, a special database with EndNote bibliographic management software (Version 5.0 for Windows) was created. In this database all information localized in the bibliographic databases mentioned above was entered. Subsequently, a close reading of each retrieved document was done, carefully analyzing the references of each publication. Each citation regarding the subject matter and produced by Colombian authors and/or foreign authors but published by journals in Colombia was faced with the database and incorporated on it if it had not been identified in the first search above. Through this careful reading of each identified document was produced a database containing references to journal articles, book chapters, and conference papers. These documents produced between 1982 and December 2012 constitutes the universe of this research. The period covered by the retrieved literature is large enough to expect some form of growth.

The analysis of the data collected was performed with the help of Microsoft Excel and SPSS (version 17.0 for Windows). With the help of these softwares the relevant descriptive and inferential statistics were made. To study the form of literature growth we used the nonlinear exponential equation proposed by Egghe and Ravichandra Rao (1992). This function is represented mathematically as:

$$C(t) = C(O)e^{at}$$

which can be rewritten as:

$$C(t) = c\,g^{t}$$

Where

C (t) denotes the total number of documents produced at time t; c and g represent constants estimated from the observed data and t is the number 0, 1, 2, ... n chronological years studied in the research time-span. In this equation, $c \geq 0$, $g \geq 1$ and $t \geq 0$.

To develop the co-authorship network in Colombian bibliometrics.

Table 1. Types of documents produced as languages.

Type of documents	Published in the country			Published abroad			Total
	Spanish	English	Portuguese	Spanish	English	French	
Articles	161	4	2	19	12		198
Papers in congresses	17			12	2		31
Book chapters	17			1	1	1	20
Letters to the editor	6						6
Total	201	4	2	32	15	1	255

BibExcel and Pajek tools were used. Bibexcel is a program developed for the administration and processing of bibliographic records. It allows the combination of information from different fields in a record, performs frequency counts, co-occurrences of authors, co-citations, and bibliographic coupling. Pajek is software for analysis and visualization of social networks, developed at the University of Ljubljana, Slovenia, by Vladimir Batagelj, Andrej Mrvar, with the contribution of Matjaž Zaveršnik. Both are public domain tools.

FINDINGS

255 documents published in Colombia and in other countries by Colombian or foreign authors who chose Colombian journals or events to communicate their research findings were found. The predominant form of communication are papers published in academic journals (78%); then papers presented at national events (12 %); less frequent are book chapters (8%), and finally letters to the editors of academic journals (2%) (Table 1). It is remarkable the small number of documents published as conference papers and as book chapters. In the scientific communication process the natural cycle of a document is first to present it at an event, either nationally or internationally, seeking to disseminate the results of a research, and then get a criticism or suggestions of colleagues to improve the results of researches or add new issues not previously taken into account (Schenkel, 2008). Later this paper, with appropriate corrections, may become a scientific paper submitted for peer review in an academic journal and finally published. Later the publications in the form of articles may be converted to book chapters or books.

This high tendency of academic articles published among Colombian scientists was also observed by Castro et al. (2009) who found that in the Colombian basic sciences, science and health technology, marine sciences and agricultural sciences, production of scientific articles are predominant. In social science programs and scientific studies of education the publication more predominant is in the form of books and book chapters; but in the field of biotechnology, environment and habitat, electronics, telecommunications and information technology, energy and mining the participation in theses and degree, records of technological production, records of

industrial secrets and works of scientific or technological consulting area preferred. Also Russell (1998) studied the patterns of publishing of Mexican scientists and found that the journal article is the kind of document with many occurrences. Similarly, Silva et al. (2003) analyzed the scientific productivity of researchers in the field of humanities and social science in Brazil. They observed that the highest incidences of publications were articles published in national journals (26%), followed by papers published in national events (18%), and book chapters (16%). It seems that Colombian scientists working with bibliometric applications in different fields follow similar patterns. It is not in vain that the scientific paper is an exercise of articulation among established theories and recognized by the academy, through which the researcher seeks public dissemination of the outcome of their studies. By this way, the academic journal becomes "the main framework of the constitution and structure of the scientific communication, as it arose from the genuine needs of exchange of scientific experiences" (Weitzel, 2006, p. 52).

36% of the documents were primarily published in 13 national and 2 foreign journals. The national *Revista Interamericana de Bibliotecología* is the journal that has disseminated the major number of papers' on bibliometrics. The journals *Universitas Psychologica* and *Revista Latinoamericana de Psicología* are the journals next preferred by authors. To publish abroad Colombian researchers have preferred Mexico through the journal *Investigación Bibliotecológica* and Netherlands through the journal *Scientometrics* (Table 2). The communication of 64% of remaining documents was through journals that had published between 1 and 2 documents.

Naturally the leading language of publications is Spanish (91%); to a lesser extent English (7.5%), Portuguese (0.8%), and finally French (0.4%). Predominance of Spanish is natural because the publications are in Colombia where the official language is Spanish. Possibly authors who published in English are looking for ways to make sure visibility of their research in a global environment; or perhaps the authors are doing graduate studies in English-speaking countries, which facilitates a collaborative publication of papers with teachers or thesis advisors in journals published in those countries. It is noteworthy to find 4 articles published in English in

Table 2. Principal academic journals.

Journal titles	No. of papers
Revista Interamericana de Bibliotecología	17
Revista Latinoamericana de Psicología	16
Universitas Psychologica	13
Scientometrics	6
Investigación bibliotecológica	5
Acta Biológica Colombiana	4
Acta Colombiana de Psicología	4
Avances en Psicología Latinoamericana	4
Ingeniería e Investigación	4
Revista Colombiana de Psicología	4
Innovar	3
Colombia Médica	3
Revista de Salud Pública	3
Revista MVZ Córdoba	3
Universitas Scientiarum	3

Colombian journals in collaboration between Colombian and Spanish authors. Probably these articles are looking for increasing visibility of journals and authors (Rojas-Solas and San-Antonio-Gómez, 2010), seeking to get a fair visibility of the national scientific production (Miranda, 1998).

Bibliometric documents produced by Colombian authors are published mainly at the national level. A still insignificant group has published their research abroad in countries like Holland, Mexico, Spain, Venezuela, Brazil, United States, England and Peru. Of the 386 authors identified in this research, few are foreigners who have sought to publish in Colombian journals or events: 13% are Spanish, 3% are Americans, 2% are Argentineans, Brazilians, French's and Mexicans; 1% are Venezuelans; 0.7% are Chileans, while Cubans, Dutchs, Puerto Ricans and Peruvians do not exceed 0.4%. In other words, the Colombian national space of publishing attracts about one-third of foreign authors.

The collaboration of authors has been preferably with authors from U.S., France, Holland and Peru; the results of these collaborations have not been communicated by Colombian publications, but through academic journals in these countries. The fact that most of the documents were published in Colombia and in Spanish (the language of the researcher) suggests publication facilities granted by formal communication channels of the institutions where authors are active researchers and an apparent difficulty in writing in other languages. These factors seem to contribute to select publications as local only. In this regard it is suggested that "the trend observed by scientists in the areas of humanities and social sciences [by] publishing more often within the country and in their own language is due in part to the very object of study in those areas" (Velho, 1997). This is the case of the Colombian bibliometrics.

Table 3 shows the type of publication according to areas of knowledge. The area with the largest number of papers published is library science with 38% and psychology with 24% of publications. Both areas agglutinate 62% of published documents. Then follow medicine (9%), management (5%), education and biology (4%). Disciplines such as economics, engineering, public health and sociology represent only 10% of all published documents. It is also striking that history (0.39%) is the only human science discipline making bibliometric applications. According to these findings, it seems that bibliometric techniques still do not attract the attention of researchers in the humanities, neither of the natural sciences researchers, since it was found only 2% of documents in physics and chemistry. This is noteworthy, especially because bibliometric models have been applied mainly in areas of the natural sciences. For example, Bradford's law was first applied in chemistry and geology (Bradford, 1934), Lotka's law in physics (Lotka, 1926), the Hirsch index or index of visibility in physics (Hirsch, 2005), and the list goes on with many other examples.

Table 4 shows the number of contributions by authors. There were identified a total of 386 different authors publishing in this field. Most of authors (77%) have published just one document, while 19% of them made between 2 and 4 contributions; 15 authors (4%) the major contributors, made between 5 to 24 contributions. The average is 0.7 publications by author, the mode being one document.

Table 5 shows the stratified categorization of authors producing publications using bibliometric techniques in Colombia. 77% of the authors were categorized as one-timers, meaning that in the period have published just one document. Very few of these authors will persist with bibliometric research and probably they will transfer their

Table 3. Areas of knowledge studied by type of publications.

Areas	Papers	Congresses	Chapters	Total
	Papers in book			
Librarianship	61	22	14	97
Psychology	57	--	3	60
Medicine	22	2	--	24
Management	13	1	--	14
Education	10	1	--	11
Biology	11	--	--	11
Economics	6	1	--	7
Engineering	4	2	--	6
Sociology	4	1	--	5
Public Health	4	--	--	4
Social Sciences	1	--	3	4
Political Sciences	2	--	--	2
Veterinary/Zoology	2	--	--	2
Physics	2	--	--	2
Agriculture	--	1	--	1
Environmental Sciences	1	--	--	1
Natural Sciences	1	--	--	1
Communications	1	--	--	1
History	1	--	--	1
Chemistry	1	--	--	1
Total	204	31	20	255

Table 4. Frequency of contributions by author.

No. of contributions	No. of authors	Percentage of authors
1	298	77.2
2	45	11.7
3	16	4.2
4	12	3.1
5	7	1.8
6	2	0.5
7	1	0.26
8	1	0.26
10	1	0.26
11	1	0.26
12	1	0.26
24	1	0.26
Total	386	100.0

Table 5. Stratified categorization of authors' productivity.

Category	No. of authors	% of publications	Average of productivity
Continuants	6	1.6	9.2
Newcomers	24	6.2	5.1
Transients	20	5.2	3.5
Terminators	38	9.8	1.6
One-timers	298	77.2	1.0
Total	386	100.0	0.7

Table 6. Number of documents produced according to number of authors.

Number of documents with 1, 2, 3 … n authors									
Period	1	2	3	4	5	6	7	8	Total
1981-1984	2	--	--	--	--	--	--	--	2
1985-1988	1	---	--	--	--	--	--	--	1
1989-1992	2	--	--	2	--	--	--	--	4
1993-1996	5	1	1	1	--	--	--	--	8
1997-2000	10	4	2	1	--	--	--	--	17
2001-2004	12	7	7	1	2	--	--	--	29
2005-2008	23	26	15	6	4	2	1	1	78
2009-2012	32	35	21	17	5	3	2	1	116
Total	87	73	46	28	11	5	3	2	255

interests to other fields. Nearly 10 % of researchers were categorized as terminators, i. e. they are leaving the field because they have not made publications in the last three years. Transient researchers (5%) have published two papers scattered sporadically between nonconsecutive periods of more than four years. Very few of these authors will become moderate and still less large producers. The newcomer authors represent 6% of the researchers and are those who have published at least two papers only in the last three years. Because these authors are exploring the area, few of them will also persist in this field. Nearly 2% are continuant authors; they will persist in searching and producing papers in this field, because they are already established as authors in the area and with a high average of productivity.

These findings are consistent with statement of David (1994, p. 8) in the sense that "the distribution of scientific production is skewed, because most of the articles published in an area of research is the work of a minority group of scientists with a high [academic] profile". This bias can apparently be explained by the notion of cultural capital and symbolic capital possessed by the authors and their dominant position in a scientific field (Bourdieu, 2008). For example, the most productive author is a professor at a Colombian university, which ensures familiarity with the matrices that enable the coding and decoding of the doxa of the field. For the moderate producers, 1 of the 3 authors is a coordinator of the research on bibliometrics of the Colombian Observatory of Science and Technology.

Table 6 shows the documents produced according to number of authors. It attempts to show whether the research in Colombia was in collaboration and if such collaboration continues a growth tendency. For this reason the data were grouped by five year periods. 34% of the documents were published by a single author, i. e. without collaboration. Papers published in collaboration by two authors represent 29%; the documents published by three authors 18%; and papers published by four authors represent 11%. Documents published by five authors made a total of 21 documents representing 8% of

the total. Since its inception in 1981 to 1992, bibliometric applications in Colombia were an isolated and personal activity. Between 1993 and 1996, only 3 documents were produced in collaboration by 2, 3 and 4 authors. This trend increases to 7 documents produced in partnership between 1997 and 2000. Yet most are published by single authors. However, collaboration begins to increase as 4 documents are produced together by two authors, 2 document by three authors and 1 by four authors.

From 2001 to 2004, co-authorship begins to grow; of 29 papers published, almost over half of them (17 documents) were in collaboration. Seven documents were produced by three authors, one paper by four, and two by five authors. The real collaboration begins from the period 2005 to 2008, because 55 documents were published in collaboration between two and eight authors. In the period of 2009-2012 the same trend continues; from a total of 116 papers, 84 were carried out in collaboration between two and up to eight authors. In the last two periods collaboration between 2, 3 and 4 authors for research and publication of bibliometric applications in Colombia has been very common. It is stated by that in the social sciences there is little collaboration and that collaboration occurs more in the hard sciences. If these claims were true, results shown here could show that Colombian bibliometrics is closer to the hard sciences than to the social sciences. Coinciding with Patel (1973) we consider that the complexity of the problems a discipline may face, leads to a process of differentiation that is accompanied by a specialization. Academic specialization helps the researcher survive in this world of competition and differentiation. So the academic invests his/hers skills and his/hers resources in areas that offer some guarantee of recognition and visibility. Therefore, collaboration is the indicator of an evolving process pursuing differentiation and specialization, through which a discipline is reconstructed and equilibrated. As in most scientific fields fewer people know enough to work and write solitarily, in an isolated way, collaboration is a natural maturation process of science, looking for "work towards a common goal and sharing knowledge gained"
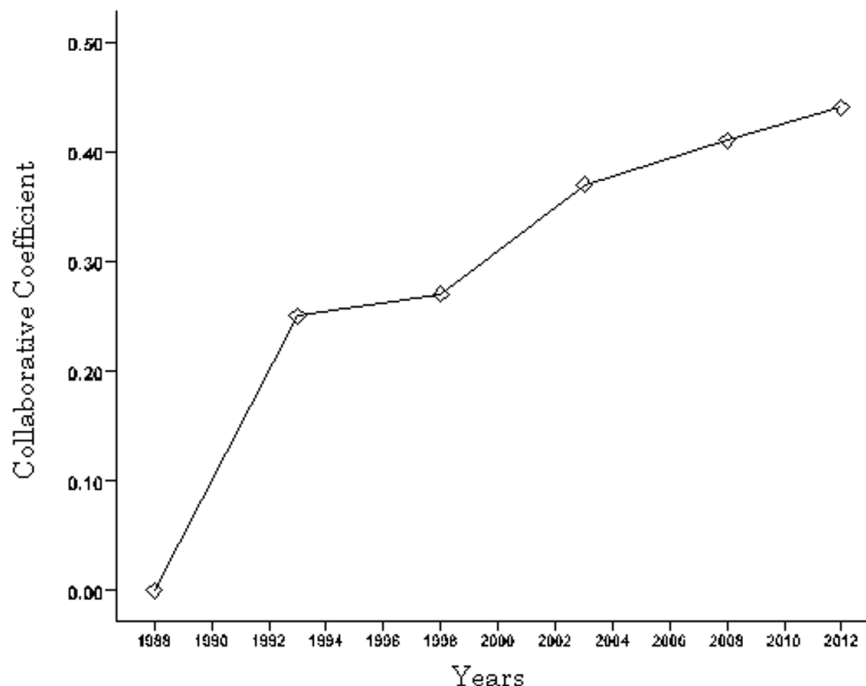
Figure 1. Coefficient of collaboration.

Table 7. Publications by 4 years period

Years	No. of publications	Percentage
1981-1984	2	0.8
1985-1988	1	0.4
1989-1992	4	1.6
1993-1996	8	3.1
1997-2000	17	8.7
2001-2004	29	6.7
2005-2008	78	30.6
2009-2012	116	45.5
Total	255	100.0

(Hara et al., 2003, p. 853). This process seems to happen in Colombia. It is enough to see Figure 1 to reconfirm the growth of collaboration between authors in publications measured through the coefficient of collaboration modified by Savanur and Srikanth (2010).

Table 7 shows the number of publications in Colombia bibliometric applications organized in periods of four years in order to show the growth of publications. In the first four years (1981-1984) only two works were published. Here is highlighted the first bibliometric application made by Leon (1982) and a practical application of the Bradford's law in an academic library by Ochoa de Ortiz (1984). Since its original formulation in 1934 by Bradford (1934), 50 years had to pass for Bradford's law began to be applied and used in Colombia. In the four year period from 1989 to 1992 there is a slight increase of almost a doubling of documents with respect to the earlier four year period. This doubling of the volume of publications continues in the next four years period until reaching the 1997-2000 period with a slight increase of the half of the previous period. This increase may be due to the appearance of the Colombian Observatory of Science and Technology, which was founded in 1999. Despite the emergence of such institutions in Colombia, interest in using bibliometric techniques has been somewhat slow; for example, Lotka's law was applied only in 2004 (Restrepo, 2004) and in 2006 (Villegas-Echevarría; Moreno, 2006). This bibliometric law appeared first published in 1926 by Alfred Lotka; 78 years had to pass for this bibliometric law to get the attention of Colombian authors. In the last two periods the increase of publications is notable and 76% of all papers were published until 2012. This may be due not only to the establishment of the Colombian Observatory of Science and Technology, but also to the introduction of a policy of evaluation and productivity indicators as well as formalization of bibliometrics, scientometrics and informetrics courses and its usefulness in monitoring technology in the Colombian universities.

Regarding growth of bibliometric applications in Colombia, Figure 2 shows how the number of publications on this issue grows with small fluctuations until 2003 indicating that to that date there is a limited growth; that is, publications are sporadic.
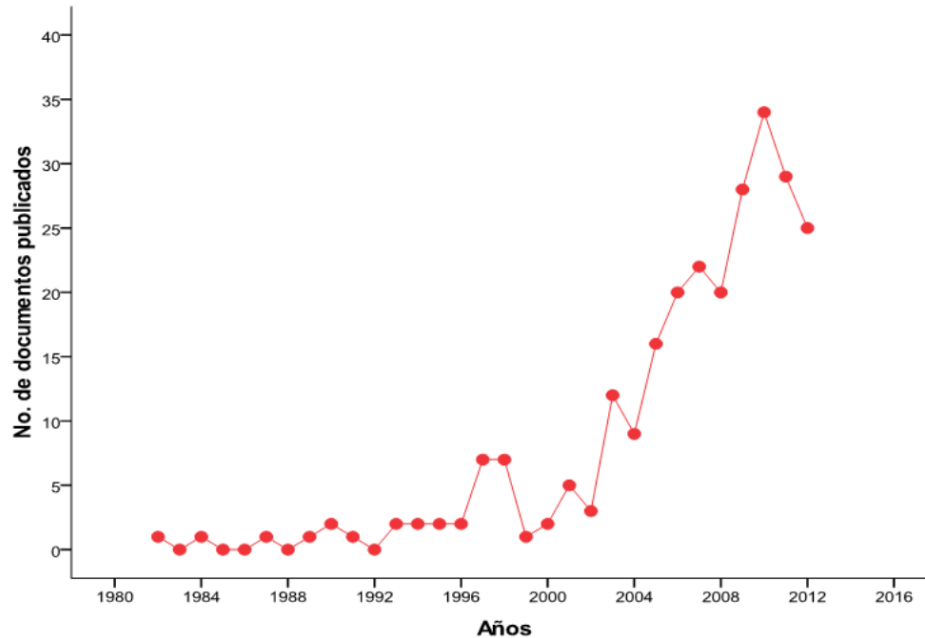
Figure 2. Documents produced on Colombian bibliometrics.

From 2003 onward there was a growth of publications to reach its peak in 2010. Also there is a small decrease in 2011 and a fall in 2012. This may be due to several factors: the databases may have not indexed the articles published in the last months of the year; the journals are in process of publishing or there is not a proper distribution of publications, since the documents are not in the web or in the bibliographic databases searched. The graph shows only the jobs that were available in the sources used at this work to collect data until December 2012.

Figure 3 shows the observed and estimated cumulative number of papers published from 1982 to December 2012. Literature growth approaches to an exponential form with initial concave part to grow gradually as time increases according the years.

To estimate the fit of this model the exponential mathematical equation proposed by Egghe and Rao (1992), the nonlinear regression method, was used. An adjusted R^2 equal to 0.993 was estimated, indicating a good fit of the data to the exponential model at 0.01 significance level. The estimated value of c was 1.092 with a standard error of 0.136. The estimated value of g was equal to 1.200 and a standard error of 0.006. Once these values are known we can set an equation that predicts the exponential growth of these publications as:

$C(t) = 1.092 \times 1.200^t$

This means that Colombian bibliometric applications are growing at a rate of 20% per year. To find the doubling time the following equation was used:

$(1.200) n = 2.0$

Taking logarithms of both sides of the equation yields:

$n(\log 1.200) = \log 2.0$

$$n = \frac{\log 2.0}{\log 1.200}$$

$$n = \frac{0.69315}{0.18232}$$

n = 3.8

Publications using bibliometric techniques in Colombia are doubling every 3.8 years, more or less every 4 years. This literature is growing very rapid, as much as it does physics or chemistry in the United States.

Figure 4 shows the network of co-authors. This network shows six research groups. The first consists of 11 authors with outstanding performance of López López Wilson; Silva, Luis Manuel and Aguilar Bustamante, Maria Constanza. The authors of this group have in common that they are university professors in the field of psychology. From this group comes another two subgroups. The first is formed by Gomez Morales, Yuri Jack; Guerrero Castro, Javier Enrique and Jaraba Barrios, Andres Bruno, who belong to the research group of social studies of science, technology and medicine.

The second subgroup consists of Quevedo Blasco, Raúl and Buela Casal, Gualberto, who are psychologists and professors of the University of Granada in Spain. The second group consists of 6 authors, of which Orozco Castro, Luis Antonio; Chavarro Bohórquez, Diego Andrés
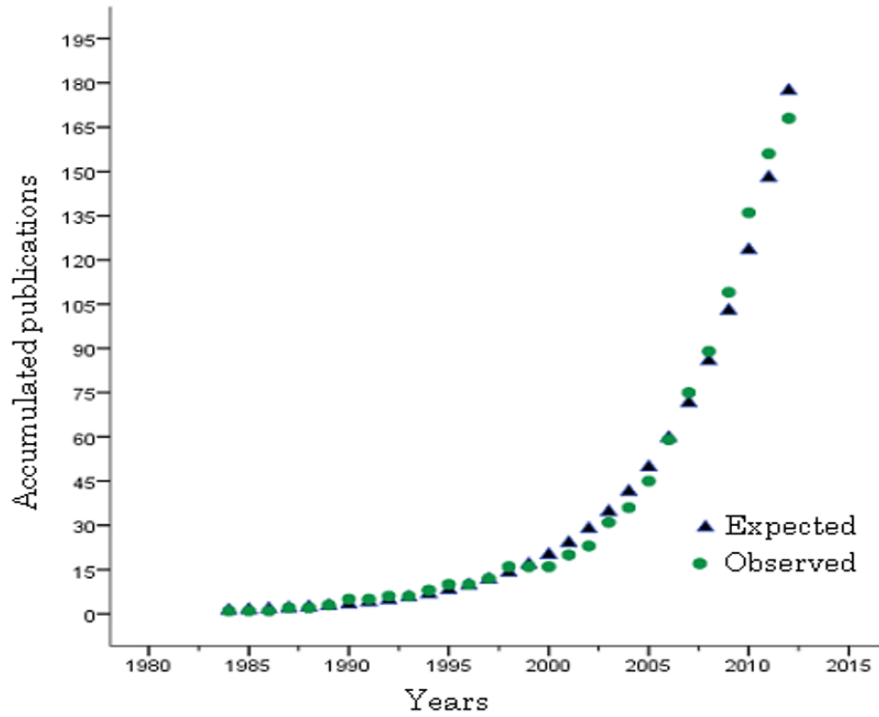
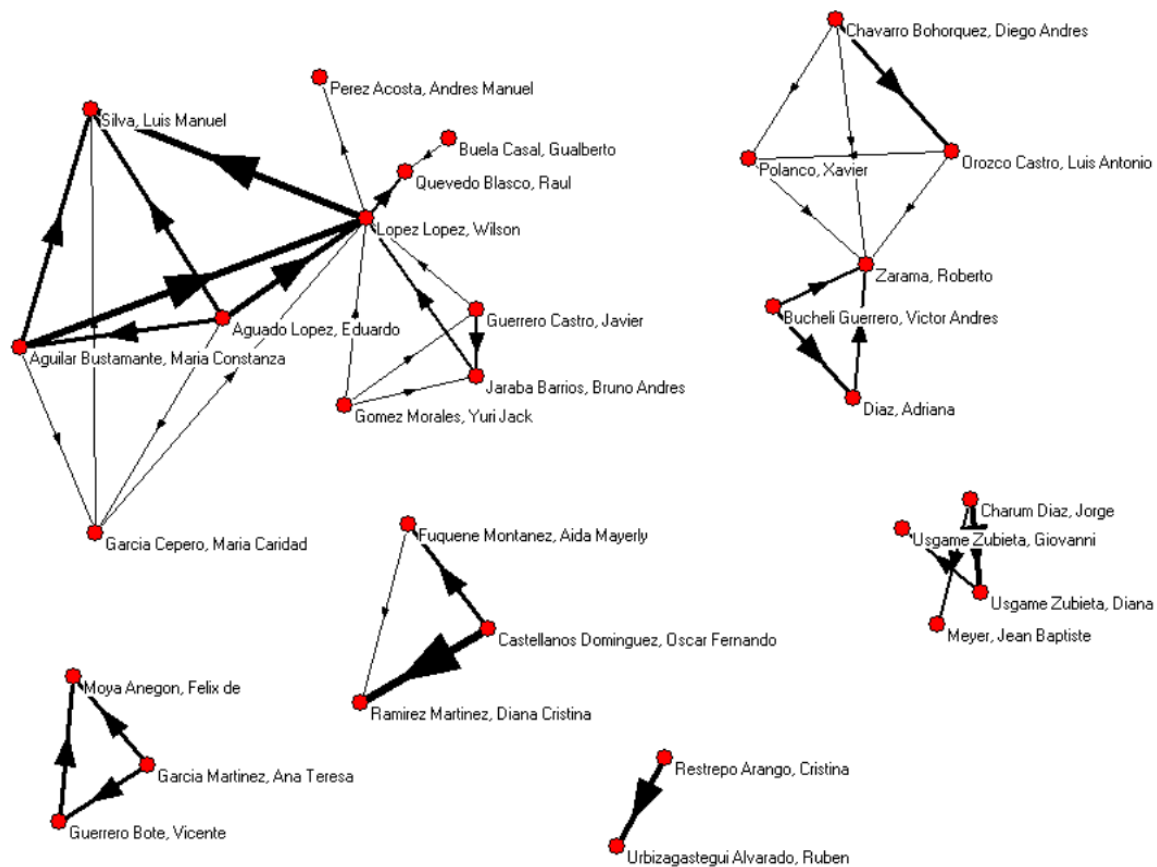**Figure 3.** Growth of literature on Colombian bibliometrics.

Figure 4. Network of co-authors on Colombian bibliometrics.

and Bucheli Bohórquez, Víctor Andrés are bacharels in engineering and are part of the research group on research management. The third group consists of 4 authors who have in common be part of the Colombian Observatory of Science and Technology, of which Usgame Zubieta, Zubieta Usgame Diana and Giovanni are graduates from the school of library and information science at the Pontificia Universidad Javeriana, where Usgame Zubieta, Diana is a teacher.

The fourth group consists of three authors who belong to the group of research and development in management, productivity and competitiveness. These authors are Fuqueñe Montañez, Aida Mayerly; Castellanos Domínguez, Óscar Fernando; and Ramírez Martínez, Diana Cristina, who are engineers and teachers. Furthermore, two of the authors are director and editorial coordinator of the journal *Ingeniería e Investigación*.

The fifth group consists of three Spanish authors; two of them are professors at the University of Extremadura (Guerrero Bote, Vicente and García Martínez, Ana Teresa). Moya Anegón, Félix is a professor and researcher at the University of Granada. The sixth group consists of two authors Urbizagástegui Alvarado, Rubén and Restrepo Arango, Cristina who are librarians working in academic libraries.

Conclusion

The purpose of this paper was to analyze the literature produced on bibliometrics published in Colombia by national or foreign authors who selected Colombian journals or events in the country to communicate the results of their investigations as well as Colombian researchers who as individual authors or in collaboration published their researches in journals or events held abroad. It was found that Colombian bibliometric applications began with the work of León (1982) and a practical application of the Bradford's law in an academic library by Ochoa de Ortiz (1984). Although an initial sporadic publication on bibliometrics were observed, research on this issue takes force from 2004 ahead, but 60% of this production is concentrated in the last period (2007-2012) analyzed.

This literature is growing at an annual rate of 20% doubling in size every four years. Research is stratified focusing on four authors considered moderate and large producers and accounting for nearly one-fifth of the total production of documents. These authors published mostly in Spanish and very rarely in English. The journals used to communicate the results of their research are six domestic journals and they accounts for 32% of everything produced on the subject.

It was also found that collaborative publishing is a recent phenomenon, which has steadily increased since 1998. The areas explored are library and information science, psychology, and applied science and technology, which account for 95% of the papers published. This area is dominated by authors from those fields.

Conflict of Interests

The authors have not declared any conflict of interests.

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