Interdisciplinarity and Transdisciplinarity in the Organization of Scientific Knowledge
Proceedings: 8th Conference of the ISKO Spanish Chapter, University of Leon, Spain, 18 to 20 April 2007

Bibliometrics: representation instrument of the multidisciplinary positioning of a scientific area. Implementation for an Advisory Scientific Committee.

Hervé ROSTAING, Nicolas BARTS, Valérie LÉVEILLÉ

Université Paul Cézanne Aix Marseille III, LSIS UMR 6168, Campus Saint Jérôme, F-13397 Marseille Cedex 20
herve.rostaing@univ-cezanne.fr, nicolas.barts@univ-cezanne.fr, valerie.leveille@univ-cezanne.fr

Abstract

Bibliometric techniques study researchers' communication activity to have a better understanding of phenomena of construction, dissemination and use of scientific and technical knowledge. In this paper, a bibliometric study was used like an assistance instrument for the strategic positioning of a scientific area. The aim of this bibliometric study was to help the work of an Advisory Scientific Committee by offering a global and "objective" view of the position and the evolution of the scientific activity of the Aix-Marseilles area. The methodology employed was strongly inspired by strategic analysis methods carried out in companies. The implemented strategic analysis process involves the definition of strategic scientific units, the selection of competitors (a set of scientific areas), the choice of measuring criterion of the scientific activity, the evaluation of the dynamics over the years and the graphical representation of the scientific portfolio of the Aix-Marseille area. Such a strategic analysis process for analyzing a scientific portfolio allows positioning the strategic scientific fields of the Aix-Marseilles area in relation to the "competition" by taking into account the dynamic history of its activity.

Keywords: Bibliometrics, strategic analysis process, strategic positioning, scientific portfolio analysis

1 Introduction

Bibliometrics is a set of techniques devoted to the quantitative analysis of scientific and technical activities. These techniques implement mathematical and statistical methods to measure the data that represent researcher contributions to science and technical development. The data used for bibliometric studies mainly stem from information produced by the activity of researchers' communication. These quantitative studies of researchers' communication activities try to have a better understanding of phenomena of construction, dissemination and use of scientific and technical knowledge.

Basic assumptions within the field of bibliometrics are that:

- scientific and technical activities produce scientific and technical knowledge,
- scientific and technical knowledge is transformed into scientific and technical information when the promoters of this knowledge seek to formalize it for communicating or storing,
- scientific and technical information is the expression of the representation of this scientific and technical knowledge
- scientific and technical information circulating by well controlled public media, the application of statistical methods measuring flows of information transmitted by these media provides a good image of the "production" of scientific and technical information.

By extrapolation, bibliometrics allows to estimate the researchers' contribution to scientific and technical knowledge production, dissemination and use.

Bibliometric research approaches the analysis of these phenomena by various methods (White and McCain 1989, Rostaing 1996, Van Raan 1997):

- measurement of the scientific knowledge concentration in scientific journals (Bradford law), by researchers (Lotka law)
- measurement of the scientific knowledge growth
- measurement of the dissemination media of scientific knowledge and more especially studies of scientific journals
- measurement of the scientific knowledge use: obsolescence and impacts within a scientific community
- measurement of the social and scientific organization of science players and its impact on the scientific knowledge development (scientific collaborations)

- measurement of the scientific knowledge structure by co-citation analysis, co-word analysis, co-heading analysis, or more recently text mining analysis (information mapping)
- measurement of the production, the productivity and even the performance of players or scientific institutions for their scientific knowledge contribution (research assessment)
- …

This bibliometric study fulfils another purpose. The main objective is the use of bibliometric techniques like an assistance instrument for the strategic positioning of the scientific potential. Companies use bibliometrics for technology watch (or competitive technical intelligence) as an assistance tool to position its R&D activity in relation to the competition. By analogy, a scientific area or a university needs to know its strengths and weaknesses compared to its "competitors". Bibliometric quantitative analysis can help to measure this competitive position and assess the efforts required to preserve or improve scientific potential.

2 Context

In the past, all the scientific orientations and funding decisions were in the French research system assigned to the national public research establishments (Research Ministry, CNRS and National Research Institutes). This situation is changing. The authority devolution to the Regions is transferring part of the decision-making centres near the local public players. In the same way, the French universities are gaining independence and must elaborate new instruments for supporting their development strategy in general, and their scientific policy strategy in particular (Rostaing et al. 2004).

In such a context, the three universities of the Aix-Marseilles area joined their efforts to organize in April 2006 an Advisory Scientific Committee (*Comité d'Orientation Scientifique*). The aim of such a Scientific Committee is not to carry out a research assessment of the three universities or its players, but much more to analyze the research potential and express recommendations on the scientific orientations to improve their research activities. The organization of this Scientific Committee process fits rather into a self evaluation process with an external expertise assistance.

This Scientific Committee was made up of scientists – about forty experts in the various scientific fields of the 3 universities (coming from many areas of France, countries of Europe or other parts of the world). These experts were on-site during one week at the 3 universities. During this week, they attended a general presentation of the universities scientific activities and their shared actions; they visited the various sites of the three universities where they met the numeros persons in charge of research.

As the members of this Scientific Committee were external to the 3 universities, they did not know very well about the scientific activities of the Aix-Marseilles area and had a vague idea of the scientific potential of this area compared to other European scientific areas. To help them, several instruments were put at their disposal: presentation documents of the research organization in the universities and their research groups; gateway on Internet presenting all these research groups and the administrative structures on which they depend... Among these instruments, the steering committee of this event considered that it was necessary to propose a bibliometric study of the three universities' scientific activities.

The aim of this bibliometric study was to try to help the work of the Scientific Committee members by offering a global and "objective" view of the position and the evolution of the scientific activity of the three Aix-Marseilles universities.

3 Methodology and data collection process

The bibliometric study is not intended to be an instrument for helping in the research assessment of the Aix Marseilles universities, but rather an instrument for helping in the strategic analysis of the three universities' scientific policy. Thus, the methodology employed for this bibliometric study was strongly inspired by strategic analysis methods carried out in companies.

The approach of these company strategy analyses is usually presented according to a strategic analysis process realized in four stages (Strategor 1997, Ernst 2003):

- Identification of the Strategic Business Units (SBU): definition of the activity fields which characterize the company trade perfectly and will be the matter of the competitive analysis.
- Choice of the competitive analysis criteria for each SBU: the chosen criteria are considered as the key factors of economic success for the strategic activity fields.
- The competitive position of each SBU: performance assessment of its company to those of its main competitors according to the criterion or the criteria chosen for each SBU.
- Portfolio management: this last stage seeks to offer a common representation of the strategic position of the company as a whole, judged by its SBU portfolio assessment. Such a representation (ex: strategic matrix of Boston Consulting Group, Arthur D Little or McKinsey) makes it possible to compare the competitive position of each SBU and to make a global analysis of the business portfolio for arbitrage making.

The methodology of the bibliometric study follows the strategic analysis process to offer a "competitive" position view of scientific activity the Aix-Marseilles universities according to:

- the "strategic scientific units" corresponding to the key factors of their scientific activities
- a set of scientific areas (considered as "competitors") with whom they wish to be compared.

3.1 Measuring criterion of the scientific activity

The scientific activity of a research center can take many forms (Callon et al. 1995): "certified" scientific research (academic research), participation in formation by research, transfer and exchange with social and economic world, commitment in public interest actions, spreading of scientific culture…

In this study, only the activity of academic research will be taken into account as measuring criterion of the scientific activity. Furthermore, this activity of academic research was restricted to only the production of scientific contributions indexed by the databases produced by Thomson-ISI. These Citation Indexes have many advantages (multidisciplinary and international cover, became a de facto standard, publications taken into account have an international dimension, relatively well normalized data…) but also many drawbacks that directly influence this bibliometric study. By using this source of information, the measurement of scientific research is only based on the scientific contributions published in scientific journals. All other means of scientific communication are not taken into account by the Citation Indexes. The scientific communities having other communication practices (books contribution, international conferences participation) are undervalued. Theses disadvantages become critical for social sciences and humanities.

The WoS[1] version of the Citation Index was used for collecting the data and, more precisely, the following databases: SCIE (Science Citation Index Expanded) and SSCI (Social Science Citation Index).

3.2 Definition of the strategic scientific units

The steering committee considered that the research fields covered by the various Doctoral Schools (*Ecole Doctorale*) represent perfectly the scientific activities of the three universities. Over several years in France, the accredited research laboratories have been brought together in Doctoral Schools. In the Aix-Marseilles area, twelve Doctoral Schools were accredited to the three universities: seven include sciences and technology fields and five social sciences and humanities fields.

The bibliometric study could not take into account the scientific fields corresponding to the Doctoral Schools of social sciences and humanities because of the lack of reliable and accurate data from Citation Index. Only strategic scientific units covered by the seven Doctoral Schools in sciences and technology fields could be used for the competitive position analysis. The names of these seven Doctoral Schools are: *1)* Mathematics and computer science (*Math-Info*); *2)* Physics and materials sciences (*Phys-Mat*); *3)* Physics, Modeling and engineering science (*Phys-Ing*); *4)* Environmental sciences (*Env*); *5)* Chemical Sciences (*Chim*); *6)* Sciences of the Human Movement (*Mouv*); 7) Health and Life sciences (*Vie-Santé*)

The scientific fields used as strategic scientific units are defined by the scientific boundaries of the seven Doctoral Schools of the Aix-Marseilles area. The use of the *Subject Category* classification seeming to be inappropriate, the steering committee of the Scientific Committee chose to define the scientific boundary of each Doctoral Schools by the selection of a scientific journals panel. As much as possible, this selection of scientific journals was carried out with the Doctoral Schools by an elicitation process. However, some Doctoral Schools didn't take part in this process. The steering committee thus had to carry out this selection by applying arbitrary criteria. The Table 1 shows the number of selected journal and how this journals panel was obtained for each strategic scientific unit.

Strategic scientific units	Number of selected journals	Way of selecting
Mathematics and computer science	146	Selected by Doctoral Schools
Physics and materials sciences	200	Arbitrary selected (1<IF<21.36)
Physics, Modeling and engineering science	200	Arbitrary selected (0.20<IF<4.35)
Environmental sciences	229	Arbitrary selected (0.83<IF<16.24)
Chemical Sciences	203	Selected by Doctoral Schools
Sciences of the Human Movement	110	Selected by Doctoral Schools
Health and Life sciences	295	Arbitrary selected (2<IF<38.57)

Table 1: results of the selecting process of scientific journals for defining the boundary of each strategic scientific unit

3.3 Selection of the set of scientific areas ("competitors")

The choice of the areas to be compared to the Aix-Marseilles area was decided by the Steering Committee of the Scientific Committee (formed of the Scientific Vice-Presidents of the 3 universities of Aix-Marseilles). The Steering Committee singled out 7 French areas (Bordeaux, Grenoble, Lyon, Montpellier, Nice, Strasbourg, Toulouse) and 5 European areas (Barcelona, Leeds, Milan, Tübingen, Turin).

[1] Web of Science produced by Thomson-ISI

This arbitrary choice is mainly based on strategic positioning expectations from the Steering Committee. In the same way that a company selects deliberately a set of companies considered as its competitors in a strategic analysis process, the Steering committee chose the scientific areas which it wanted to be gauged with.

Even so, this choice tried to respect two criteria:

- limitation of the size effect by selecting scientific areas having a scale rather similar to the scale of the Aix-Marseilles area,
- keeping a scientific coherence by selecting scientific areas having a spectrum of scientific activities characteristic of the Aix–Marseilles area.

The extraction from a database of all the publications of a university is quite impossible by only seeking the university name(s) in the address of the authors. For various reasons this process is unsuccessful (Van Raan A, 2005). Furthermore, the scientific publications representing the activity of a scientific area were extracted according to following constraints:

- the geographical localization indicated in the authors addresses : the three universities of Aix-Marseilles are scattered in several cities over a wide area of about thirty kilometers (the cities of Marseilles and Aix-en-Provence are 30 km apart). All the publications indexed by the SCIE or the SSCI mentioning one of these cities (where the universities are located) are attributed to the cluster of the three universities. The same principle was applied to the twelve other scientific areas.
- the universities' names belonging to the scientific area: if some scientists of a university are not resident in these cities or if the author address is not specified in the bibliographic record, the previous search is unsuccessful. Therefore, publications containing one of the universities' names as affiliation were also required. As unfortunately some universities are known with several names (especially for French universities), we tried to take into account all these variations of names for each university.

For example, here is how we queried the WoS databases to extract the publications of the Aix-Marseilles area:

CI=(marseille OR marseilles OR aix en provence OR les milles) OR AD=((aix SAME marseille I) OR (aix SAME marseille 1) OR (univ provence) OR (provence univ)) OR AD=((aix SAME marseille II) OR (aix SAME marseille 2) OR (univ medit SAME france) OR (medit* univ SAME france)) OR AD=((aix SAME marseille 3) OR (aix SAME marseille III) OR (Univ SAME Paul Cezanne) OR (UDESAM) OR (univ SAME droit SAME aix))*

The set of publications extracted by such a query represents much more the scientific activity of Aix-Marseilles area than the scientific activity of the three Aix-Marseilles universities. This is the reason why, in this paper, we are talking about the analysis of the scientific portfolio of a scientific area and not of a universities cluster.

3.4 Evaluation of the dynamics over the years of strategic scientific units

For evaluating the evolution of the activities of the 13 areas in the scientific fields, the data were collected over a 24-year period (1981-2004) divided into 4-year windows. Therefore, the dynamics of the areas in the various strategic scientific units are estimated with 6 periods of 4-year windows.

4 Results

4.1 Raw data scoreboards

The collected data were compiled in "scoreboards". A first scoreboard compiles the evolution of the global production of each scientific area for the 6 periods of 4-year windows (Table 2). A similar scoreboard is built up for each strategic scientific unit. Charts of these 8 scoreboards were produced (for example, the Figure 1 is the chart of the Table 2).

	81-84	85-88	89-92	93-96	97-00	01-04	Total	Rank	Rank 81-84	Rank 01-04
Aix-Marseilles	5862	6743	7024	9316	11484	12482	52911	**7**	**5**	**7**
Bordeaux	3746	4842	5084	6635	8283	8874	37464	12	11	12
Grenoble	5332	6790	8643	11100	14559	15691	62115	5	6	4
Montpellier	4502	5613	6338	8586	10896	12028	47963	9	9	8
Nice	2236	2933	3467	4416	5372	6005	24429	13	13	13
Lyon	8443	9677	6214	13214	15846	17060	70454	3	1	3
Strasbourg	5970	6691	7349	9126	10804	10662	50602	8	4	11
Toulouse	5310	6497	6875	9748	12636	13936	55002	6	7	6
Barcelona	4425	7847	10553	15261	21750	26377	86213	2	10	2
Turin	2856	3470	4931	7266	8624	10762	37909	11	12	9
Leeds	7584	8925	9045	11070	14375	14863	65862	4	3	5
Tubingen	5201	5797	5941	7704	10339	10671	45653	10	8	10
Milan	8349	10448	13204	19729	24727	27296	103753	1	2	1

Table 2: evolution of the global production of each scientific area

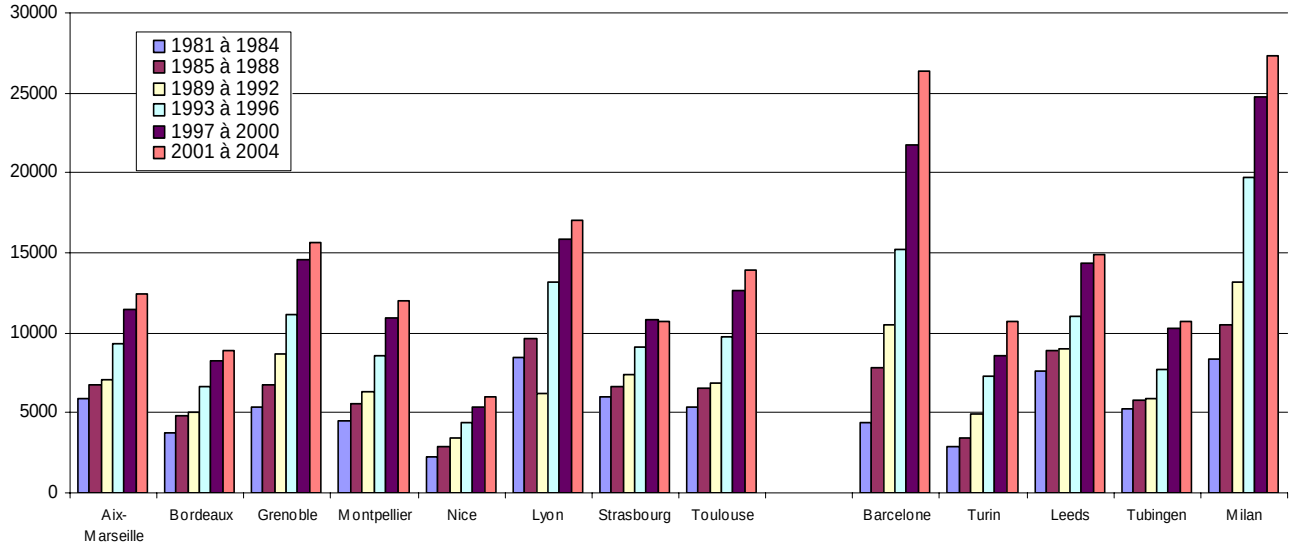

Figure 1: chart of the evolution of the global production of each scientific area (Table 2)

The complexity and the number of these raw data scoreboards (or theirs charts) do not make easy the analysis of the potential research positioning of the Aix-Marseilles area. It appears very difficult to evaluate dynamics of the area in each scientific field because the size effect could strongly influence the interpretation of the results. It appears significant to be able to weigh the effort provided by the actors of a scientific field by the global effort provided by the area during the same time period.

To make such raw data useful, relative indicators were computed for reducing the effect of size and translated into graphs in order to offer a global view of the evolution of the Aix-Marseilles area positioning in the chosen fields compared to the 12 other scientific areas.

4.2 Representation of the portfolio of the strategic scientific units

By analogy with the strategic matrices developed by consultancy firms, the portfolio of the strategic scientific units of the Aix-Marseille area is graphically represented according to two indicators (fig 2).

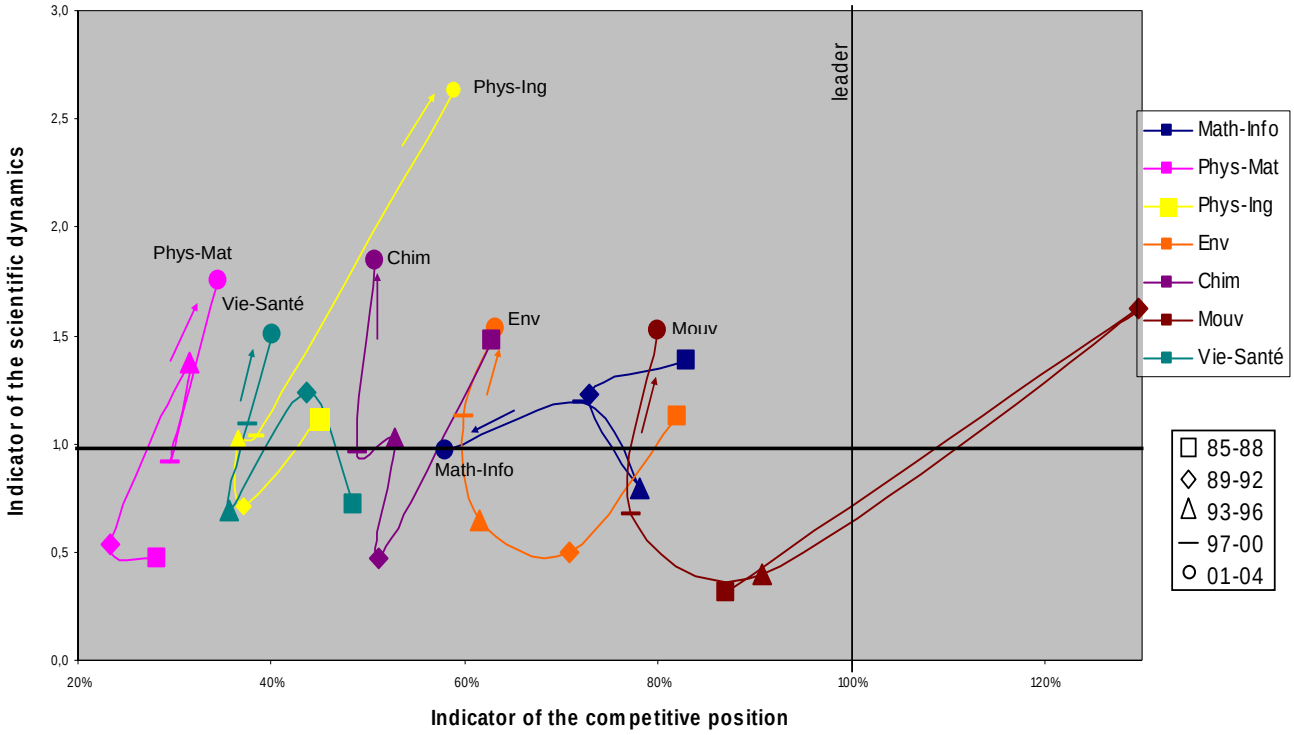

Figure 2: competition position dynamics of a scientific portfolio for the Aix-Marseilles area

The scientific fields (strategic scientific units) are scattered according to these two axes:

- indicator of the "competitive" position on the x-axis: the research activity of the Aix-Marseilles area in a strategic scientific unit is positioned on the x-axis in proportion to the research activity of the most active competitor in this field. As all the strategic scientific units are represented on the same graph, this gap with the leader is expressed as a percentage to minimize the size effect. Thus the gap between the dot of a scientific field and this 100% vertical line corresponds to the effort that the Aix-Marseilles area should make to catch up with the leader of this scientific field. If the Aix-Marseilles area is the leader in a strategic scientific unit, then the dot is positioned beyond the vertical line and the gap to this line corresponds to how far it has pulled away from the second most active area in this field.
- indicator of the scientific dynamics on the y-axis : a strategic scientific unit is positioned on the y-axis according to the growth of the scientific activity of the Aix-Marseilles area in this field. This growth measures the evolution (expressed as a percentage) of the production between a time window and the previous time window. To standardize this measurement for the set of the strategic scientific units, this growth is reduced by the measurement of the growth of the areas set in this scientific field. Thus, the horizontal line having the ordinate 1 symbolizes the position at which the Aix-Marseilles area has a growth equivalent to the global growth for a time window. A strategic scientific unit located above this horizontal line shows that the Aix-Marseilles area has a dynamics more significant than the dynamics of the areas set for this period of 4-year window.

As the two axes are relative indicators, it is possible to locate the strategic scientific units for all the 4-year windows on the same graph.

5 Conclusion

Such a representation of the scientific portfolio has the advantage of:

- summarizing the eight raw data scoreboards in only one graph (information loss but significance gain)
- positioning all the fields of the scientific area on the same graph (according to the indicator of the competition position of the x-axis, the field *Mouv* has the best position while the field *Phys-mat* the worst one)
- evaluating the effort that the scientific area must make to catch up with the leader in each field (gap to reach the leader line)
- showing if the scientific area activity is growing sufficiently in each field either to maintain or catch up the gap with the leader (according to the indicator of the scientific dynamics on the y-axis Aix-Marseilles area tends to have a better growing of their activity that the global growth in all the fields except in the field *Math-Info*)
- showing the trend through time of the area scientific activity in each field (the dynamics of positioning on the x-axis and the y-axis of each field indicates if the scientific area tends to fall behind or to catch up with the leader of each field and if it tends to have superior or inferior growth relative to the scientific areas set)

Such a scientific portfolio representation allows positioning the strategic scientific fields of the Aix-Marseilles area in relation to the "competition" by taking into account the dynamics history of its activity.

References

CALLON, M.; LARRÉDO, P.; MUSTAR P. *Gestion de la recherche. La gestion stratégique de la recherche et de la technologie*. Paris: Economica, 1995

ERNST, H. Patent information for strategic technology management. *World Patent Information*. 2003, Vol. 25, p. 233-242

ROSTAING, H. *La bibliométrie et ses techniques.* Toulouse: Sciences de la Société, 1996

ROSTAING, H.; GIMENEZ TOLEDO, E.; KISTER, J. Système d'information pour l'aide à la gestion stratégique de la recherche dans un établissement public de recherche. *Proceedings: VSST'04, Veille Stratégique, Scientifique & Technologique.* Toulouse: Université Paul Sabatier - IRIT, 2004, vol. 2, p. 157-168

STRATEGOR. *Strategor. Politique générale de l'entreprise.* Paris: Dunod, 1997 (third edition)

VAN RAAN, A.F.J. Fatal attraction: conceptual and methodological problems in the ranking of universities by bibliometric methods. *Scientometrics*. 2005, vol. 62, n. 1, p. 133-143

VAN RAAN, A.F.J. Scientometrics: State-of-the-Art. *Scientometrics*. 1997, vol. 38, n. 1, p. 205-218

WHITE, D.H.; MCCAIN, K.W. Bibliometrics. *Annual Review of Information Science and Technology*. 1989, vol. 24