Scientific portfolio analysis of a scientific area by a competitive position approach

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Abstract

The bibliometric study presented in this communication was carried out in 2006 for an Advisory Scientific Committee organized by the 3 universities of Aix-Marseilles[1]. This Scientific Committee was made up of scientists coming from other areas of France, from countries of Europe or other parts of the world.

To help the Scientific Committee, the steering committee considered that it was necessary to propose a bibliometric study of the three universities' scientific activities.

The bibliometric study was 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 collected data from the WoS were compiled in "scoreboards" showing the evolution of the production of the 13 scientific areas compared in each scientific field for the 6 periods of 4 years.

To make the use of such scoreboards easier, relative indicators were computed and translated into graphs in order to offer a global view of the evolution of the Aix-Marseilles area positioning in the chosen scientific fields in relation to the activities of the 12 other scientific areas.

Introduction

The bibliometric study presented in this communication was carried out in 2006 for an Advisory Scientific Committee (*Comité d'Orientation Scientifique*) organized by the 3 universities of Aix-Marseilles. This Scientific Committee was made up of scientists – about forty experts in the various scientific fields of the 3 universities - coming from other areas of France, from 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, and they visited the various sites of the three universities where they met numerous persons in charge of their research.

The aim of such a Scientific Committee is not to carry out a research assessment of the three universities or its actors, but much more to analyze the research potential and express recommendations on the scientific orientations to improve their research activities. The

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[1] The three universities of Aix-Marseille are : *Université de Provence (Aix-Marseille I)*, *Université de la Méditerranéen (Aix-Marseille II)* and *Université Paul Cézanne (Aix-Marseille III)*

organization of this Scientific Committee process fits rather into a self evaluation process with an external expertise assistance.

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.

This bibliometric study tried to accompany 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.

Methodology

The bibliometric study was 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.

Strategic analysis process

The greatest part of these strategic analyses is founded on the principles of economic competition. The ground, where all competitors and all the strategies clash, is the market. This market plays the ultimate role of judge who will consolidate the most effective strategies. The market is thus very often one of the main elements to be evaluated by these analysis tools.

The whole of the approaches of these company strategy analyses is usually presented according to *a strategic analysis process* realized in four stages:
- 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. These SBU correspond to the unit of 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 three main categories of criteria usually exploited are: 1) the position on the market (market share), the position in the life cycle of an activity (life cycle often expressed in 4 stages: start up, growth, maturity, decline), the cost-based position (expressed by the production cost, the marketing cost, supply cost)
- **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. The measurement of a criterion is often very simple. This measurement is summarized by a score on a scale of 5, 10 or 100 values. If several criteria are necessary for the measurement of a SBU, a total score is obtained by the sum of each criterion score weighted according to an importance coefficient.
- **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. This common representation of the SBU portfolio is constructed as a matrix or a "business grid" according to two indicators: competitive position and an indicator showing the position in the life cycle (dynamism notion of the SBU). 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.

By analogy with this strategic analysis process, it's a fair assumption that the universities are clashing on a scientific ground (and not commercial) where a scientific competition state of mind can influence the strategy of the scientific actors.

The methodology of the bibliometric study follows the strategic analysis process to offer a "competitive" position view of 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.

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. For several years, the accredited research laboratories have been brought together in Doctoral Schools. A Doctoral School must have a coherent and multidimensional project of training for research and by research. A doctoral school can belong to only one university or be shared by several universities. The Doctoral Schools must be in keeping with the scientific and teaching policy of the university (or the universities). This research organization in Doctoral Schools aims not only to offer an administrative structure for thesis supervision but must also contribute to the consistency and the international visibility of French academic research.
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. All the Doctoral Schools (except one) in materials science, life science and applied science have an accreditation shared by the three universities. It is one of the characteristics of the local research organization: the research centers in science and technology are not concentrated in only one university but are distributed in the three universities.
Therefore, the choice of the Doctoral Schools as strategic scientific units for the bibliometric study was suitable because the scientific granularity obtained seemed accurate enough for a global analysis of the Aix-Marseilles research and the common research policy of the three universities is perfectly represented.

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).
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 scientific activity of these 13 areas has to be estimated according to the strategic scientific units previously defined.

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 is estimated with 6 periods of 4-year windows.

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[2] 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.

Therefore, 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. In the end, 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:

- Mathematics and computer science
- Physics and materials sciences
- Physics, Modeling and engineering science
- Environmental sciences
- Chemical Sciences
- Sciences of the Human Movement
- Health and Life sciences

Representation of the portfolio of the strategic scientific units

By analogy with the strategic matrices or the business grids developed by consultancy firms, the portfolio of the strategic scientific units of the Aix-Marseille area is graphically represented according to two indicators (fig 1). The scientific fields (strategic scientific units) are scattered according to these two axes for a 4-year window:

- 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. This indicator shows the gap between the research activity of the Aix-Marseilles area and the research activity of the leader in this scientific 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. The position of the leader of each strategic scientific unit is symbolized by a vertical line which has abscissa 100%. Thus the gap between the dot of a scientific field and this 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 this 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 this 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.
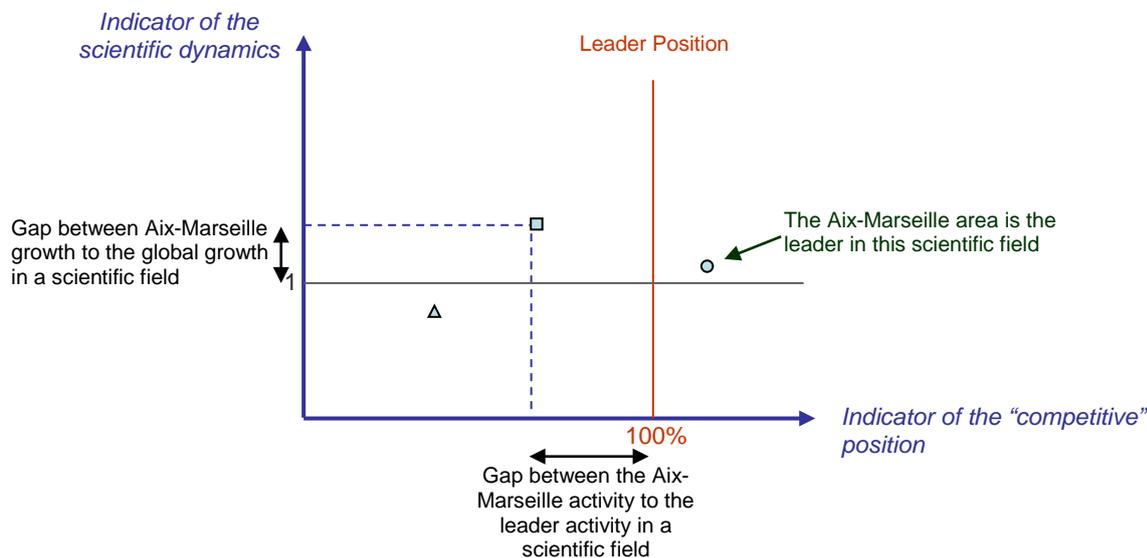
Figure 1: competition position of a scientific portfolio

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 (fig. 2). Such a representation of the scientific portfolio makes it possible to position the scientific fields in relation to the "competition" by taking into account the history of the activity dynamics of the Aix-Marseilles area in each one of these fields.
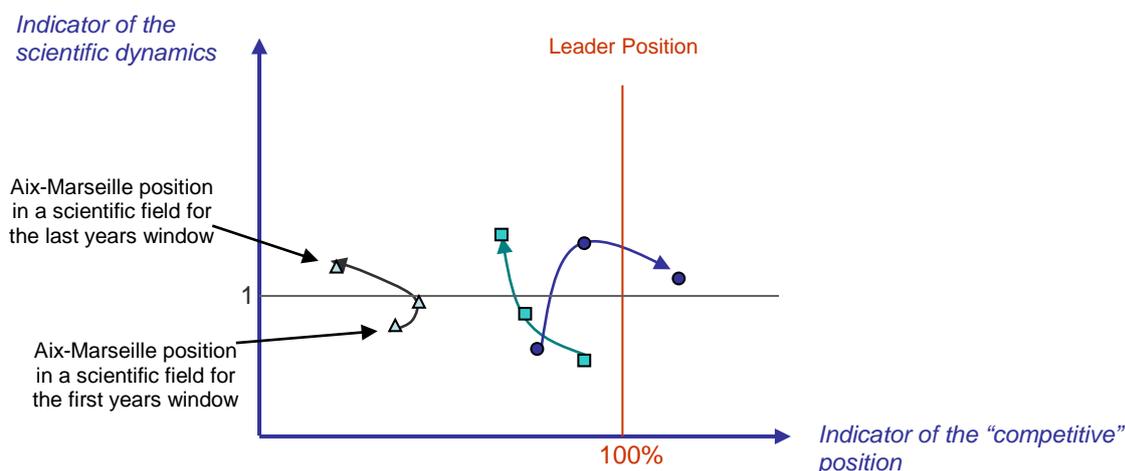
Figure 2: competition position dynamics of a scientific portfolio

Implementation

Data collection source

The WoS[3] 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). This data collection was carried out by taking particularly into account the boundary identification of the "competitors" areas and the boundary identification of the seven strategic scientific units.

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[3] Web of Science produced by Thomson-ISI

Boundary identification of the scientific areas
It is well-known that it is not possible to extract from a database all the publications of a research establishment by only seeking its name 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 the 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 query 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 the 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.

Boundary identification of the strategic scientific units
The scientific fields used as strategic scientific units are defined by the scientific boundaries of the seven Doctoral Schools of the Aix-Marseille 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 scientific boundary of such a Doctoral Schools was first of all roughly estimated by choosing codes of *Subject Category* classification. Then, the whole of the journals indexed by these *Subject Category* codes was gathered and arranged by decreasing Impact Factor. The journals selected for defining the scientific activity of a Doctoral School were the journals ranked at the top of the Impact Factor arranged list if the Aix-Marseilles area had published in them at least one article during the last four years (2001-2004).

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

Results

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. A similar scoreboard is built up for each strategic scientific unit.

For example, Tab. 2 and Fig. 3 show the evolution of the global production (without scientific field restriction) of each scientific area for the 6 periods. Tab. 3 and Fig. 4 show the same type of scoreboards for the strategic scientific unit *Mathematics and computer science*.

	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

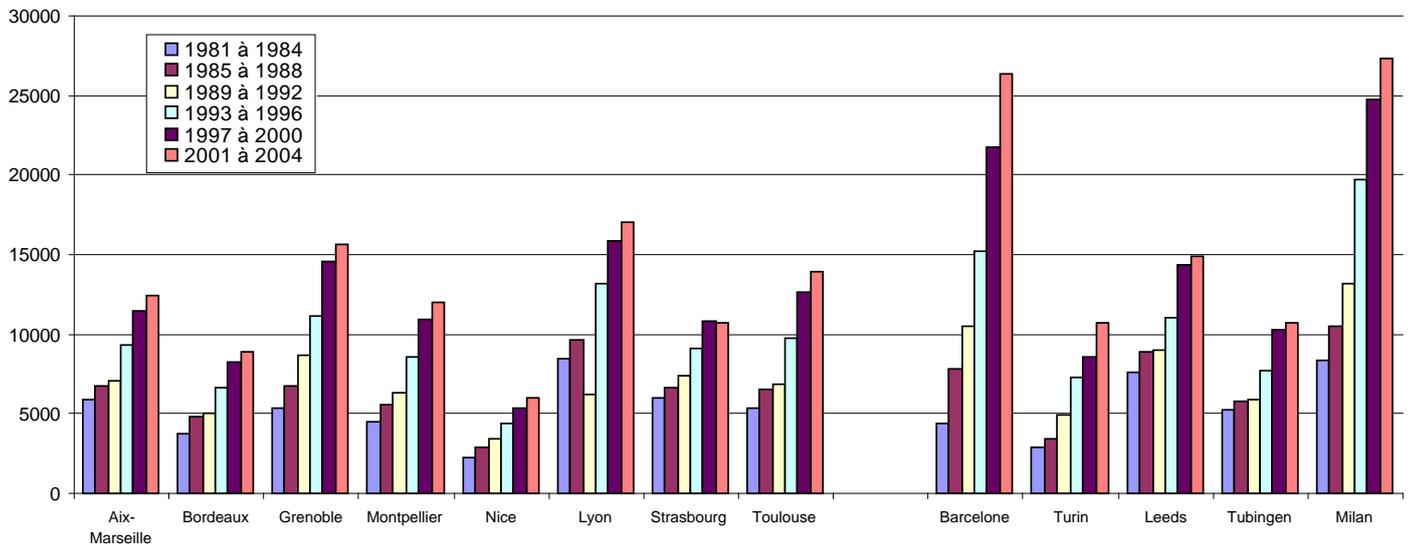Table 2: evolution of the global production of each scientific area

Figure 3: graphical representation of the evolution
of the global production of each scientific area

	81-84	85-88	89-92	93-96	97-00	01-04	Total	Rank	Rank 81-84	Rank 01-04
Aix-Marseilles	101	150	198	282	416	625	1772	**5**	**7**	**5**
Bordeaux	113	157	172	280	318	423	1463	8	3	8
Grenoble	107	174	213	313	409	585	1801	4	5	7
Montpellier	49	73	72	113	143	256	706	13	13	11
Nice	114	139	210	260	343	587	1653	7	2	6
Lyon	72	75	129	327	422	652	1677	6	11	4
Strasbourg	123	151	140	172	217	254	1057	10	1	12
Toulouse	110	146	164	318	513	700	1951	3	4	3
Barcelona	89	181	272	361	577	1078	2558	1	8	1
Turin	59	74	113	190	254	373	1063	9	12	9
Leeds	107	90	85	114	174	279	849	11	5	10
Tubingen	85	96	83	103	206	234	807	12	10	13
Milan	88	137	220	351	461	718	1975	2	9	2

Table 3: evolution of the production of each scientific area
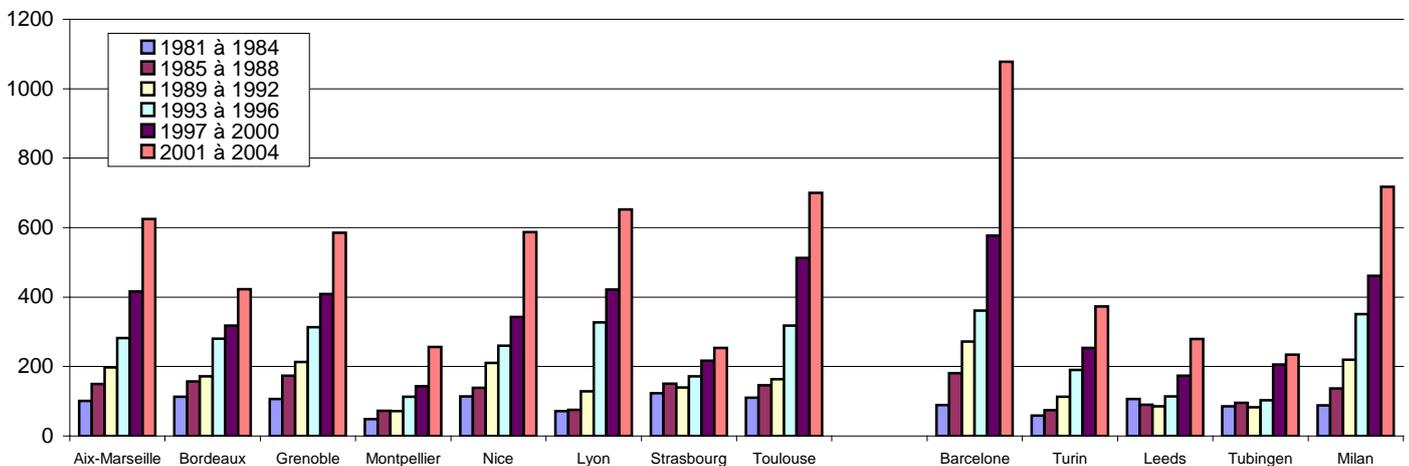in the field of *Mathematics and computer science*

Figure 4: graphical representation of the evolution of the production of each scientific area in
the field of *Mathematics and computer science*

Based on all these scoreboards, the competition position dynamics of a scientific portfolio for Aix-Marseille area was computed (Tab. 5) and graphically represented (Fig. 5).

|	Math-Comp		Phys-Mat		Phys-Eng		Env		Chem		Move		Health-Life	
	Comp. Pos.	Sc. Dyn.	Comp. Pos.	Sc. Dyn.	Comp. Pos.	Sc. Dyn.	Comp. Pos.	Sc. Dyn.	Comp. Pos.	Sc. Dyn.	Comp. Pos.	Sc. Dyn.	Comp. Pos.	Sc. Dyn.
85-88	83%	1,39	28%	0,47	45%	1,11	82%	1,12	63%	1,48	87%	0,32	49%	0,72
89-92	73%	1,23	23%	0,54	37%	0,71	71%	0,50	51%	0,47	130%	1,62	44%	1,24
93-96	78%	0,79	32%	1,38	37%	1,02	62%	0,64	53%	1,02	91%	0,40	36%	0,69
97-00	72%	1,19	30%	0,92	38%	1,03	60%	1,13	49%	0,96	77%	0,67	37%	1,09
01-04	58%	0,97	35%	1,75	59%	2,63	63%	1,53	51%	1,85	80%	1,52	40%	1,50
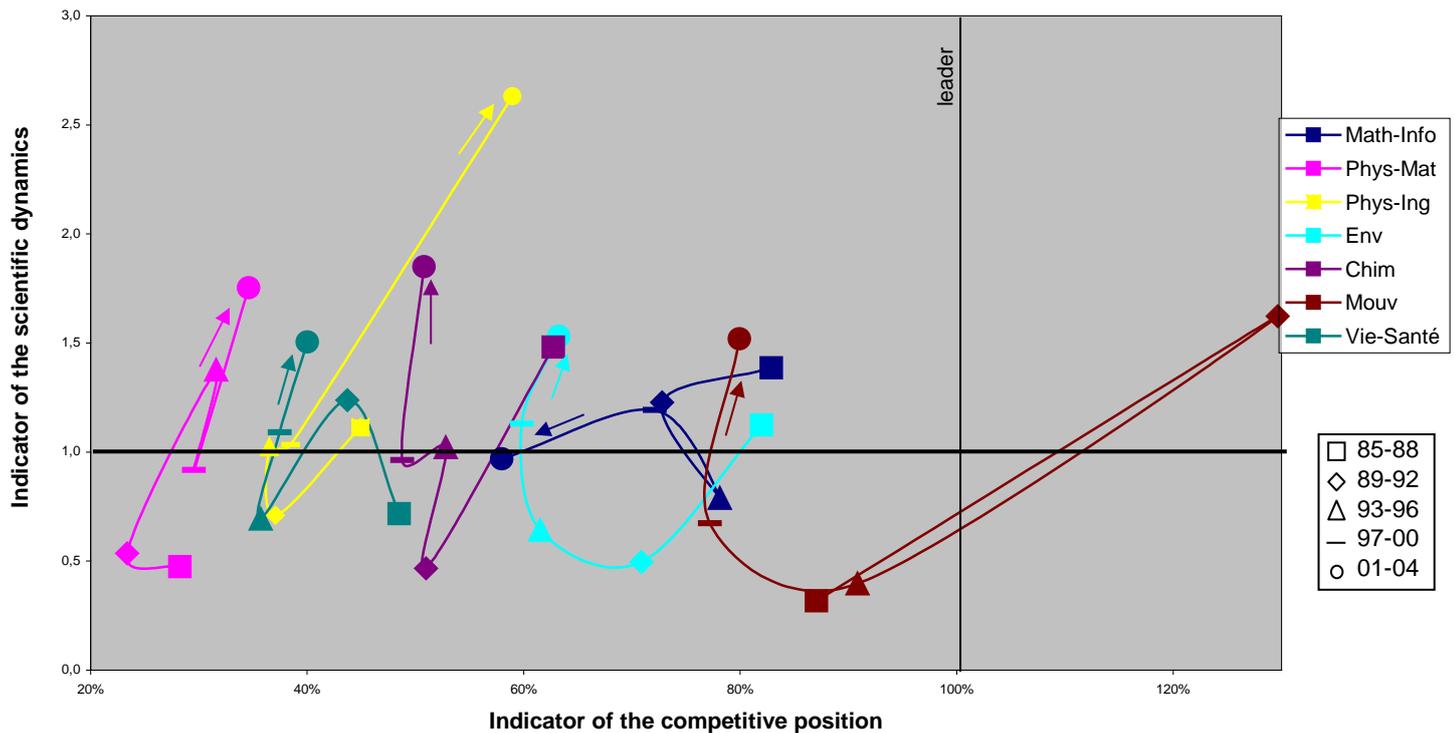
Figure 5 : competition position dynamics of a scientific portfolio for the Aix-Marseilles area

These results and the implementation process will be exposed. And finally, the contribution of such a bibliometric representation of a scientific area within the framework of a Scientific Committee will be discussed.

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