IS IT OPENED OR CLOSED?
COLOMBIAN SCIENCE ON THE MOVE

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Using recent original data from three different sources, the article exhibits some strengths and weaknesses of science in Colombia. It shows that research in this country is in a process of growth although recent results of this positive trend are still to be confirmed. Comparing the evolution of science in Colombia with that of Latin America as a whole, describing and explaining its geographical and institutional concentration as well as its thematic distribution, it also reveals the interdependance between science production dynamics and international cooperation programmes. A basic argument is that the development of science in this country, even though it is fragile and erratic, does not lack sound bases. The indicators used suggest indeed an autonomous scientific motion and inspiration which does not contradict the internationalization process of Colombian science but rectifies the picture of an excessively isolated or dependent community that used to be portrayed.

Introduction

Colombian science is on the move. From a time of marginalization in the national culture and society, it has undergone since 1991 a dramatic shift in its orientation and its recognition, through a triple process of institutionalization, internationalization and resource allocation. Law 29 of 1990 instituted the National System of Science and Technology, which gave S & T a framework and political priority in relation to the overall development of the country. The Caldas network of Colombian expatriated scientists and engineers emerged. It is a new and original instrument for linking the local intellectual community to the outside world through Colombians living in other countries. IBD (Interamerican Bank of Development) loans for financing research activities showed a fourfold increase during the same period. But the recent tendency does not erase the remnants of history when science was considered a luxury for this country which did not invest in its research community. Comments about the latter

used to point out its weaknesses for two, apparently contradictory, reasons: its excessive openess and/or its isolation. On the one hand, researchers appeared to be entrenched in their own restricted fields and units, lacking interactions between them and thus critical mass to eventually confront with their peers in foreign countries. In one case, data about publications led to this interpretation.[1] On the other hand, the systematic review of publications involving Colombian authors showed a significant and unusual propensity to coauthor with foreign partners.[2] Such a proportion of co-authorship would indicate a strong dependence on the foreign community for the production of Colombian science, a kind of extrovert research activity.[3] Which picture is true? Both refer to the same Science Citation Index (SCI) sources and share the same diagnosis on the structural weakness of Colombian scientific productivity but they differ in their interpretation of this phenomenon. Actually, both may be superseded by the description and explanation we propose here. Taking new, non-SCI, data changes the view point and the terms of the question. It leads to an approach where the exogeneity or endogeneity of national science in developing countries is dealt with a less dichotomic manner.[4]

Data sources and methodology

The core data which is used in this article consists of publications lists extracted from the PASCAL data base of the I.N.I.S.T. (Institut National de l'Information Scientifique et Technique), C.N.R.S. (Centre National de la Recherche Scientifique – France). The merits and limits of this data base compared to those of the ISI (Institute for Scientific Information) have already been presented and discussed elsewhere.[5] For our purpose here, the PASCAL data base has the advantage of taking into account a greater number of publications sources than the SCI (roughly 7800 vs. 3000);[6] it is less selective and more diversified, including for instance proceedings of meetings which took place in Colombia, which obviously do not appear in the SCI. However, a deficiency of the PASCAL base is the absence of geographic origins of the authors, except for the first one. Therefore, the publications headed by non-Colombian scientists and to which Colombian authors contributed remain concealed. Consequently, the picture provided by the two data bases is expected to be different: they highlight a different part of the scientific landscape and production. Some of their references are common and others not. However, beyond the variation of bias that they introduce, many convergences may be seen: they exhibit roughly comparable proportions between disciplines and countries in many cases.

The second source of information is a combination of data bases provided by international scientific cooperation agencies on projects they have supported with developing countries research teams. These are basically three data bases; the IDRIS which gathers the information from eight agencies: JICA (Japan International Cooperation Agency), BOSTID (Board on Science and Technology in Developing Countries), FINNIDA (Finnish International Development Agency), UNU (United Nations University), ICOD (International Center for Ocean Development), IFS (International Foundation for Science), SAREC (Swedish Agency for Research Cooperation with Developing Countries) and IDRC (International Development Research Center). The second data base is the USAID (United States Agency for International Development) PSTC (Program in Science and Technological Cooperation) programme, and the EC–STD2 (European Community Science and Technology for Development) programme is the third.

Another source of information utilized is the CINDEC (Comité de Investigaciones y Desarrollo Científico) data base of the National University of Colombia. It documents the scientific activity led by the personnel of this entity which is the main research institution in the country.

All these sources are not always immediately and directly comparable. The PASCAL data base covers the time period from 1987 to 1993, while the IDRIS and USAID bases collect data from 1980 to 1991, the EC–STD from 1988 to 1992 and the CINDEC from 1977 to 1992. The distribution of disciplines may also differ from one to the other: the IDRIS and CINDEC include social sciences while the USAID PSTC, the EC–STD and the PASCAL bases respectively deal with biological, medical/agricultural, and natural hard sciences. Nonetheless, with the appropriate precautions, these various sources allow interesting and fruitful comparisons. The assumptions drawn from PASCAL are correlated, explained, detailed and specified by the others. The combination of these various sources definitely converges in an exercise of "epistemometria" for describing Colombian scientific activity and production.[7]

Dynamics and characteristics of Colombian science

Scientific production in Colombia has increased during the last seven years. However, its growth has been limited (7% in seven years) and its pace is slow and

erratic which is not surprising for a small community where the average annual production is only 200 recorded publications. With a small volume of projects, the production variations between years is more acute than when many research projects balance the overall picture (Fig. 1).
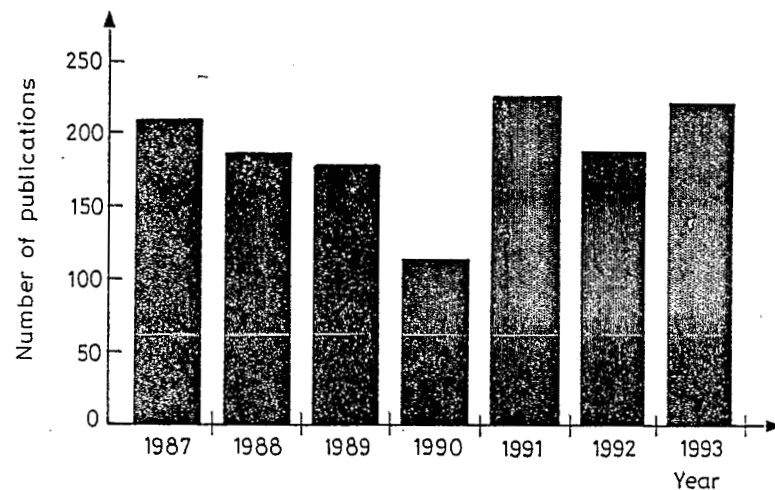

Fig. 1. The evolution of Colombian scientific production (1987–93), Source: PASCAL

For the period considered, this growth is a general phenomenon in the whole world and especially in Latin America whose relative weight has risen.[8] In this region, each sub-region augmented its scientific production, though with important variations between countries.[9] It is relatively limited in Colombia compared with global figures of Latin America and the United States (see Fig. 2). The Latin American countries included in the calculation of average growth, are the main scientific producers of the region: Brazil, Mexico, Argentina, Chile and Venezuela.[10] Clearly, their overall growth rate is catching up with that of the United States. At the same time, their differential with the sixth producer of the region. Colombia, is increasing. Considering the difference in size on which these rates of growth apply (Brazil's production is more than ten times that of Colombia), this country is obviously losing ground compared to the others.[11]

Moreover, if the figures for all countries in Latin America are taken into account, it appears that Colombia, which used to produce 3% of the total output of the region in 1987, only produced 2.7% in 1993.
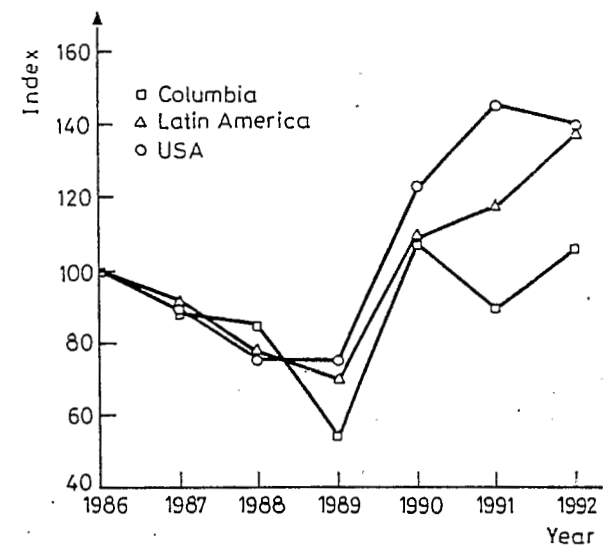

Fig. 2. Indices of publications growth 1987–93 (1987= 100); Source: PASCAL

Even though the data produced here are the most recent, they obviously do not reflect the impact of the financial and institutional support for research that has been implemented since 1991. This should start to be felt within two years in the publications volumes. It will then be very interesting to follow the extent and dynamics of these changes through bibliometric tools.

Science production in Colombia is quite concentrated, both geographically and institutionally (Fig. 3).

Bogota, the capital, is by far the major center of production with more than a third of the country's publications. The region Valle del Cauca (Cali) shows significant dynamism at the national scale, with more than a quarter of the total. The third pole is the city of Medellin, though well behind the others. Other regional centers have a much lower production.

The map depicted in Fig. 3 highlights two points:
– There is a strong concentration of scientific production in only three places and this production is dominated by Bogota. This polarization reflects an irregular density of research capacities as well as discontinuities in the scientific fabric of the country. It is a phenomenon that the current regionalization process intends to rectify and whose results might be interesting to check in a future comparative map.
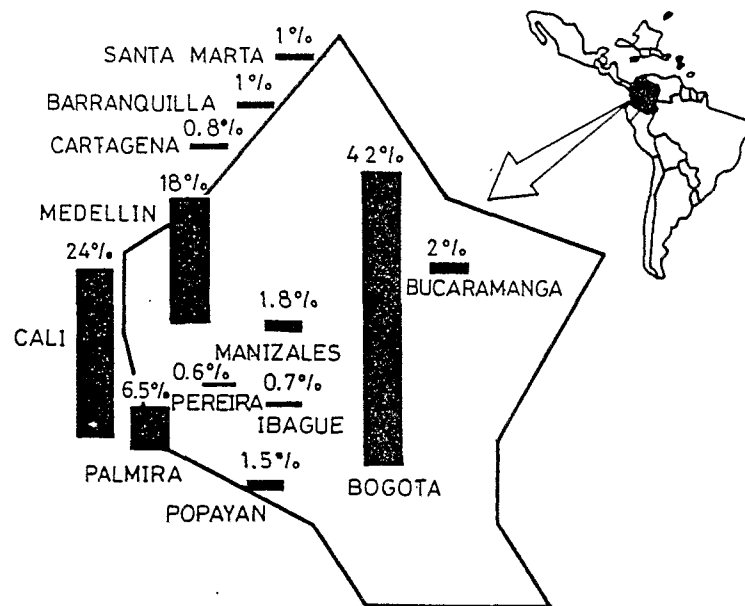
Fig. 3. Concentration of publications by geographic centers of production; source: PASCAL

Fig. 4. Comparison between production and cooperation; sources: PASCAL, IDRIS, USAID, CCE

– There is a strong discrepancy between this map and the one indicating the distribution of manufacturing activities in Colombia. The case of Medellin, an industrial centre of major importance but with comparatively limited scientific production, stresses this separation.

International cooperation has a definite tendency to accentuate this concentration of scientific production. Cooperation and production are two variables that show a strong correlation (Fig. 4). The higher the concentration of publications, the higher the level of cooperation. The interdependence may function both ways: on the one hand, the visibility of the most productive centers in the large cities attracts foreign cooperation; on the other hand, the implementation of projects with foreign teams and agencies generates publications in international journals more easily. What seems clear though, in Fig. 4 is that production is less dependent on cooperation than the reverse: the small centers of scientific activity ("others") still produce eventhough the level of international cooperation is extremely modest; at the opposite, Bogota attracts almost 80% of international projects but does not produce to the same extent.
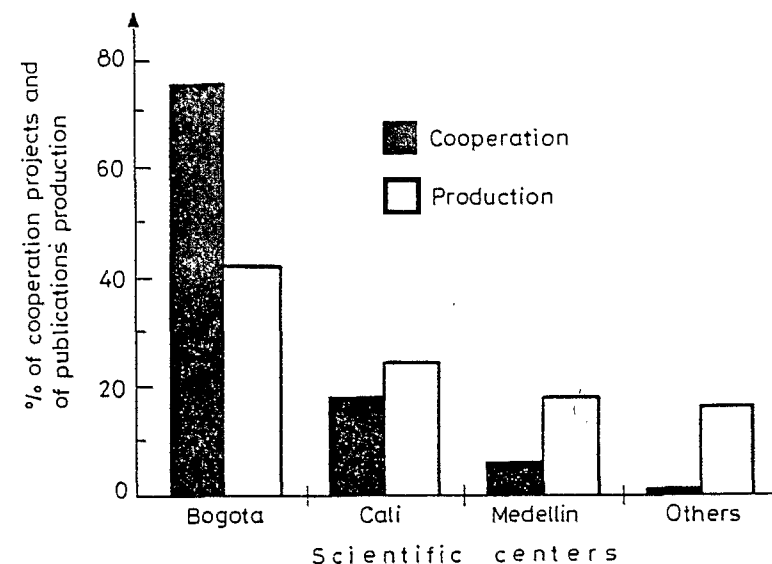
The concentration is not only geographic, it is also institutional. Distribution by research institutions shows a real contrast between a small group that produces comparatively a lot of publications and a multitude that produces few.

There are 140 distinct organisations which published at least one paper between 1987 and 1993. The five first of these represent 60% of the total. The leadership of the public sector over the private one is clear (Fig. 5).

It is in the traditional, state-run universities that the infrastructure has been built and the scientific disciplines have been institutionalized.[12] Also, the existence of the academic career in these institutions permits greater work stability and the guarantee of continuity in the ongoing research, thereby permitting the accumulation of knowledge, the creation of traditions, the conformation of stable research groups and, in general, a research infrastructure. This explains, in part, why it is these universities that contribute a significant percentage to national publications. The private universities, being more flexible and pragmatic in their search for funding and in the topics they research, tend to consider a research project completed when the final reports are presented, and do not seek to have these reports published. The career researcher who is working on a long term project finds a more propitious environment in the public universities.
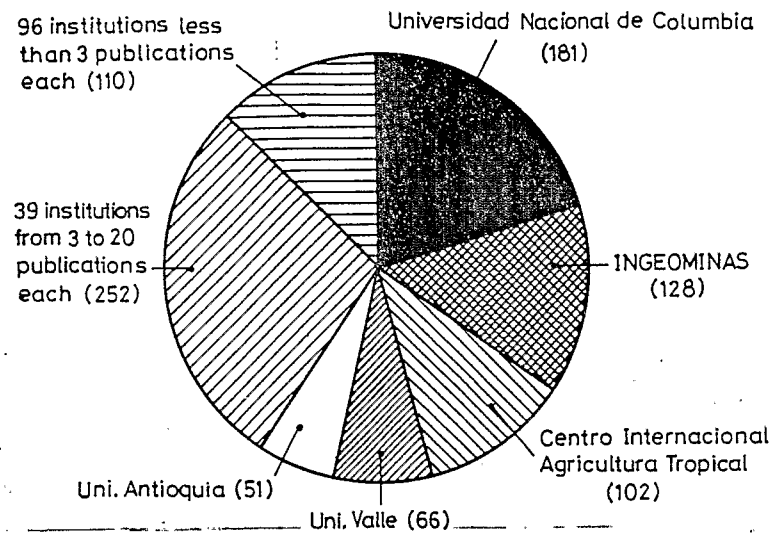
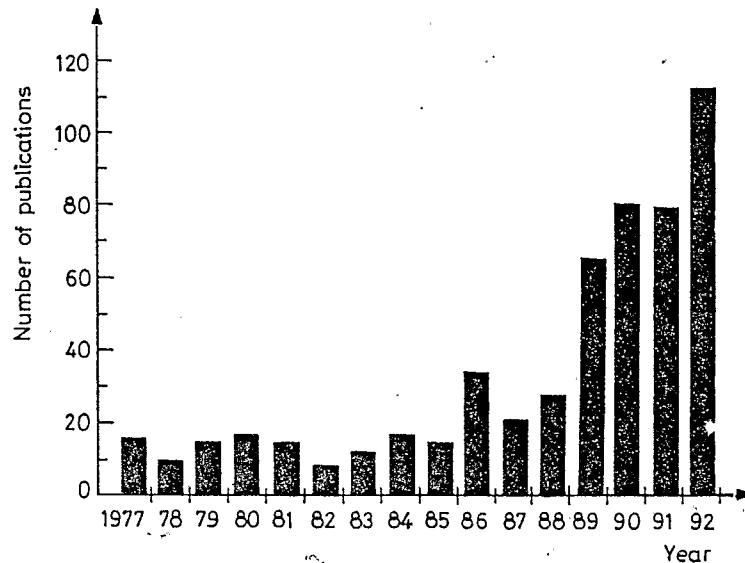Fig. 5. Scientific publications by institution; source: PASCAL

Fig. 6. Number of publications in international scientific reviews from researchers of the National University of Colombia; source: CINDEC

The increase in the number of publications can be explained by the change in strategy that makes researchers and their work more visible. The recent emphasis on evaluating academic activity through its productivity has indeed provided new incentives to publishing efforts. These were made possible by the formation and activities of research networks as well as the changes in standards at the international level. The case of the National University is a good example. The number of publications (journal articles, chapters in books, and books) outside the country in all disciplines, including science and technology, social sciences, humanities and arts, that were submitted in order to qualify for points for academic production, has seen an enormous increase (Fig. 6). In this way, the average has gone from 4 publications per year in the period 1971–1976, to 16.4 during the next five years, to 23.6 during 1982–1986, and to 78.6 during 1987–1991. In 1992, there were 169 publications. If we take into account only journal articles we observe the following figures: 1972–76, 2.8; 1977–81, 14.6; 1982–86, 17.6; 1987–91, 54.9. In 1992 113 journal articles were published.

This would also explain the level of participation and high profile within Colombian science of the state institution INGEOMINAS, which plays a pivotal role in the assignation of resources and for research on geological disasters done during the period referred to above. CIAT is an organization affiliated with international research networks in the field of agriculture and that would explain its high profile in that field.

The orientation of Colombian science

For its inspiration and dissemination, Colombian science is neither massively outward nor exclusively inward oriented. Three convergent indicators show that it is balanced between internal and external determinants: the disciplinary or thematic components, the places of dissemination of results or publication, the associativity with coauthors. Colombian science shows tendencies associated with the proper conditions of the country, that orient the research. This tropism manifests itself in a specific disciplinary composition (Fig. 7).

– Medicine is the most important academic field (322 publications) and also it is the most diverse (34 disciplines) with an emphasis on local pathologies (tropical medicine, immunology, clinical medicine).

– Earth sciences (259 publications) shows a comparative pattern: exploration of the Colombian territory and its pecularities (geological, volcanic, hydrological).

– Natural science (245 publications) are oriented toward problems related to population and rural economy (agronomy) as well as the discovery and study of plant species and tropical insects (phytopathology, phytogenetics, entomology, botany)

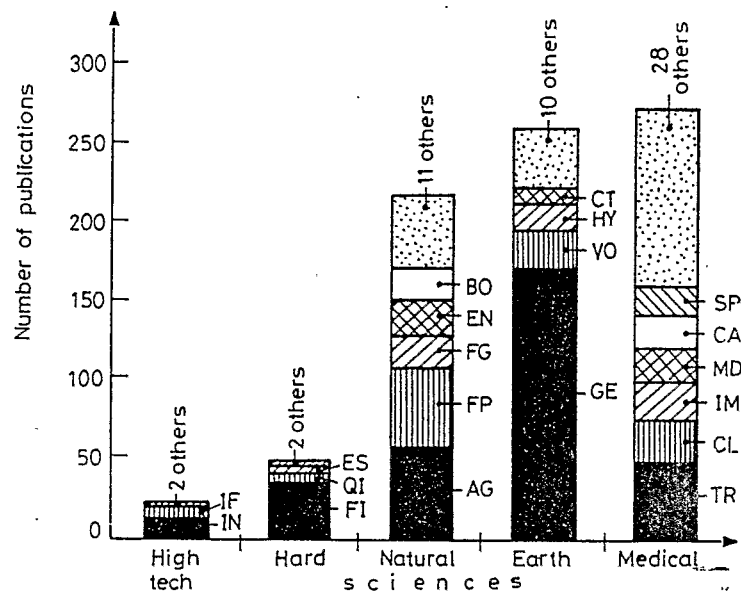– Pure sciences and technology are weaker, except for physics.

Fig. 7. Disciplines and topics of Colombian scientific publications; source: PASCAL

The tendency in Colombian science is toward questions that come up in the environment, though research resources needed to answer these questions are limited. This implicit strategy passes over some basic fields but it is a more adequate strategy than that seen in certain other developing countries whose research capacity is concentrated on specialties that are very removed from their real needs.

A relative majority (40%) of the research is published in Colombia. Practically none of it appears in the SCI North American data base although it demonstrates a significant national "scientific community" with the will and capacity to achieve the internal dissemination of information.
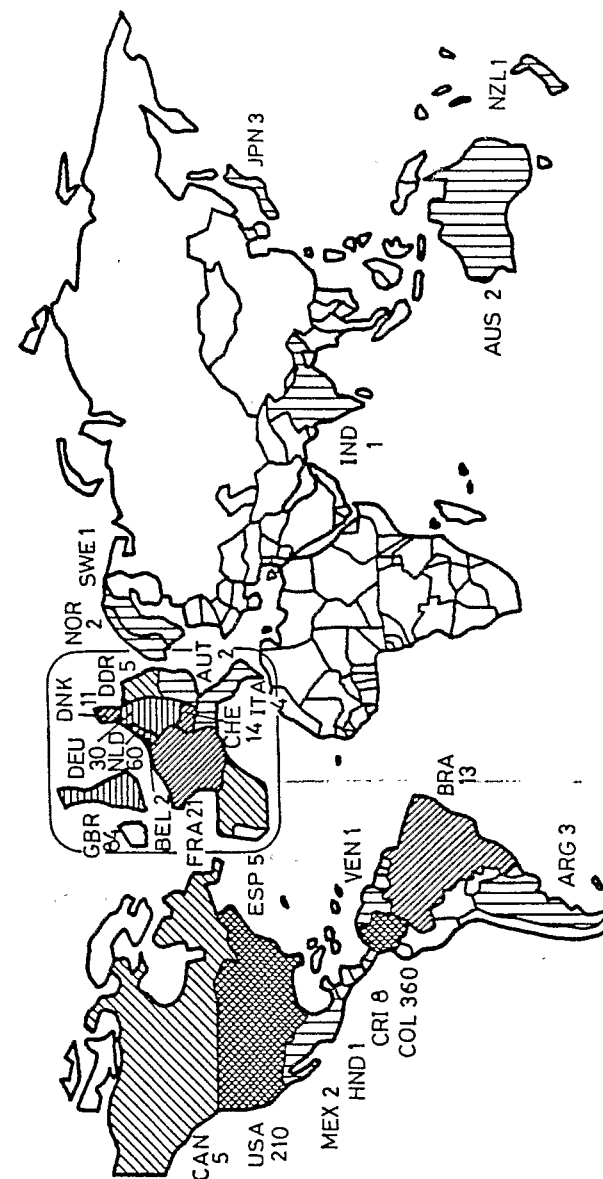

Fig. 8. Places of publication of Colombian scientific work; source: PASCAL

With respect to foreign publications, the journals of the United States are those which most attract Colombian researchers. If this phenomenon reflects the proximity and cooperative relations between the two countries, it is not an exclusive relationship: with their abundance and diversity, the North American journals publish papers from researchers from all over the world. Europe (AELE) also offers many possibilities and it total volume of "Colombian" publications (230) in more than that of the United States and Canada put together. This offsets the centrism of these two North American countries. The diversity in place of publication is interesting (India and New Zealand, for example) but the modest output from Latin America is telling: it reflects the embryonic state of cooperation with the sub-continent.[13] The language of publication underlines this phenomenon: English is the main language (445) while Spanish, despite the considerable number of Colombian publications, is second (412) which means there is little exterior dissemination in the Spanish-speaking world. French, German, Portuguese, and Italian are the language in only 28 publications.

The diversity of form (journals, conference papers, books, etc...) in which Colombians publish, is ample: 818 of the publications appeared in 303 journals, conference proceedings or books. Of these, 200 of the titles only published the work of a Colombian once during the 1987–93 period.

In the 818 publications, only 371 (45%) appear in the SCI database. Of the first, 445 (55%) were published in journals or more frequently in conference proceedings, inside the country. This observation confirms the relatively self-centered nature of Colombian science that is suggested by the distribution within the discipline.

Of the publications referenced in the SCI, the journals in which Colombians have published have a superior impact (1.186) over the world average. This means that although Colombia contributes only marginally to mainstream science in quantitative terms, its visibility is a little higher than the rough figures would indicate.

Table 1
Number of Colombian authors/publication

Publications with 1 author	269	30%
Publications with 2 authors	228	26%
Publications with 3 authors	175	20%
Publications with 4 authors	105	11%
Publications with more than 4 authors	120	13%
Total	897	100%

The majority of the scientific work in Colombia is published under collective authorship. Of every four publications, three have more than one author and at least half have two or more authors.

The publications comprised a total of 1460 different authors,[14] among which many of the names are apparently Colombian.[15] This shows a high level of intra Colombian scientific association which contrasts with the presumption that places emphasis on the association of Colombian scientists with foreign authors.[16] Above all, this contradicts the vision of an extrovert scientific community that is dependent on the exterior to orient itself, which was suggested by the supposedly high rate of international association.[17] In reality, this was an illusion caused by the SCI data base used in the studies. If one takes into account only mainstream international science and looks at Colombian authors and co-authors, one can observe a relatively significant proportion of research done in association with foreign authors. However one cannot conclude that this indicates a systematic policy toward the exterior, nor an orientation that dominates and affects all the scientific work undertaken in the country. In effect, by adopting another set of premises, one can look at the ample specter of published scientific research of primarily Colombian authorship, which is seen when one takes into account the "hidden" publications, local production undertaken in different collective associations.

Conclusion

This article introduces a perspective that changes the image of Colombian science, either determined by external factors or excessively inward oriented. The disciplinary and topical focus oriented on local problems and questions, the way the majority of the publications are disseminated within the country and the associativity of Colombian authors are three convergent indicators that suggest an internal dynamics of the development of an authentic scientific community. Without overlooking its weaknesses and limits, especially in comparison with other Latin American countries, there is a local potential with the possibility of taking advantage of the new conditions in order to generate greater scientific and technical development. With the current reflexion on Colombian epistemometric indicators for following and assessing such a process, within a few years we should be able to see how this promise becomes a reality.

Notes and references

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12. This situation may be compared to convergent results presented for other Latin American countries: Argentina, Brazil, Mexico, Venezuela. See: H. VESSURI, La institucionalización de las ciencias básicas en América Latina. Problemas y perspectivas, 1991, mimeo.
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14. To be compared with the figure of 4449 researchers, including social sciences, which do not appear here; source: ACAL, UNESCO, In: R. VILLEGAS, G. CARDOZA, *op. cit.*
15. These are definitely Spanish Latin American names; considering the low level of co-authorship in Latin America following N. NARVAEZ-BERTHELEMOT, (1992), *op. cit.*, we can logically deduce that the population which appears here is Colombian in its majority.
16. N. NARVAEZ-BERTHELEMOT, (1992) and (1993), *op. cit.*; R. VILLEGAS, G. CARDOZA, (1993), *op. cit.*
17. This would be 63.6% according to M. LECLERC, (1993), *op. cit.*