MISJUDGEMENTS AND SHORTCOMINGS IN THE MEASUREMENTS OF SCIENTIFIC ACTIVITIES IN LESS DEVELOPED COUNTRIES

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ABSTRACT

The bibliographic database widely used for measurement of scientific production (counting of publications) either for developed or developing countries is Science Citation Index. So then, only the contribution of each country to the "mainstream" of world science is evaluated. In the case of LDCs this contribution is negligible. The use of international specialized or multidisciplinary databases for the measure of eight LDCs production is presented, and the results are compared to those provided by SCI alone. Most of the specialized databases give more information than SCI for each country, as well as a great deal of data and features of each field that can not be possibly obtained by using SCI as unique data source. In the case of Cuba, Biosis and CA supply 17 and 15 times respectively as much information on Cuban scientific production in Biology and Chemistry than the SCI in the same period of time. The use of Cuban local database and its comparison with international ones is also discussed.

RESUME

La base de données bibliographiques utilisée le plus couramment pour mesurer la production scientifique des pays en développement comme des pays dévelopés est le Science Citation Index. Ainsi, seule la contribution d'un pays à la science "mainstream" est évaluée. Dans le cas des PED cette contribution est très faible. Ici nous présenterons les résultats sur la production de huit PED à partir de bases de données multidisciplinaires et spécialisées et nous les comparerons avec ceux de SCI. La plupart des bases de données spécialisées donnent plus d'information que SCI pour chaque pays ainsi qu'un grand nombre de caractéristiques de chaque domaine qui ne sont pas disponibles en utilisant le SCI. Dans le cas de Cuba, BIOSIS et CA offrent 17 et 15 fois plus d'information en Biologie et Chimie que le SCI pour la même période. L'utilisation d'une base de données locales et la comparaison avec les bases internationales est également présentée.

INTRODUCTION

The process of Science can be regarded as an input-output phenomenon, capable of being quantified. In general, input is much easier to measure than output, since all of its elements are tangible and input calculation does not require experience in science: manpower, financial resources, equipment, materials, buildings, etc. whereas the output of science consists of the knowledge generated during the research process, which is rather intangible and hence difficult to quantify directly.

It is very often assumed that the results of any research must have a close correlation with the investment made into the said research, and so input indicators have been used sometimes to estimate research results. However this assumption is very misleading. In fact, there is still no generally accepted system for output measurement, neither in terms of quantity nor of quality.

Nevertheless it is commonly accepted that the results of any research are worldwide diffused and made available to the scientific community by publishing them through established communication channels. Those publications generated during the research proccess, should represent the output of science. Consequently, the scientific level of any country is usually estimated by bibliometric methods measuring the output of its scientific activity using quantitative indicators based either on its scientific production (counting of publications), or on the worldwide diffusion of its publications (citation analysis, source quality, etc). All are "extrinsic" indicators easy to measure numerically.

Such traditional indicators are based on conditions and assumptions that are only relevant to industrialized countries where a very long tradition of scientific and technical activity exists, a well established information infrastructure and appropriate systems to collect reliable data are used, and where the "publish or perish" maxim is strongly enforced.

This is not the case with underdeveloped countries, which have very different conditions dealing with their severe social political, and economic problems. We should point out the "scientific isolation" or "island effect" that generally characterizes the status of science in the periphery. That means: lack of collaborative research projects with foreign institutions, dissemination of research results in local rather than in international journals, or through no conventional channels at all (internal reports, informal notes, oral discussions, etc., since researches are not rewarded for publishing their results), lack of information resources and absence of national bibliographies.

According to Frame (1), some of the facts that influence the tendency of LDCs to publish in local sources are: inability to write in English, the sense that local problems are not of worldwide interest, the urgency in certain research areas to solve critical problems and not to "waste time" in writing papers, and the lack of clerical support to assist in the writing of papers.

Gordon (2) examines the editorial evaluation of papers produced by LDCs authors and submitted to two prestigious physical journals during 1968-74. In

this period, authors from LDCs had their papers rejected more frecuently (57%) than authors from advanced countries (17%), not because their low scientific quality, but mainly for giving inadequate references to relevant literature, lack of clarity and excessive length of papers. This indicates the low level of awareness of current literature possessed by LDCs researchers, the lack of experience in gaining access to scientific information, and lack of document availability. On the other hand, it has been noticed that journals of developed countries mostly reject papers from Third World institutions (3), and even when those are published, a manifest tendency exists to refuse their citation or at least those papers are cited less frequently than their colleagues in the developed countries (4,5).

For these reasons, bibliometric evaluations when applied to LDCs, without proper modifications, often lead to inaccurate judgements, since it may appear that the scientific productivity of small countries is lower than it actually is, due to the current international communication and information systems which are strongly biased against less developed countries.

The Science Citation Index (SCI) database, owing to its multidisciplinarity, is commonly used as a unique data source for evaluating scientific literature in both production and diffusion aspects. So it has become a "classic" when conducting bibliometric studies.

It is the purpose of this paper to prove that scientific indicators obtained from specialized international databases, other than SCI, reveal the scientific development of each country more accurately, owing to their more comprehensive worldwide coverage, and the inclusion of a larger selection of local journals.

Specially the cooperative database AGRIS (International Information System for Agricultural Sciences and Technology) of FAO, for Agriculture, should be taken into consideration. It offers a quite comprehensive coverage of primary sources, both formal and informal, from peripheral countries since it belongs to a cooperative network between countries. One remarkable limitation is the tremendous delay in updating, at least for LDCs data (6,7).

At the same time national databases, when they exist, covering local journals only, are essential to achieve comprehensive data in bibliometric studies, since a high proportion of local documents does not achieve international diffusion.

1. USE OF THE SCIENCE CITATION INDEX AS EVALUATIVE SOURCE

Even though for impact measurements of scientific works, the SCI is the only worldwide source, as it provides citation frequency of all cited articles in its source journals, it is however inappropriate for the assessment of scientific production, mainly due to the following points: 1) In spite of its multidisciplinarity it includes only about 3200 "core" journals as source journals

regarded as covering the most significant research papers in the world ("mainstream" of world research). Each core journal issue is indexed comprehensively (cover to cover), 2) Usually developing countries' journals are excluded from the SCI, which covers less than 2% of the all LDCs journals, 3) SCI is strongly biased in favour of Anglosaxon journals, mainly from the USA, neglecting a great number of relevant periodicals from other countries and non English languages, 4) A great number of these journals belong to the biomedical field, disregarding other important areas, i.e. applied science and technology, 5) The SCI based evaluations ignore the works that are not published by conventional and formal journal channels (reports, patents, workshops, notes etc), which may be heavily used in transmitting scientific research among scientists from LDCs, and could be significant in research, particularly in applied sciences.

2. CONTRIBUTION OF LDC's TO THE "MAINSTREAM" OF SCIENCE.

In any case, the use of SCI as a bibliometric indicator will only be suitable for evaluating the contribution of each country to the "mainstream" of world science, and not to find out the total scientific production of countries (8). As a matter of fact, the underdeveloped countries' contribution to the "mainstream" of science is almost negligible (9), as is shown in the following data.

According to Garfield (10) and Frame (11) in 1973 (data from SCI) 90% of the world "mainstream" scientific papers came from Europe, USA, USSR and Japan, whereas the Indian contribution was 2%, Argentina 0,4% and Brazil 0,23%. In 1978, the scientific production of Argentina, Mexico, Chile, and Venezuela, altogether represented only about 1% of all published articles in SCI (12), whereas the USA generates 40% of all international scientific literature, obtains 60% of all citations, and the 80% of the world scientific literature was written in English (10).

These figures, based on SCI data, have remained without significant variations. In a more recent study carried on by Schubert (13) in 1981-85 period, it is deduced that almost 85% of all world scientific production is generated in the USA, Europe, USSR and Japan. In the said period, the contribution of Brazil to the "mainstream" of world science was 0,36%, Argentina 0,28%, Mexico 0,17%, Venezuela 0,07, India 2,64%, Taiwan 0,13% and Singapore 0,05%.

In spite of the above points about awkwardness, shortcomings and lack of adequacy for evaluating Third World science, SCI is widely used even in the less developed countries as a bibliographic database for publication counting to quantify their own scientific production (4,8,14,15,16,17,18,19,20,21). This method when used without supplementary information derived from other sources, supplies mistaken and false results.

Many bibliometric studies based in SCI database indicate that papers from peripheral countries covered by SCI have certain characteristics in common, which are:

1) Much of the research in developing countries pertains to the biomedical area (4,17,22,23,24).

2) Almost all the papers done in LDCs and covered by SCI are written in English and published in periodicals in the Western World (often in low impact journals) (4,23,24).

3) Most foreign journals come from the USA, UK or Netherlands, except in the case of Cuba, where journals from GDR and USSR are highly used (6).

4) A great number of papers from LDCs are rarely cited even if many of them have appeared in journals having impact factors greater than one (4,24). However, papers published in UK and USA journals have better citation records than those publised elsewhere.

3. INCONSISTENCIES IN THE USE OF SCI AS AN EVALUATION SOURCE.

Some inconsistencies can been observed when using SCI as an evaluative resource. For instance: much of the work done in areas such as tropical medicine and agriculture, public health, parasitology, soils (fertilizing and microbiology), tropical fishes biology, etc. is underrepresented in SCI (17,25). However, when using the French bibliographic database Pascal to establish the world bibliographic production in tropical soil sciences during 1983 (22), a considerable percentage (65%) of the 2040 retrieved references corresponds to research made in peripheral countries, showing that scientists from those countries play an important role in Agricultural Sciences as a whole, and in Tropical Agriculture in particular.

The analysis of 258 papers published from Singapore institutions and covered in SCI (1979-1980) (4), indicates than most of the research made belongs to the Medical field (48%), whereas Engineering reports only 11%. That research output does not match the Singapore national priorities in view of the Goverment's investment promotion and Economic Planning Organization that has choosen 11 industrial fields for prioritary promotion, among them: automotive components, machine tools, computers, electronic instrumentation, optical equipment, etc. Also Singapore has the world third largest petroleum refining centre and the second largest oil rig construction. Other major industries include ship building also.

These kinds of scientific and technical priorities agree with data given by the National Development Research Centre from Canada (NDRC) about research in small countries (26), which reports that, in 1987, the 72% of Singapore government funding was assigned to Engineering and Technology, whereas the Medical Sciences funding was of 13% and Natural Sciences 10%. It seems that

the research made in Engineering and Technology does not reach international diffusion through SCI as it originates internal reports or is published in domestic sources or in international ones not covered by SCI.

The same can be said about Agricultural Science, which as Engineering and Technology, does not fit in the concept of mainstream proposed by SCI, being a subject of more local than international interest. According to SCI none of the 25 journals of higher impact factor belong to Agriculture and none of the most cited papers from LDCs authors deal with Agriculture (25). That agrees with Velho (27) who shows that 85% of all Brazilian papers in Agriculture are published in local journals, and with our previous paper about Cuban productivity (6), where we demonstrate that the great majority of Agricultural subject papers are written in domestic journals.

A bibliometric analysis of papers published over a two year period (1979-1980) from the five ASEAN countries (Indonesia, Malaysia, Philippines, Singapore and Thailand), and covered by SCI (24), reveal than those countries have the largest number of papers published in medical journals. In Philippines, Medicine comes on second place very close to Agriculture. Taking into account that the International Rice Research Institute (IRRI) is located in Manila, it seems quite probable that the number of agricultural research publications were greater than those supplied by SCI. It would be useful to verify this feature in local or specialized databases.

In a study by Schubert (13), data from 45 different developed and underdeveloped countries having at least 50 papers published in SCI in five major fields (Life Sciences, Chemistry, Physics, Engineering and Mathematics) during 1981-1985 period were presented. It was revealed that the scientific effort of the great majority of countries was conducted mainly in the Life Sciences field: 27 countries have published more than 50% of papers in the said field; 11 of them have devoted the greatest percentage of research to Life Sciences (between 35% and 50% of all papers), and only 6 countries afforded a greater percentage of publications in any other fields as Chemistry, Physics, etc. These figures certify the lack of data provide by SCI for analysing any matter not included in Life Sciences field.

The use of SCI as bibliographic database for publication counting might produce misleading results mainly for LDCs where an increasing amount of their research is dedicated to national needs, and its results are disseminated in non conventional ways (other than those used in developed countries). For that reason a high proportion of local documents fail to become part of the science mainstream and do not gain international acknowledgement at all, so they remain as "grey literature".

4.SCIENTIFIC EVALUATION USING DIFFERENT DATABASES: COMPARISON OF RESULTS

A large percentage of LDCs research results are published in relevant international journals, not covered by SCI, but by other prestigious specialized or multidisciplinary databases. Those results will achieve international visibility.

With the aim of obtaining information about the possible differences in scientific productivity of each country by counting retrieved references from SCI in comparison with other databases, searches in SCI, Chemical Abstracts (CA), BIOSIS, INSPEC, CAB and EXCERPTA MEDICA during the period 1985-1989 were made, in order to find the scientific productivity of a total of 8 countries, chosen at random between those considered as less developed (Table 1).

Table 1. Papers from eigh LDCs retrieved from different databases (1985-1989)

	SCI	CA	BIOSIS	INSPEC	CAB	EXCERPTA
Singapore	2370	1131	2116	1054	316	1328
Taiwan	6994	7008	5692	4099	2282	3042
Perú	509	102	455	20	421	151
Brazil	13469	8323	4289	3788	9081	4785
Nigeria	4610	1910	4645	639	3762	2377
Kuwait	1711	674	1177	390	193	972
Malaysia	1279	455	1506	272	644	574
Cuba	534	1265	2117	205	2529	551

SCI covers papers in any scientific field which have been published in about 3200 journals of considerable scientific standing. CA, BIOSIS, INSPEC, CAB and EXCERPTA, all more specific in subject (dealing with chemistry, biology, physics, agriculture and medicine respectively), are, however, more comprehensive in journal coverage than SCI (CA covers 13.000 journals, Biosis 9000, Inspec 4000, CAB 10.000 and Excerpta 3500 journals), although not all original papers in those journals are processed, since a previous selection of their papers is made by each database.

The SCI search was performed in the SCI CD-ROM version, hence nearly 3000 journals of Current Contents, which are added to the SCI online databases, were excluded. All other databases searches were performed on-line through Data-Star and ESA/IRS hosts. All on-line and CD-ROM searches were performed according to the same strategy by locating the country name in the field "corporate source", and limiting that set to the studied years.

In spite of its specific subject area, CA gives much more bibliographic information than SCI at least for Cuba, and quite similar for Taiwan. BIOSIS gives more information in the case of Malaysia and Cuba, and quite similar in the case of Singapore, Nigeria and Peru. CAB provides more references in the case of Malaysia and Cuba and similar number in case of Nigeria. EXCERPTA offers more documents in the case of Cuba.

In a bibliometric study promoted to establish the worldwide scientific productivity in the field of sugar cane by products, (1983-87) (7), it was proved that Cuba is the world leader according to number of scientific publications in that subject (128 papers), followed by Brazil (115 papers) and US (93 papers). The results agree with those mentioned by Ubell (28): "In some applied areas; for example, sugar cane by products research, Cuba has jumped to world leadership". To obtain these figures eight international databases had to be used, due to the multidisciplinarity of the subject (CA, BIOSIS, PASCAL, COMPENDEX, FSTA, AGRIS and SCI) as shown in Table 2. 1) CA, BIOSIS and AGRIS, give more information than SCI; 2) all databases other than SCI produce references in any other document types, being remarkable CA in patents and AGRIS in dissertations, congresses and reports, etc. 3) all SCI references were overlapped among other databases. In this report it was also revealed that the Spanish language is the second most widely used (16%), after English (65%), to publish this kind of research.

Table 2. Sugar cane by products (1983-1987). Pertinent references according to data bases and document type

Database	J.	C.	B.	R.	P.	D.	Total
AGRIS	90	34	2	44	-	27	197
BIOSIS	165	14	2	-	-	-	181
CA	272	6	1	5	36	4	324
CAB	109	13	5	16	-	3	146
COMPENDEX	90	2	3	-	-	-	95
FSTA	37	6	2	-	3	-	48
PASCAL	121	21	2	2	1	1	148
SCI	173	-	-	-	-	-	173

J = journal; C = congress; B= book; R = report; P = patent; D = dissertation.

5. SCIENTIFIC EVALUATION USING SPECIALIZED DATABASES

The specialized international databases when used for evaluative purposes, can lead to more deep inquiries and accurate conclusions, since they reveal a great

deal of data and features of the field that could not be possibly obtained by using SCI as a unique data source, as it is presented in the following examples related to Chemical Abstracts database.

According to the Cuban Chemical literature it is shown (6) that the Cuban papers retrieved in CA, 33% correspond to Biochemistry sections, followed by Macromolecular Chemistry (23%), Physical Chemistry (20%) and Applied Chemistry (19%). The limited extent of Cuban research published in Organic Chemistry (4,5%) is also to be noted.

In another bibliometric study (29), Cuban research in Chemistry through Chemical Abstracts database, during 1985-87, was reported. 737 references were retrieved. It was shown that Cuba is making its research effort in the subjects related to the following CA sections: Industrial Carbohydrates (sect. 44), Cellulose, Lignin, Paper and other Wood products (sect. 43) and Food and Animal Nutrition (Sect. 17 and 18). The percentage of Cuban papers covered by CA in said sections is very much higher than the world average. So Cuban Activity Indexes are: in Industrial Carbohydrates subfield 147,5; in Cellulose, Lignin and Paper subfield 13,3 and in Animal and Human Food 3,9. (Table 3).

Table 3. Cuban scientific production in CA (1985-1987)
Most studied CA subjects

CA Section	N. Papers	% Cuba (85-87)	% World (85)	AI*
Industrial Carbohydrates	132	17,7	0,12	14,5
Cellulose Lignin, Paper	60	8,0	0,6	13,3
Animal & Human Food	76	10,2	2,6	3,9
Industrial Biochemistry	35	4,7	2,7	1,7

* Activity Index = The given field's share in the publication output/ The given share in world publication output

6. SCIENTIFIC EVALUATION USING LOCAL DATABASES

In the case of Cuba its own database, a multidisciplinary publication (Revista de Información Científica y Técnica Cubana, RICTC), which encloses the most relevant Cuban journals, has been taken into consideration with the purpose of detecting the Cuban scientific production published in national journals. 9319 papers were retrieved (Table 4). None of those papers could be retrieved by SCI, since no Cuban journal is included as source journal in the said repertory,

however, most of those papers are able to be retrieved from CA, BIOSIS, INSPEC, etc. since some Cuban journals are included in said databases. As seen in Table IV, 60% of all Cuban papers published in local journals corresponds to Medicine and Agriculture.

Table 4. Subject and chronological distribution of Cuban papers retrieved from RICTC

	1985	1986	1987	1988	1989	Total	%
Medicine	577	337	544	713	735	2906	31
Agriculture	395	309	617	756	606	2647	28
Engineering	437	215	265	365	295	1577	17
Chemistry	196	125	191	427	118	1057	11
Biology	39	72	55	369	208	743	8
Geology	3	3	12	74	74	166	2
Mathematics	56	24	15	17	6	188	1
Physics	15	20	14	24	26	99	1
Total						9319	

7. SUMMARY

In summary of the above said, to accomplish evaluative assesments of LDCs scientific activity dealing with publication based indicators, the following points must been taken into consideration:

1- The use of SCI multidisciplinary database for publication counting, will supply data only about the contribution of each country to the "mainstream" of world science (often insignificant data in LDCs)

2- The use of other specialized or multidisciplinary international databases will give a bigger amount of publication data coming either from international or local sources not covered by SCI. At the same time further aspects of each specialized field have been analysed.

3- The use of national databases providing access to local literature, will retrieve documents that otherwise would remain unknown (grey literature).

As an example, by comparing SCI Cuban papers by subjects (Table 5), with Cuban data from CA and BIOSIS (5), it has been noticed that: 1) The 74 and 123 references retrieved by SCI in Chemistry and Biology represent the Cuban contribution to the mainstream of world science in those two fields; 2) CA and BIOSIS provide fifteen and seventeen times more information than their equivalent chemical and biology SCI subjects, in the same period; 3) CA and Biosis provide more information about Cuban research than RICTC itself. This fact evidences that Cuban scientists in these fields publish more papers in international journals than in Cuban ones.

On the other hand, total overlapping is produced between SCI and CA and BIOSIS (no more than 74 and 123, of course), some is produced between CA and RICTC and Biosis and RICTC, and no overlapping at all is produced between RICTC and SCI since no Cuban journal is covered by SCI.

Table 5. Cuban scientific production (1985-1989) Number of references retrieved in Chemistry and Biology fields using different databases

Fields	Databases			
	SCI	CA	BIOSIS	RICTC
Chemistry	74	1265		1057
Biology	123		2177	743

CONCLUSION

The scientific productivity of the LDCs is considerably higher than the estimated by conventional ways. A great amount of their scientific literature remains unknown (grey literature) to the rest of the scientific community, because it is not covered by international databases, since the greatest research effort in LDCs is dedicated to local necessities, and its results are published mainly in domestic sources. That kind of significant research will never be detected since it is at no time promulgated outside of the narrow circle of local scientists.

For the above reasons, the following points are recommended:

1. The creation of national databases where all local literature is collected.
2. The promotion of cooperative databases like AGRIS for Agriculture or LILACS for Biomedicine.
3. The use of databases other than SCI to obtain references to LDCs publications.
4. The formation of information networks between peripheral countries and between peripheral and central ones, in order to avoid the "island effect", and to improve the sharing of resources within regions.
5. The development of new reliable scientific indicators capable of reflecting the real scientific effort of the Third World countries more in accordance with their special characteristics.

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