COLLECTIVE INDICATORS AS ALTERNATIVES FOR SCIENCE AND TECHNOLOGY MEASUREMENT IN DEVELOPING COUNTRIES

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ABSTRACT

This article adresses the questions arising from the assessment of the scientific performance of developing countries in terms of available indicators. Various alternative indicators measuring the contribution of science to the nation are proposed.

RESUME

Cet article examine les problèmes que pose l'utilisation des indicateurs conventionnels pour mesurer les performances scientifiques des pays en voie de développement. Des indicateurs différents sont suggérés qui tenteraient de mesurer la contribution de la science dans le contexte d'un pays donné.

INTRODUCTION

Citation based indicators that are used for the evaluation of performance of science and technology (S&T) are only measuring what is measurable rather than what is valid[1]. The limitations of citation counts for measuring quality as well as performance of developing countries are now well known. Various alternatives have been proposed (the immediacy index, the affinity index, the openness index)[2], which would permit the assessment of developing countries without having to use exclusively the citation data base (SCI). Our experience in India is that the Indian journals which are poorly represented in the SCI, are definitely in a better position when they are evaluated with these others indicators. We have notices that Indian journals have high values for the openness indicator and high affinity index for others journals in the same field.

However, these indices do not measure all the moral and ethical dimensions of the scientific endeavour, since they most often imply that science in the developing countries is a mere appendice of the mainstream countries[3]. This difficulty is particularly apparent when using evaluation based on the SCI, because of its limited coverage of local journals, at the micro-level.

CONTRASTING MICRO LEVEL VS. MESO AND MACRO LEVEL INDICATORS

Vinkler[4] has proposed the micro, meso and macro level as reference standards for examining the S&T performance, based on the individual, the theme and the organisation as a whole. At the micro level, the developing countries have a low impact on the scientific activity of mainstream countries. However this does not mean that S&T originating from these countries with low "impact factors" have no relevance to the advancement of knowledge. There can be other, social, ethical and behavioral patterns which are also responsible for such a situation. If one now turns to the meso or macro level, the picture is not as alarming as it appears at the individuals level.

TABLE 1. PUBLICATION DATA OF THE NATIONAL LABORATORIES OF INDIA (1988)

Lab	Paper	IF	Avg. IF	SCI	NSCI	Ratio	Indian	Foreign	Ratio
CBRI	8	2.181	0.273	5	3	1.667	2	6	0.333
CCBM	26	32.690	1.257	25	1	25.000	11	15	0.733
CDRI	172	102.214	0.594	117	55	2.127	88	84	1.084
CECRI	133	19.482	0.146	10	117	0.081	120	13	9.231
CFRI	35	12.758	0.365	11	24	0.458	23	12	1.917
CFTRI	100	49.145	0.491	72	28	2.571	44	56	0.786
CLRI	42	35.463	0.858	42	22	1.909	27	37	0.730
CSMCRI	64	54.924	0.858	42	22	1.909	27	37	0.730
IICB	60	78.909	1.315	55	5	11.000	17	43	0.395
IICT	120	91.086	0.759	96	24	4.000	44	76	0.579
ITRC	130	63.326	0.487	87	43	2.023	57	73	0.781
NAL	39	15.164	0.389	26	13	2.000	15	24	0.625
NCL	153	113.492	0.742	130	23	5.652	32	121	0.264
NPL	144	101.355	0.704	107	37	2.892	56	88	0.636

The output of chosen institutions from developing countries have been examined by a number of authors in the past. For example Garg and Rao[5] have examined the scientific productivity of an Indian Physics Laboratory and have shown that on the whole, the scientists of this laboratory publish a large portion of their papers in international journals, and some Indian journals, all covered by the SCI. This situation is not true of this laboratory alone, The data pertaining to the National chemical laboratory of India shows that 70 to 75% of their publications are in journals covered by the SCI. This is the situation of various leading laboratories in the country. Table 1 shows the data for various national laboratories of India to substantiate this contention. It may seem ironical that the scientific output of indian laboratories is not available for Indian journals. An analysis by Krishnan and Viswanathan[6] reveals that the leaders of Indian Science, fellows of the academies and members of editorial boards of Indian journals, publish the bulk of their work in international journals, so that communication of science among Indian scientists takes the circuitous route of international journals. The impact factor per paper of the Indian national laboratories is given in Table 2.

TABLE 2. PUBLICATION DATA AREAWISE FROM SELECTED NATIONAL LABORATORIES (1987 DATA)

PHYSICS Laboratory	Total no. publications	Total IF	Avg. IF
CECRI	3	1.502	0.50
CEERI	4	2.925	0.73
CGCRI	16	11.730	0.73
CLRI	4	8.732	2.18
CMRS	3	4.997	1.66
CSIO	4	1.301	0.33
IICB	1	3.300	3.30
NAL	10	7.296	0.73
NCL	30	26.934	0.90
NEERI	5	1.699	0.34
NPL	84	41.716	0.50
CHEMISTRY			
CCMB	2	0.798	0.40
CDRI	40	22.745	0.57
CECRI	78	19.221	0.25
CFRI	23	2.323	0.10
CFTRI	7	7.680	1.09
CLRI	66	15.282	0.23
CSMCRI	14	16.110	1.15
NCL	81	70.581	0.87
IICT (RRH,H)	62	65.413	1.06
RRL (Jt)	17	14.542	0.86

It can be seen that the average impact factor for most of these laboratories are higher than that of any Indian journal. It is thus apparent that, at the meso level, Indian laboratories are in no way lagging behind and that their performance is not as poor as the one reflected by the impact factors of Indian journals.

Another useful and relevant measurement of S&T performance can be -also at the meso level- through the analysis of a specific area or sub-field of science and technology. Data are given in Tabes 2 and 3. As can be seen, the performance is much higher than results revealed at the micro level.

TABLE 3. PUBLICATION DATA OF THE NATIONAL LABORATORIES (1987 Data)

Area / Subject (field)	Total	Total IF	Avg. IF
PHYSICS			
Acoustics	10	1.593	0.16
Astronomy & Astrophysics	2	0.203	0.10
Crystallography	5	3.369	0.67
Material science	53	34.189	0.64
Optics	9	5.458	0.61
Physics	21	7.370	0.35
Applied Physics	26	20.526	0.79
Atomic, Molecular Physics	7	14.363	2.05
Condensed matter physics	19	28.786	1.51
Spectroscopy	1	1.700	1.700
TECHNOLOGY			
Biotechnology & Applied microbiology	21	16.207	0.77
Computer and Cybernetics	9	3.729	0.41
Chemical engineering	47	23.416	0.50
Civil engineering	21	12.947	0.61
Material science ceramics	26	8.129	0.31
CHEMISTRY			
Chemistry	43	24.210	0.56
Analytical chemistry	16	17.528	1.10
Applied chemistry	90	13.700	0.15
Inorganic chemistry	10	11.344	1.10
Organic chemistry	135	128.456	0.95
Physical chemistry	26	40.145	1.54
Electrochemistry	68	11.273	0.16
Energy & Fuels	38	8.203	0.22
Polymer science	26	18.925	0.73

Rather than considering the individual publications one should therefore use groupe and total publications to evaluate India's performance. Additionally, in the case of developing countries, one should look at the citation from a different perspective. One should consider the citations received for the knowledge generated within the country itself since its relevance is higher. If one examines the "self-citation" of a country by researchers of that same country, one would see that India is not unfavorably situated. This may not show the impact of the information that is generated but certainly reflect the consistency of the research activity. The analysis would thus take into account the fact that the developing countries cannot afford to wither away their resources in fashionable and frontier areas without maintaining a continuity in the research efforts.

At the macro level, an appropriate and valuable indicators for evaluation the S&T performance could be the doctoral dissertations submitted to the various institutions/universities of the country. In fact, this would cover an important portion of the scientific effort in any country. The data pertaining to doctoral dissertations in natural and applied sciences submitted to 100 or so institutions/ universities in India are given in Table 4.

TABLE 4. DATA ON THE DOCTORAL DISSERTATIONS SUBMITTED TO THE INDIAN UNIVERSITIES

BRANCH	1980-81	1983-84	1984-85
Agriculture	500	691	576
Animal Husbandry	98	144	153
Anthropology	20	11	16
Astronomy	14	14	9
Biochemistry		127	110
Biology	75	36	54
Botany	389	442	382
Buildings			1
Chemistry	768	792	687
Earth sciences	142	148	131
Engineering	227	277	261
Environmental sciences		101	57
Forensic sciences			2
Mathematics	267	277	261
Medical sciences	243	263	227
Microbiology		38	30
Paleontology	6	11	8
Physics	270	357	304
Technology	110	110	94
Zoology	422	368	345
Total	3551 (105)	4213 (107)	3698 (112)

The data show that Indian Scientists and Technologists are active almost in all areas of research and as is true in the case of all countries, India is strong in some specific areas. The reasons for these choices should be traced down to the traditions left behind by individual scientific leaders as well as the necessities and requirements of the community.

A RESEARCH PROPOSAL

Science in developing countries is mostly or heavily dependent of the individual's efforts though the collective system seems to sustain this activity. This may be also true for developed countries. The generation of a scientific community rests also upon some individuals whose inspiration, dedication and motivation permitted to create a research group. This group usually appears to have set traditions and some particular behavioral patterns without much lateral interactions with other groups for various social and cultural reasons. Maybe this is also the reason why performance at the micro level in developing countries seems to be difficult to evaluate or even if it is done, the result is not encouraging.

One way of circumventing these effects would be to trace a growth tree with respect to a particular group or to a particular domain, and evaluate the impact of findings on the subsequent efforts within the group or area of research within the country. This method of evaluation would overcome the shortcomings normally associated with the non-availability of information. This normalization procedure would also have the following advantages:

1. It would be capable of reflecting the intrinsic values of a given scientific community though it would not evaluate the relative standard of this community on a global scene.
2. It would be, at least theoretically, possible to construct indicators measuring activity, productivity, progress, quality, importance or impact for those limited situations. These indicators would be of course highly site specific, but at the same time they would allow an evaluation of that specific community in relation to the needs of the country as well as in relation to the pursuit of the particular goals of this group.

The scientific effort in developing countries very often centers around certain leaders in science who, because of their peculiar position and status in society, can form, sustain and nurture a scientific community around them. Evaluations are thus necessary at this level: in India, for instance, the performance of the communities grown by these leaders of science would probably raise better results than the overall performance of the country. These groups are still in a state of insulation with respect to other scientific groups in the country. Arunachalam and his co-workers[7] have shown an intellectual "island effect" which is a common feature in middle level and peripheral countries. Science published in national journals are insular and make very little cognitive contribution to the rest of the world. This insulating effect can be seen through the maps showing the interactive cooperative links in science. These maps contain some principal and regional clusters of countries with strong links: USA, Western Europe and Canada. More moderate links appear with European countries, USSR, Australia and New Zealand. Countries like India, South Africa, Brazil, Argentina and Chile do not seem to be linked to any of these principal countries. There exists a sort of seclusion either imposed, or internally developed.

This isolation must be taken into account when evaluating science on the basis of citation counts. Konrad and Wahl have recently advocated for some collective indicators for developing countries in terms of generativity, potential and receptivity to absorb scientific results. They proposed a procedure in order to obtain suitable quantitative measures for these three indicators for 30 countries and a socio-economic database. This method of computation, highly desirable, still lacks some important aspects like the relevance and need for S&T activities for the country and whether these efforts are in tune with the local scientific tradition.

It would be worthwhile to create some indicators based on the scientific tradition of the country as well as the existence of specialized skills. However one could argue that there are no input parameters available. One could investigate those aspects by means of perceptual indicators on the capacity to generate suitable human resources, the capacity to provide a suitable infrastructure for science and scientific education, the capacity of industry to rapidly transform the results of R&D into production and the capacity of society to be informed on the scientific activities. These four questions could well be measured by perceptual indicators in the case of developing countries.

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