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S&T Academic Indicators for developing countries

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***Abstract*—S&T decision making will be more meaningful if it is based on reliable information based on indicators of social and economic impact. Although there have been advances in developing S&T impact indicators, there is still work needed to clearly correlate academic achievements with economic and social advances for the common citizen. In this paper, indicators available at present shall be discussed and the necessity of developing new methodologies is focused on.**

Keywords— Academic Indicator; S&T; Evaluating; Developing Countries

I. INTRODUCTION

Countries and regions which recognize the value of higher education and the value of S&T are the ones playing a leading role in global development. These countries have been investing important economic resources for becoming active participants in the new "Knowledge Age." This Age is essentially characterized by an intensive use of knowledge as well as trade in goods, processes, and services of high added value. The best way to reduce the gap between under-developed and developed regions would be to increase investment which promotes education, research, technological development, innovation, and industrial competitiveness. This strategy will stop under-developed and developing countries from being mere minor players in the transfer of technology [15].

Decisions for allocating financial support for Educational and S&T policies are based on several indicators, each of which should provide reliable information in such a way that money goes to the right people in the right places. For under-developed and developing nations there is not a unique and standard description of their Higher Education system dimensions. Moreover there is not enough information about researchers, engineers, and other professional people. This difficult situation is not made any easier by a paucity of specific data describing the S&T sector. Therefore, a lack of information about Education and S&T data could hamper the establishment of adequate strategies and policies related to innovation and competitiveness [1].

In order to justify governmental investment in S&T, it is especially important for institutions spending public resources on scientific activities to have reliable indicators [5]. Nevertheless, according to Kostoff [8], there are obvious discrepancies between research impact evaluation methodologies and their respective social contexts.

The present paper pursues two objectives. The first relates to concerns about the necessity of possessing organized data as indicators and their use for implementing decisions making policies. The second is to show the necessity of developing other research impact measures in order to recognize the way S&T impacts on social, economic, cultural and environmental issues.

II. S&T INDICATORS

Indicators represent in a quantitative way S&T achievement levels and trends, and also evaluate the impact of resources as these apply to our research efforts [11]. It is of course essential for every country to measure its innovativeness precisely, in order to have sufficient valid information for appropriate decision making. Since the early 1960s, the Organization for Economic Cooperation and Development (OECD) has been constructing a conceptual and methodological system that can appropriately select and measure S&T information. The OECD has also been working on updating and tailoring indicators methodologies used according current situations.

S&T indicators were compiled taking into account research conditions and the economic environment of developed countries. But for under-developed and developing nations, these indicators may not be completely pertinent because they do not take into account the main problems of an underdeveloped society: dependence on transnational technology, citizens unsatisfied needs, poor quality of life, reprioritization of S&T, among others. Furthermore, according to Martinez and Albornoz [10], the use of S&T conventional information could be counterproductive for, for example, Latin-American countries, producing inappropriate policy outcomes and creating S&T administration structures and monitoring processes which are self-defeating. OECD indicators may therefore not be the best way to reflect S&T real conditions everywhere and under all conditions, even though they might be used and accepted all over the world for national and international S&T reporting.

III. CRITERIA AND CONSIDERATIONS

S&T activities are evaluated taking into account, systematic activities which are closely related to production, progress, promotion, diffusion and application of S&T knowledge. They include technological research and development, scientific and technological education and instruction, and scientific and technological services. So the information gathered is related with per year:

- S&T expenditures.
- S&T expenditures as a percentage of Gross Domestic Product.
- S&T expenditures by sector of performance.
- S&T expenditures by source of funds.
- S&T expenditures by source of funds.
- Human Resources (researchers and administrative staff) in S&T.
- Research and Development personnel by discipline.
- Persons completing Graduate studies by academic level and discipline.
- Publications (considering only scientific indexed articles).
- Citations (researchers citations in international databases).
- Patent applications and granted per year and per nationality.

All the above mentioned indicators, do not take into account the real social impact. This impact, of prime importance for developing countries, where it is especially sensitive the issue of considering academic research as "academic luxury". So two additional indicators are proposed. .

- Theses: the annual amount of thesis publication, especially those written to gain masters degrees and doctorates, as a good reflection of the academic and research work developed within an Academic Institution and its impact inside scientific and technological education and instruction.
- Research projects: this indicator shows types,1 disciplines, and quantities of research developed within an Academic Institutions and its internal and external impact. It could reflect S&T research and development, liaison with real problems of society

Iς. OUTLOOK

The academic indicators are well recognized within S&T fields because their methodologies have long enjoyed international acceptance and usage. However, there is a lack of a specific indicator relating engineering activity, technological output, and economic benefit by measuring accurately the social, educational, cultural, environmental, and commercial impact(s) of engineering researcher.

Currently, there is threefold approximation of such a specific indicator that is, those related with S&T investment, human resources, and scientific production indicators. These latter three indicators give an indirect and incomplete measure of relationships between S&T activities and socioeconomic advancement, as might be the case of Latin-American countries. This is not to suggest that those three existing indicators can somehow be replaced by one super-indicator. In the future, by further refining statistical evaluation of raw research output data, it will hopefully be possible to synthesize indicators which are more sensitive to the evolutionary complexities of technology and its generation in developing nations, including Latin-American societies..

The information gathered by those indicators may suffice for decision making within the context of developed policies. However, in the case of so-called under-developed and developing countries, one must give particular consideration to the fact that technological development and concomitant innovations are completely dependent on incremental modifications of adaptations of national S&T infrastructure using foreign technology. This transnational predetermination of S&T effectiveness is inadequately accounted for in the current international set of performance indicators. Cutting edge S&T advancements surelydepend on guaranteed and immediate access to cutting edge material infrastructure which latter enables the former.

In order to maintain a semblance of international competitiveness, the authorities governing research in under-developed and developing countries are making with the internationally accepted indicators, to ascertain performance and value. Nevertheless, it is necessary to consider local limitations, local advances, local and/or international impact, and the challenges researchers shall confront in its environment. This will enhance the realism of technological goals and the policies designed to pursue and/or facilitate them, thereby hopefully benefiting each respective society as a whole.

Publications and citations indicators have a distinct disadvantage for under-developed and developing countries. Databases used for compiling these kinds of indicators only take into account a limited sample of journals from under-developed and developing nations, so research from these countries is bound to end up being underestimated internationally. Nor are patents completely adequate as indicators of S&T performance, if one is going to take into account the fact that a lack of material resources for facilitating work in the area of technology disadvantages those countries whose economies are not thriving. Further the commercial-industrial sectors of under-developed and developing economies are far less willing to participate in investing in imported technologies because that is not in their direct commercial interest. They would rather protect their stake in less advanced industrial practices.

The two additional academic output indicators mentioned above, can have greater utility when it comes to evaluating the S&T impact of universities in the areas of technological research and development, education and training in science and technology, and the scientific-technological service sector.

These additional output indicators are the production of theses and the conduct of research projects. Data for both these indicators is accessible for easy compilation and analysis. Also, the particular advantage of both indicators is their facilitation of quantitative comparisons between universities in under-developed and developing countries.

Using these indicators will produce a more realistic performance profiles and compensate for the disadvantaging of such countries in the registration of articles in scientific journals. Hopefully, incorporating both indicators into performance profiles will mean that fewer universities in under-developed and developing countries will seem to have been left behind in the academic performance race. Detailed reference to these indicators enables one to monitor the following aspects of S&T performance: the activities of researchers; the contribution of specific disciplines; the efficiency of work teams and/or research processes and/or disciplinary categories; the sectors of performance; the commercial enterprises involved; the impact on society and productive sectors.

ς. CONCLUSIONS

In general, S&T expenditure, staffing, and bibliometric parameters are acknowledged measurements of academic impact. Nevertheless, a more refined methodology is needed to calculate the real impact of S&T on a society and its sectors of production.

Accordingly there is value in continuing to work towards identifying and applying easy indicators that give a more accurate account of investment in S&T resources, economic benefit, improvements in the quality of life, which latter involves socio-economic sectors such as education, culture, the environment, to name only a few.

Meaningful and useful diagnostic evaluation of S&T's socio-economic impact(s) must be recognized as central to processes designed to solve social problems, as these abound in under-developed and developing countries, in particular, as opposed to processes that merely remain part of the problem.

More effective evaluation of the impact of S&T research would provide a mathematical basis for the formulation of socially effective and/or materially beneficial objectives and goals, that would lead to meaningful assessment of S&T performance and its repercussions for the societies in which it occurs. Calculations could also be used to analyze and/or diagnose past performance and current conduct of research, which would naturally provide insights for defining research goals in the future.

Perhaps most importantly, if there was empirical evidence of the value of science and technology for society as a whole, its practice could be logically legitimized and accorded all the support it requires to perform at an optimal level of efficacy contributing to the advancement of one or more nations.

REFERENCES

[1] BID. (2006), Educación, ciencia y tecnología en América Latina y el Caribe: Un compendio estadístico de indicadores, Departamento de Desarrollo Sostenible Interamericano de Desarrollo, Washington D.C.

[2] CONACYT. (2006), Informe general del estado de la ciencia y la tecnología, Dirección de análisis estadístico, México, D.F.

[3] CONACYT. (2007A), Indicadores de actividades científicas y tecnológicas, México, D.F.

[4] CONACYT. (2007B), Conceptos básicos y definiciones, México, D.F.

[5] ESPINOSA, G. y WIGGINS, S. (2003), Beneficios económicos potenciales de la tecnología bovina de doble propósito en México, Técnica pecuaria en México, 41:19-36.

[6] Google Schoolar. http://scholar.google.com.mx/ [May 20, 2008].

[7] ISI Knowledge Database. http://apps.isiknowledge.com/WOS_GeneralSearch_inputdo?product=WOS&SID=X1lGP5kAEOFFI7oGf4&search_mode=GeneralSearch [May 24, 2012].

[8] KOSTOFF, R. (1998), S&T metrics, Office of Naval Research, Arlington VA.

[9] LEY DE CIENCIA Y TECNOLOGIA, ARTÍCULO 12 SECCIONES I y VIII. (2006), Cámara de Diputados del H. Congreso de la Unión, México, D.F.

[10] MARTINEZ, E., ALBORNOZ, M. (1998), Indicadores de ciencia y tecnología: Estado del arte y perceptivas, Nueva Sociedad, Caracas.

[11] OECD. (2003), Manual de Frascati 2002: Propuesta de normas prácticas para propuestas de investigación y desarrollo experimental, FECYT (ed.), Paris.

[12] OECD. (2004), Main S&T Indicators, Paris.

[13] OEA. (2005). Ciencia, tecnología, ingeniería e innovación para el desarrollo: una visión para las Américas del siglo XXI, Oficina de Educación, Ciencia y Tecnología. 2ª ed. Washington, D.C.

[14] SANCHO-LOZANO, R. (2002), Indicadores de los sistemas de ciencia, tecnología e innovación, Economía Industrial 343 (1) : 97-109.

[15] SCOPUS Database. http://www.scopus.com/scopus/search/form.url [May 29, 2008].