

The cost of Latin American science Introduction for the second issue of CBP-Latin America

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Abstract

Latin American researchers in science and engineering (S&E), including those in biology and biomedical sciences, are frequently exposed to unstable conditions of financial support, material and human resources, and a limited number of positions at public and private institutions. Such uncertainties impose continuous challenges for the scientific community which, in the best of cases, responds with careful planning and creativity, and in the worst scenario endures the migration of scientists to the USA or Europe. Still, the number of scientific publications from Latin American institutions in the last decade increased at a much faster rate than publications from the USA and Canada. A brief analysis per country of the gross domestic product (GDP) spent in research and development (R&D) and the S&E production reported by the Pascal bibliographic database suggests that the number and quality of S&E publications is directly proportional to the financial support for R&D. However, the investment in R&D in Latin America did not increase at the same rate (from 0.49 to 0.55% of GDP, from 1990 to 2003) at which S&E publications did in the same period (2.9-fold increase, from 1988 to 2001). In Latin America, the traditional financial support for scientific research continues to be from federal and state government funds, associated in some cases with institutional funds that are mostly directed towards administrative costs and infrastructure maintenance. The aim of this introduction is to briefly discuss the production cost of articles published in refereed S&E journals, including the cost of the scientific research behind them, and, at the same time, to increase the awareness of the high quality of scientific research in Latin American institutions despite the many challenges, especially financial constraints, faced by their scientists. The second issue of *Comparative Biochemistry and Physiology* dedicated to Latin America (“The Face of Latin American Comparative Biochemistry and Physiology”) celebrates, by means of 26 manuscripts from five countries, the diversity and quality of biological science in the continent.

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1. Investment in science and technology in Latin America

Science has become an issue of increasing public awareness in Latin America in the last decade. An increase, albeit small, in the investment in scientific research and development (R&D)

occurred in Brazil, Chile and Mexico within the past 10–12 years (Pinheiro-Machado and Oliveira, 2001; RICYT, 2003, 2004; UIS Report, 2005). In Latin American and Caribbean countries R&D expenditure is approximately 0.1% to 1.0% of the gross domestic product (GDP), a relatively small investment compared with Canada, the USA, Japan or Europe, where the investment is typically 2–3% of their GDP (Tables 1 and 2) (Kawha and Ramkissoon, 2005; UIS Report, 2005; Hermes-Lima and Navas, 2006). It is not difficult to visualize a cumulative deficit in R&D expenditure between Latin America and Canada or the USA through time. While the investment in R&D has only increased modestly in Latin American countries

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Table 1

Key indicators of world gross domestic product (GDP), population and gross domestic expenditure on research and development (GERD) during 2002

	GDP (in billions)	% world GDP	Population (in millions)	% world population	GERD (in billions)	% world GERD	% GERD/GDP	GERD per inhabitant
Developed countries	28,257	59.4	1195.1	19.3	645.8	77.8	2.3	540.4
Developing countries	18,607	39.1	4294.2	69.5	183.6	22.1	1.0	42.8
Less-developed countries	736.4	1.5	686.9	11.1	0.5	0.1	0.1	0.7
Americas	14,949	31.4	849.7	13.8	328.8	39.6	2.2	387.0
North America	11,322	23.8	319.8	5.2	307.2	37.0	2.7	960.5
Latin America and the Caribbean	3628	7.6	530.0	8.6	21.7	2.6	0.6	40.9
Europe	13,286	27.9	795.0	12.9	226.2	27.3	1.7	284.6
Argentina	387	0.8	36.5	0.6	1.6	0.2	0.4	44.0
Brazil ^a	1300	2.7	174.5	2.8	13.1	1.6	1.0	75.0
Japan	3481	7.3	127.2	0.1	106.4	12.8	3.1	836.6
México	887	1.9	100.8	1.6	3.5	0.4	0.4	34.7
United States of America	10,414	21.9	288.4	4.7	290.1	35.0	2.8	1005.9

Modified from source: UNESCO Institute for Statistics estimations, December 2004, www.uis.unesco.org/TEMPLATE/pdf/S&T/WdScienceRepTable1.pdf.^a GERD value for Brazil is from 2000; GDP and GERD are shown in US dollars.

(Table 2), the number of scientific publications in Latin America increased at a much faster rate in the last decade than publications from the USA and Canada (Holmgren and Schnitzer, 2004; Hermes-Lima and Navas, 2006).

The correlation between R&D invested (in millions of USD) by Latin American countries and their number of science and engineering (S&E) publications recorded in Pascal in 2003 suggests that a country's scientific production is directly proportional to its expenditure in R&D (Fig. 1; when data are analysed as % GDP spent in R&D, the correlation is also valid: $r=0.761$; $P<0.05$, $n=17$ countries). A similar correlation was done by King (2004); however, it involved mostly developed nations. Similarly, the number of researchers (per million inhabitants) of Latin American nations correlates with spending in R&D ($r=0.564$; $P<0.05$, $n=17$ countries; see also Hermes-Lima and Navas, 2006). Furthermore, the proportion of GDP invested in R&D by several developed and developing countries correlates significantly with the number of citations per S&E paper (Fig. 2). It is noteworthy that G7 countries had 5.5 to 8.5 citations per paper (between 1997 and 2002) while Brazil had only 3.5. These data suggest that increasing a country's expenditure in R&D would result in a proportional increase in its researcher population, its output in S&E publications and, assuming that the number of citations a paper receives is a

reflection of its relevance/impact (see: Pellegrini Filho et al., 1997), in the scientific quality of those publications.

From the data shown in Figs. 1 and 2, it is possible to calculate the cost of producing a scientific publication in Latin American countries relative to the proportion of their GDP directed to S&E. Resulting estimates vary from 140,000 to 750,000 USD per S&E paper ($n=16$ countries). These figures are significantly lower when compared with Canada (1.4 million USD per paper) and the USA (1.8 million USD per paper). These observations may suggest that scientific research is less expensive in Latin American countries. However, there are other costs involved in producing a scientific paper that might underline this inequality. It is commonly assumed, and generally true, that salaries and overhead charges are lower, while the costs of reagents, materials and scientific equipment, as well as costs of traveling to meetings, conferences and training fellowships are higher in Latin America than in the USA and Canada. The question then becomes, what is the real cost of scientific research in Latin America?

2. The cost of scientific research in Latin America

In order to compare the cost of scientific research in Latin America, Canada and the USA, we surveyed prices of basic reagents, materials and equipment commonly used by biochemists and physiologists. As an example, Table 3 shows a comparison of the costs of glucose, cryovials and a micro-centrifuge obtained from catalogues, supplier listings, quotes from suppliers and distributors or receipts from recent purchases. These results briefly estimate that, on average, Latin American researchers pay 3.1 times more on reagents, 1.9 times more on materials and 1.5 times more on equipment than our counterparts in the USA. It is interesting to note that, even within the same country, prices can be highly variable depending on the region and the proximity to major cities. These differences in cost are caused by the location of the larger manufacturers and suppliers of materials, reagents and scientific equipment in the USA and Europe. Smaller manufacturers have started to appear in some Latin American regions (for example,

Table 2

Evolution of investment in R&D as a percentage of GDP in Latin America and Caribbean (LAC) and four selected countries

	LAC	Brazil	Mexico	Chile	Argentina
1990–1991	0.49%	0.82%	n.a.	0.52%	0.33%
1992–1993	0.46%	0.83%	0.22% (1993)	0.60%	0.40%
1994–1995	0.57%	0.90%	0.30%	0.62%	0.46%
1996–1997	0.53%	0.77% (1996)	0.33%	0.51%	0.50%
1998–1999	0.57%	n.a.	0.40%	0.50%	0.51%
2000–2001	0.55%	1.00%	0.38%	0.53%	0.49%
2002–2003	0.55%	0.96%	0.40% (2002)	0.65%	0.45%

Values are average of 2 years, except when indicated. For comparative purposes, the percentage of GDP spent in R&D by Canada grew from 1.5% (1990) to 1.9% (2003). Data taken from RICYT, 2004. n.a.: Data not available.

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