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Latin American Research. Part 1. Where It Is Published and How Often It Is Cited

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Last January, I addressed the fifth congress of the National Academy of Medicine of Mexico on the productivity and impact of Latin American research. Naturally, new data were generated for this occasion, but this was not the first citation analysis of Latin American science. A number of excellent studies based on ISI® data have been conducted by Latin American researchers.[1-5] However, these studies concentrated on one field, one scientist, or one nation. The present talk provided data across all fields of science in Central and South America. The main purpose was to review Latin American research in an international context, much as we had done in our earlier report on Third World science.[6]

The data on Latin American science were based on a special file we created from the 1978 *Science Citation Index®* (*SCI®*). This file contains about 3,100 articles whose first authors are affiliated with institutions located in Central and South America. We also determined in what journals and languages these articles were published. Then we used the cumulated *SCI* files for 1978-1982 to find how often each article was cited.

We also kept track of the nationality and language of the *citing* articles. This gives us a unique perspective on international and interlingual citation patterns in the world scientific press. In addition, we identified those specialties in which Latin American researchers had published in 1981. These research front analyses provide insights into *current* areas of research activity in Latin America. They are one example of several modeling techniques one can use to "map" Latin American science.

In Part 1 of this essay, we'll discuss productivity and impact—the number of 1978 *SCI* articles authored in Central and South America, and the number of citations they received from 1978 to 1982. We'll compare these results to similar data for the totality of countries represented in *SCI*. We'll also indicate the journals that published Latin American papers and in what languages. In Part 2, we'll list and discuss the most-cited articles as well as fields of science in which the Latin American contribution is concentrated. That discussion will include maps of the fields in which Latin American scientists were most active.

In 1978, *SCI* indexed more than 500,000 articles published in 2,600 journals. While most of these articles listed an author's address, many were anonymous editorials, obituaries, correction notes, etc. The latter were omitted, as were some substantive articles published in journals that do not provide author affiliations, or give only incomplete addresses. I've discussed the problem of missing or incomplete addresses previously.[7] However, even after all of the above items were removed from the study, more than 388,000 articles remained.

In this study, an article's "nationality" is defined by the country given for the *first* author's address. For example, if an article lists a first author based in Brazil, it is considered a Brazilian paper even though it was coauthored with researchers from other countries. Although this method is not perfect, the "bias" it introduces is minimal. Only four percent of 1979 and 1980 *SCI* articles were internationally coauthored.[8] (p. 229)

Of course, a higher percentage of Latin American papers may be multinationally coauthored. In recent years, the US and Europe have established cooperative scientific agreements with many developing nations, including those in Latin America—joint research projects, exchange of scientists, funding of regional laboratories, etc.[8] (p. 27) The number of collaborative articles produced as a result of such programs is a small proportion of the very large number of articles from the US and Europe. But these articles may represent a significant percentage of Latin American publications because the total output of Latin American science is much smaller compared to that of the US and Europe.

About 3,100, or one percent, of 1978 *SCI* articles listed first authors from Central and South America. Table 1 shows the geographic distribution and impact of all *SCI* articles. The Latin American proportion has remained constant at one percent from 1973 to 1982.

Other indexing services report similar proportions. According to Richard Sharpe, *Chemical Abstracts*, one percent of their 1982 file was from Latin America.[9] And Cathy Ferrere, *Physics Abstracts*, says that Latin American articles account for less than one percent of their current file.[10] As early as 1972, *SCI*'s coverage of the world's literature was shown to be in close agreement, in terms of national distribution, with that of other abstracting services including *Biological Abstracts*, *Psychological Abstracts*, and *Engineering Abstracts*.[11]

Table 1: Percentage and impact of 1978 *SCI*® articles by country. A = geographical region. B = percent of 1978 *SCI* articles. C = 1978-1982 impact.

A	B	C
US	44	5.7
Western Europe	17	4.5
UK	9	5.2
USSR	6	1.5
Japan	5	4.0
Canada	4	4.9
Third World Nations	4	1.7
Eastern Europe	3	2.3
Scandinavia	3	6.4
Australia	2	4.4
Latin America	1	2.9
All Others	2	4.0

Table 2: Productivity and impact of Latin American countries. A = country. B = 1978 articles. C = 1978-1982 impact.

A	B	C
Brazil	1060	2.6
Argentina	643	3.1
Mexico	611	3.1
Chile	312	3.3
Venezuela	261	3.0
Colombia	64	2.5
Peru	35	1.5
Costa Rica	35	2.8
Uruguay	25	2.4
Guatemala	23	3.3
Cuba	22	2.4
Ecuador	13	.8
Panama	7	4.0
Honduras	5	.8
Bolivia	4	1.0
El Salvador	4	1.3
Haiti	1	0
Dominican Republic	1	7.0
Total	3126	2.9

The 388,000 articles in the 1978 *SCI* received about two million citations between 1978 and 1982. Thus, the average *SCI* article had a five-year impact of 4.8. Impact was calculated by dividing the number of 1978-1982 citations to 1978 articles by the number of articles published in 1978. The 3,100 Latin American articles received 9,000 citations, giving an impact of 2.9.

Table 2 provides details on the 18 Latin American countries represented in this study. Data on the number of arti-

cles and their impacts are given for each nation. The top five countries—Brazil, Argentina, Mexico, Chile, and Venezuela—account for 92 percent of the Latin American articles indexed in the 1978 *SCI*.

The same five countries are the leaders in Latin America in terms of the number of their articles in the 1973, 1978, and 1982 *SCI*. However, their *relative* rankings have changed over the years, as shown in Table 3. Argentina slipped from first place in 1973 to second in 1978 and 1982, trading places with Brazil. Mexico advanced from fifth place in 1973 to third in 1978, but slipped to fourth in 1982. These changes may be a reflection of economic or political events. Increases in foreign debts, for example, might result in austerity measures that reduce science budgets. Thus, fewer funds are available to support basic research, and the number of published articles declines.[12]

M.J. Moravcsik and J. Blickenstaff, Institute of Theoretical Science, University of Oregon, Eugene, used ISI data to study the number of publishing scientists in the Third World from 1971 to 1976.[13] They found that countries with stable political systems have a steady and fast "growth rate" of science. Moravcsik explained that many people, including scientists, emigrate abroad during domestic political upheavals. Venezuela often is the *recipient* of refugee scientists from Central and South America because of its relative stability. Thus, both the number of scientists and articles fluctuate sharply over time for Venezuela. Moravcsik notes that this "inter-regional migration" is characteristic of Latin America, and is less frequently observed in Africa and Asia.[14]

Table 3: Most productive Latin American nations in 1973, 1978, and 1982 *SCI*®. A = country. B = 1973 articles. C = 1978 articles. D = 1982 articles.

A	B	C	D
Argentina	1526	643	1217
Brazil	812	1060	1531
Venezuela	589	261	318
Chile	565	312	822
Mexico	535	611	735

Table 4: Impact of articles for Latin American countries that produced at least 35 articles in 1978. A = country. B = impact. C = 1978 articles. D = 1978-1982 citations.

A	B	C	D
Chile	3.3	312	1017
Argentina	3.1	643	1987
Mexico	3.1	611	1871
Venezuela	3.0	261	789
Costa Rica	2.8	35	97
Brazil	2.6	1060	2720
Colombia	2.5	64	157
Peru	1.5	35	51

Table 4 gives the impacts for eight Latin American nations that produced at least 35 articles, or one percent of all Latin American publications in the 1978 *SCI*. Although Brazil ranked first on the number of articles it produced, it ranks sixth in impact. Articles from Chile had the greatest impact at 3.3, followed closely by Argentina and Mexico.

Latin American articles in our 1978 "sample" were published in seven languages. They are shown in Table 5. More than 80 percent were in English, and they had the greatest impact. Although Spanish and Portuguese are the major domestic languages in Latin America, only 17 percent of Latin American research articles were published in these languages. In the 1982 *SCI*, about 80 percent of Latin American articles were in English.

Clearly, English is the dominant language of Latin American research reported in the international scientific journals. This statement shouldn't be surprising. English is the dominant language of *all SCI* articles, and its use has increased. Table 6 shows the major languages of publication for *SCI* articles in 1973, 1978, and 1982. The number of articles indexed in *SCI* grew by 26 percent from 1973 to 1982. English-language articles accounted for 83 percent of the 1973 *SCI* file, and 89 percent in 1982. Span-

Table 5: Languages of publication and impact for 1978 Latin American articles. A=language. B=1978 articles. C=percent of total. D=impact.

A	B	C	D
English	2520	81	3.4
Spanish	450	14	.6
Portuguese	91	3	.2
German	30	1	2.5
French	30	1	.7
Russian	4	—	.3
Italian	1	—	1.0
Total	3126	100	2.9

Table 6: Languages of publication for all *SCI*® articles in 1973, 1978, and 1982. A=language. B=1973 articles. C=1978 articles. D=1982 articles.

A	B	C	D
English	292,261	343,640	394,281
Russian	19,477	15,011	17,360
German	18,140	14,651	15,702
French	16,020	10,168	10,219
All Others	7350	4806	6193
Total	353,248	388,276	443,755

Table 7: Countries that published at least 12 Latin American articles in 1978. A=publishing country. B=1978 articles. C=1978-1982 citations. D=impact. E=number of Latin American countries.

A	B	C	D	E
US	1317	4884	3.7	17
UK	369	1233	3.3	14
Netherlands	231	1128	4.9	12
Mexico	217	87	.4	3
Brazil	144	46	.3	2
Switzerland	140	408	2.9	8
FRG	138	428	3.1	9
Chile	122	79	.7	1
Argentina	78	79	1.0	2
France	73	91	1.3	10
Denmark	36	74	2.1	8
Italy	31	44	1.4	6
Venezuela	31	18	.6	3
GDR	29	65	2.2	6
Japan	28	49	1.8	5
Costa Rica	23	13	.6	7
Spain	23	16	.7	7
Canada	19	43	2.3	6
Austria	15	42	2.8	3
USSR	12	2	.2	5
All Others	50	106	2.1	
Total	3126	8935	2.9	

ish- and Portuguese-language articles accounted for less than one percent of *SCI* articles in 1973, 1978, and 1982. *Chemical Abstracts* reported the same percentage for Spanish and Portuguese articles in its 1982 file.[9]

English dominates Latin American science publication because the majority of Latin American articles in the 1978 *SCI* were published in English-language journals. Table 7 lists 20 nations that published at least 12 Latin American articles. Fifty-five percent of the 3,100 Latin American articles were published in the US, UK, and Canada, where English is the most common language of publication. In fact, English accounts for the majority of articles published in Switzerland, the Federal Republic of Germany (FRG), Denmark, Italy, the Netherlands, and other countries whose native language is *not* English.

The US published more Latin American articles than any other nation—1,300. This amounts to only one percent of all articles published in the US. But it represents 42 percent of the 1978 *SCI* articles from Latin America. The US also published articles from 17 Latin American nations. Thus, more Latin American authors found a publishing opportunity in the US than in any other country.

Table 7 shows that Latin American articles published in the Netherlands had the greatest impact—4.9. The average Latin American article published in the US received 3.7 citations from 1978 to 1982. For the UK, this figure is 3.3 and for the FRG 3.1. Latin American articles published in Argentina had an impact of 1.0, the highest of all six Latin American publishers in Table 7.

However, only 700 articles published in Latin American journals were indexed in the 1978 *SCI*. Conclusions on the relative impact of Latin America as a scientific publisher drawn from such a small sample must be tentative. Clearly, the processing of more Latin American publications *might* increase the impact

Table 8: Journals that published at least ten 1978 Latin American articles.* A = journal. B = Latin American articles. C = Latin American impact. D = total articles. E = total impact.

A	B	C	D	E
Rev. Invest. Clin.	157	.1	161	.1
Rev. Med. Chile	122	.7	128	.6
An. Acad. Brasil Cienc.	106	.3	112	.3
Medicina—Buenos Aires	78	1.0	79	1.0
Arch. Invest. Med.	48	1.4	67	1.9
Rev. Brasil Pesquisas Med. Biol.	38	.4	40	.4
Acta Cient. Venez.	31	.6	32	.6
Bull. Amer. Phys. Soc.	27	.1	5765	.3
Solid State Commun.	26	2.4	991	6.5
J. Chem. Phys.	25	7.8	1668	11.5
Biochim. Biophys. Acta	23	8.0	2079	13.7
Phytochemistry	22	4.6	584	6.2
Turrialba	21	.6	28	.5
Biochem. Biophys. Res. Commun.	20	9.9	1095	13.2
Experientia	20	2.8	1364	2.6
Phys. Rev. B—Condensed Matter	20	3.8	947	11.6
Sangre	20	.7	382	.1
Trans. Roy. Soc. Trop. Med. Hyg.	20	1.6	194	3.4
Amer. J. Trop. Med. Hyg.	18	3.8	178	6.5
Pediat. Res.	18	1.4	1511	1.3
C.R. Acad. Sci. Ser. II—Mec. Phys.	17	.3	478	.5
Fed. Proc.	17	.5	7144	1.2
Phys. Rev. D—Part. Fields	17	4.1	784	10.2
Abstr. Pap. Amer. Chem. Soc.	16	0	4290	0
Astrophys. J.	16	12.1	1191	12.6
Agent. Action.	15	1.1	148	4.6
IEEE Trans. Power App. Syst.	15	.3	501	.7
Fert. Steril.	14	5.7	294	6.4
Lett. Nuovo Cim.	14	1.9	417	2.5
FEBS Lett.	13	7.5	1210	11.2
J. Phys.—C—Solid State Phys.	13	2.1	562	5.9
Nature	13	17.4	2252	20.1
Phys. Rev. A—Gen. Phys.	13	8.3	883	6.6
Publ. Astron. Soc. Pac.	13	1.8	167	3.0
Brain Res.	12	9.8	983	16.4
Chem. Phys. Lett.	12	3.9	988	8.4
Int. J. Androl.	12	0	216	1.4
J. Food Sci.	12	2.4	516	3.9
J. Opt. Soc. Amer.	12	.7	1116	1.2
J. Org. Chem.	12	6.3	1360	8.8
Patol.—Mex.	12	.3	12	.3
Phys. Status Solidi B—Basic Re.	12	2.0	713	3.4
Plant Dis. Report.	12	2.0	336	1.5
Amer. J. Phys.	11	.7	304	1.1
Arch. Biochem. Biophys.	11	9.3	441	12.0
J. Math. Phys.—NY	11	2.6	409	3.9
J. Membrane Biol.	11	7.0	131	15.4
Phys. Lett. A	11	3.1	782	4.4
Plant Physiol.	11	1.1	1074	5.1
Trans. Amer. Geophys. Soc.	11	.1	2724	.1
Exp. Parasitol.	10	5.7	77	6.2
J. Appl. Phys.	10	2.6	1149	6.5
J. Electrochem. Soc.	10	2.7	1417	2.3
J. Sound Vib.	10	1.9	601	.8
J. Steroid Biochem.	10	1.8	556	2.7
Life Sci.	10	3.7	533	13.9
Plast. Reconstr. Surg.	10	1.9	255	4.5
Trans. Amer. Nucl. Soc.	10	.6	1384	.6

* Data for *Acta Physiologica Latino-Americana* are not available because its 1978 issues were processed in 1979.

Table 9: Journals that published high-impact Latin American articles in 1978. A = journal. B = Latin American impact. C = Latin American articles. D = total impact. E = total articles.

A	B	C	D	E
Gene	162.0	1	20.7	40
J. Immunol.	40.3	3	21.1	867
J. Clin. Invest.	35.0	2	34.1	353
Biochimie	31.0	1	6.1	142
J. Physiol.—London	30.3	3	7.8	1028
Proc. Roy. Soc. London Ser. B	29.0	1	13.8	102
Proc. Soc. Exp. Biol. Med.	25.0	3	6.3	353
Proc. Nat. Acad. Sci. US	24.0	4	40.6	1208
J. Volcanol. Geotherm. Res.	23.0	1	7.0	26
Amer. Heart J.	21.5	2	6.1	315
Parasitology	19.7	3	1.7	346
Eur. J. Biochem.	19.3	4	17.2	740
J. Cell Sci.	19.0	1	13.4	148
Nature	17.4	13	20.1	2252
Phys. Rev. Lett.	17.3	4	19.7	1099
Naturwissenschaften	17.0	1	5.0	171
Artery	17.0	1	4.4	43
Annu. Rev. Biophys. Bioeng.	16.0	1	48.8	18
J. Exp. Med.	15.0	1	50.5	300
Photochem. Photobiol.	15.0	2	11.5	254

of particular journals or articles, but their overall impact could *de*crease. Assuming that the journals we do not cover are of lower impact than those we already index, adding more of them to our data base can only lower even further the average impact of any group of low impact journals.

The 3,100 Latin American articles in the 1978 *SCI* were published in about 850 journals. Table 8 lists 58 journals that published at least ten Latin American articles. Eight of them are Latin American journals. Mexico and Brazil account for two journals each. Argentina, Chile, Costa Rica, and Venezuela have one journal each. Thirty of the journals were published in the US, seven in the UK, five in the Netherlands, and two in Switzerland. Denmark, France, the FRG, German Democratic Republic, Italy, and Spain account for one journal each.

Table 9 lists 20 journals with the greatest impact for the Latin American articles they published. No Latin American journal is listed. The US accounts for ten journals. Six were published in the UK, two in the Netherlands, and one each in

France and the FRG. Although only 52 Latin American articles were published in these 20 journals, they received almost 1,300 citations. That is, these 52 articles account for 15 percent of all 1978-1982 citations to Latin American articles in the 1978 *SCI*. Most of these journals are in biomedicine or clinical medicine. These fields tend to produce more "superstar" papers than earth sciences, botany, or mathematics. This is primarily due to the great number of papers published in biomedicine. Also, in biochemistry, the average number of references cited per paper is very high and increasing.[15]

In Part 2, we'll identify the 1978 Latin American articles that were most cited from 1978 to 1982. We'll continue our journal analysis and describe the fields of science that Latin American literature is concentrated in. An analysis of research fronts that include Latin American papers published in 1981 provides an interesting insight into their research emphases.

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