

LATIN AMERICAN SCIENTIFIC OUTPUT 1986-91 AND INTERNATIONAL CO-AUTHORSHIP PATTERNS

G. LEWISON,* A. FAWCETT-JONES,** C. KESSLER***

* *General Technology Systems Ltd, Brunel Science Park, Kingston Lane, Uxbridge, UB8 3PQ (UK)*

** *Department of Materials Science, Brunel University, Uxbridge, UB8 3PH (UK)*

*** *Commission of the European Communities, 200 rue de la Loi, 1049 Brussels (Belgium)*

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Results are presented of a study covering 1986-91 of the scientific output of Latin American nations. The distribution of the output within the countries is shown: in most countries there is a high concentration in the national capital. The papers co-authored with scientists from other countries are also examined. There has been a notable rise in both the number and proportion of papers co-authored within the region, with the USA and Canada, and, especially, with the countries of the European Community, where a programme of International Scientific Co-operation, to promote just such links, has been active since the mid-1980s in many Latin American countries.

Introduction

Scientific co-operation between countries has been increasing noticeably in recent years. It is seen as a means of promotion of international amity and is an overt sign of the growing desire among nations to work together on peaceful activities. It also enables multi-national scientific teams to be formed that are often better able to tackle the multi-disciplinary problems of today. A particular example of such international co-operation is afforded by the Member States of the European Community (E.C.), who participate in many specialised research programmes. However it is worthwhile to consider to what extent co-operation in science takes place on other continents.

The immediate stimulus for this paper came from a series of studies on individual Latin American countries carried out by the authors during the last year. They were designed to assist the Commission of the European Communities (the CEC) in Brussels with the management of the European Community International Scientific Co-operation (ISC) programme. This programme has operated since the mid-1980s and is intended to form links between scientists in the E.C. and their colleagues in Asian, Latin American and Mediterranean (ALAMed) countries. The programme

provides for *post-doctoral fellowships*, typically of one year, in which ALAMed scientists visit an E.C. laboratory in order to plan a *joint research project*. These in turn may be submitted to the CEC for possible funding. The last activity is the holding of *workshops* in order to provide a focus for a subject and stimulate the submission of fellowship and research project proposals.

Now that the programme has been running for some seven years, a record of its achievements is being prepared in the form of reports¹ on the activities supported under these three heads. Each report covers one ALAMed country, or group of cognate countries, e.g. those of the Andean Pact (Bolivia, Colombia, Ecuador, Peru and Venezuela.) The first author has been editing these reports and has appended to each one a bibliometric study. This allows the publications produced as a result of the programme to be seen in the context of the country's overall scientific output and in particular of its record of trans-national collaboration in publications.

This paper presents material from the introductions to these reports and much additional material, collected together in a uniform format so as to allow comparisons to be made between countries and trends with time in individual countries to be seen. The information covers six years, 1986-91, and is taken from the *Science Citation Index* (SCI) of the Institute for Scientific Information, CD-ROM version. It thus represents what is conventionally called "mainstream" science, nearly all written in English and published in international journals. The results update those given by *Narvaez-Berthelemot* et al.,² which cover the six years 1981-6, and also embrace more countries. They also extend and complement those of *Russell* and *Narvaez-Berthelemot*³ in a forthcoming paper.

There are disagreements between authors on whether the SCI is an appropriate data-base for the study of Third World science. *Sancho*⁴ is highly critical of the SCI because so many of the publications by Third World scientists are omitted, perhaps as many as 90%. The bias towards medicine and away from engineering is also held to distort the perception of the balance of the science actually carried out. On the other hand, *Spagnolo*⁵ found that the SCI gave a fair coverage of activities in chemistry and electrical engineering by Brazilian scientists, and *Krauskopf*⁶ used the SCI to appraise Chilean universities active in the life sciences. The discussion by Spagnolo, and the long essay by *Schwartzman*,⁷ make it clear that the university scientists are primarily concerned with international publications as a criterion of the quality and relevance of their work. A further important factor is that many Latin American papers in international journals are co-authored with scientists from other countries. Accordingly, a data base that only lists the address of the first or principal

author will omit many papers by Latin American scientists. We conclude that the SCI, despite its limitations of coverage – it only covers 11 journals published in Latin America – is not seriously flawed as a statistical source of information.

Whereas science in Western Europe and North America is characterised by a rather high degree of stability, with the SCI recording hardly any change in the relative output of the major scientific countries, this is not true for Latin America. Some countries, such as Venezuela, have exhibited apparent stability in their output, see below, but this conceals a very turbulent situation as *Krauskopf et al.*⁸ and *Roche and Freitas*⁹ make clear. *Vessuri*¹⁰ presents a depressing overall picture of the university scene in Latin America, where the political desire to expand the facilities for higher education and research has often foundered on the rocks of economic policy or innate academic conservatism. There is also, according to *Delgado and Russell*¹¹ a tendency for Mexican scientists, at least, to have less international visibility because many of the articles they do publish in international journals are in ones with low impact factors (based on their numbers of citations).

Another aspect of science policy in many Third World countries is the concentration of scientific resources in the national capital, which may have a detrimental effect on the quality of life elsewhere. *Cronin and Licea de Arenas*¹² draw attention to the case of Mexico but the situation is similar in all but one or two of the other Latin American countries as we shall see.

Methodology

For the purposes of this study, the countries of Latin America were taken as the ones formerly associated with Spain and Portugal, including the Caribbean Islands (Cuba, Dominican Republic, Haiti) but excluding the Guyanas (Guyana, French Guyane, Surinam). There were therefore 20 countries, of very different sizes, with a combined population (in 1990) about 30% greater than that of the E.C. but with a total gross domestic product less than one-fifth as large, see Table 1.

The CD-ROM version of the SCI comes with convenient software that allows many types of search, but errors can easily trap the unwary. For example, there is no specific code to identify the country of a corporate address and a country name may be found elsewhere in an address. Thus there are a number of papers from PANAMA STREET, STANFORD, CA, USA which have no connexion with Panama, and most of the addresses containing the word PARAGUAY are in Buenos

Aires, Argentina. Boolean operations can solve most problems, following visual inspection of a sample of the actual records to identify problems such as these.

The distribution of papers by city in each country was determined first by listing all the papers whose address contained the leading cities *and* the country name (e.g. SAO-PAULO AND BRAZIL) and then examining the addresses of papers from the country but not in any of the cities so far listed (e.g. BRAZIL NOT SAO-PAULO NOT RIO-DE-JANEIRO NOT BELO-HORIZONTE...). This process enabled all significant scientific centres (> 10 SCI papers/year) to be identified easily. All items included in the SCI were considered for this study and paper counts were integer counts.

Table 1
Nations of Latin America with their parameters in 1990

Nation	ISO Code	Population, M	GDP, 10 ⁹ \$
Argentina	AR	32.3	70.1
Bolivia	BO	6.7	4.3
Brazil	BR	153.8	375.0
Chile	CL	13.0	25.5
Colombia	CO	32.6	38.6
Costa Rica	CR	3.0	4.2
Cuba	CU	10.6	28.0
Dominican Republic	DO	7.3	4.8
Ecuador	EC	10.5	10.7
El Salvador	SV	5.2	5.3
Guatemala	GT	9.3	8.2
Haiti	HT	5.9	2.5
Honduras	HN	5.3	4.4
Mexico	MX	88.3	204.0
Nicaragua	NI	3.6	2.1
Panama	PA	2.4	4.2
Paraguay	PY	4.7	4.7
Peru	PE	21.9	39.3
Uruguay	UY	3.0	8.4
Venezuela	VE	19.8	47.1
Total		439.2	891.4

Results - national output

The number of papers with at least one author from each of the 20 Latin American countries in Table 1 is shown in Table 2 for the two three-year periods, 1986-8 and 1989-91 on an annual basis, and also for the previous quinquennium, 1981-5, as given by *Schubert and Braun*.¹³

Table 2
Number of papers per year in the SCI by 20 Latin American nations, 1981-91

Country	Overall	81-85 ¹³	86-88	89-91	$\frac{89-91}{81-85}$
BR	2604	2254	2754	3036	1.35
AR	1910	1657	2358	1885	1.14
MX	1213	1033	1320	1364	1.32
CL	1202	1205	1367	1034	0.67
VE	445	445	450	442	0.99
CO	139	123	139	167	1.36
CU	106	89	100	141	1.58
PE	99	76	109	126	1.66
CR	78	68	85	86	1.26
UY	66	61	63	77	1.26
PA	51	33	60	70	2.12
GT	42	43	41	44	1.02
EC	28	20	29	40	2.00
BO	22	22	17	25	1.13
DO	16	16	16	18	1.12
HT	9	8	8	11	1.38
PY	9	5	13	12	2.25
HN	8	8	3	13	1.17
NI	5	2	8	7	3.18
SV	4	6	3	3	0.47
Total	8057	7175	8965	8619	1.20

The last column shows the change in output between 1981-5 and 1989-91, a mean interval of seven years. Most of the countries have shown a substantial increase in performance; the growth has, however, been far from uniform and several countries saw an appreciable decline in their output around 1988-89 before a rise again in 1991. (This may be an artefact of the data source, however, because in 1989 the output of the US was 15% below the level in 1987 and that of the E.C., 7% below, which suggests a change in journal coverage by the SCI.) Among the larger countries, the steady increase in output from Brazil and Mexico is noteworthy, as is

that from Cuba and Peru. Figures for the smaller countries are not very reliable as so much of their output is co-authored with scientists from larger countries.

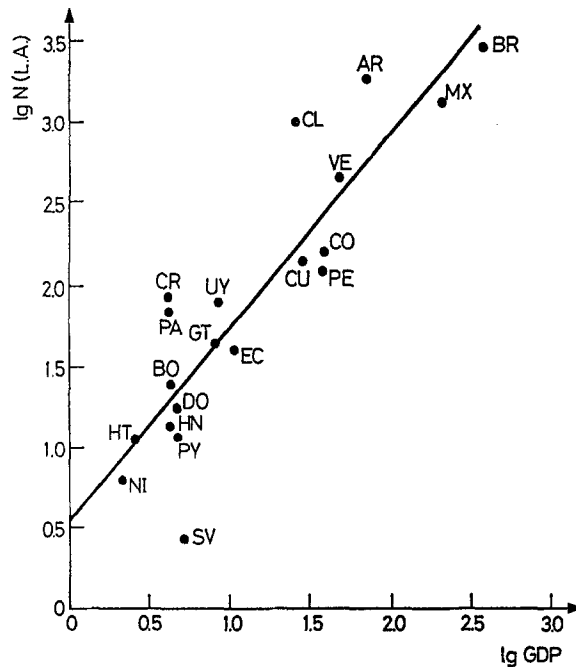


Fig. 1. Log-log plot of number of papers per year in *Science Citation Index* for 1989-91 from 20 Latin American nations against their GDP in milliard US \$ (estimated in 1990)

Several studies, e.g. those by *Price*¹⁴ and *Frame* and *Narin*¹⁵ have noted the strong correlation between scientific output and national wealth. A previous paper by *Lewison*¹⁶ covering the nations of Western Europe showed a high correlation ($r^2 = 0.83$) and a slope of unity on a log-log plot. The data for 1989-91 when plotted on log scale against log g.d.p for 1990 show a rather similar relationship, Fig. 1. There are some outliers, such as El Salvador, which does very little science (an order of magnitude less than might have been expected), and Chile, Costa Rica, Panama and Argentina, with about five times as many papers as would be expected in relation to their wealth. (Two thirds of the Panamanian papers, however, are by authors working at the Smithsonian Institution in Balboa, most of whom are probably from the US.) The coefficient of correlation, r^2 , is 0.89 and the slope of the regression line is 1.20.

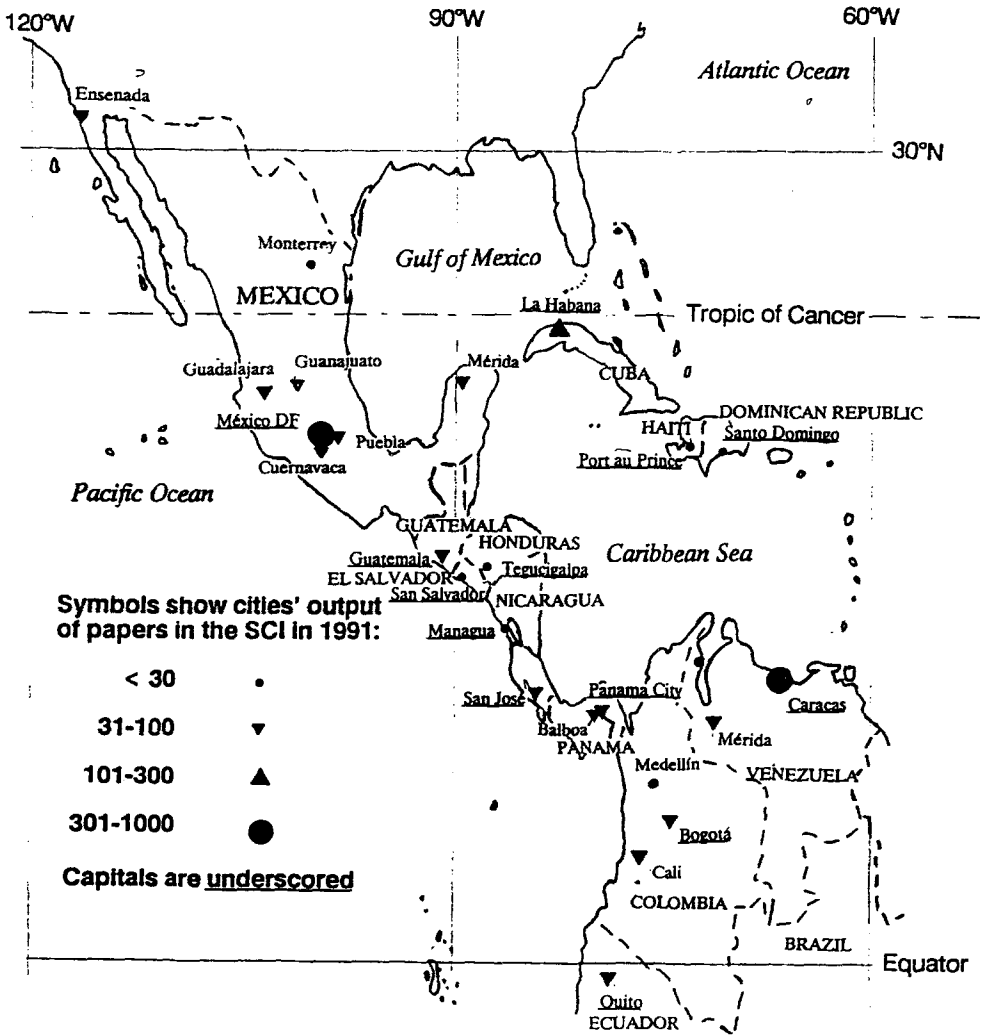


Fig. 2. Sketch map of Latin America, north of the equator, showing the output of papers in the *Science Citation Index* in 1991 for major cities. (National boundaries are for illustrative purposes only and have no political significance)

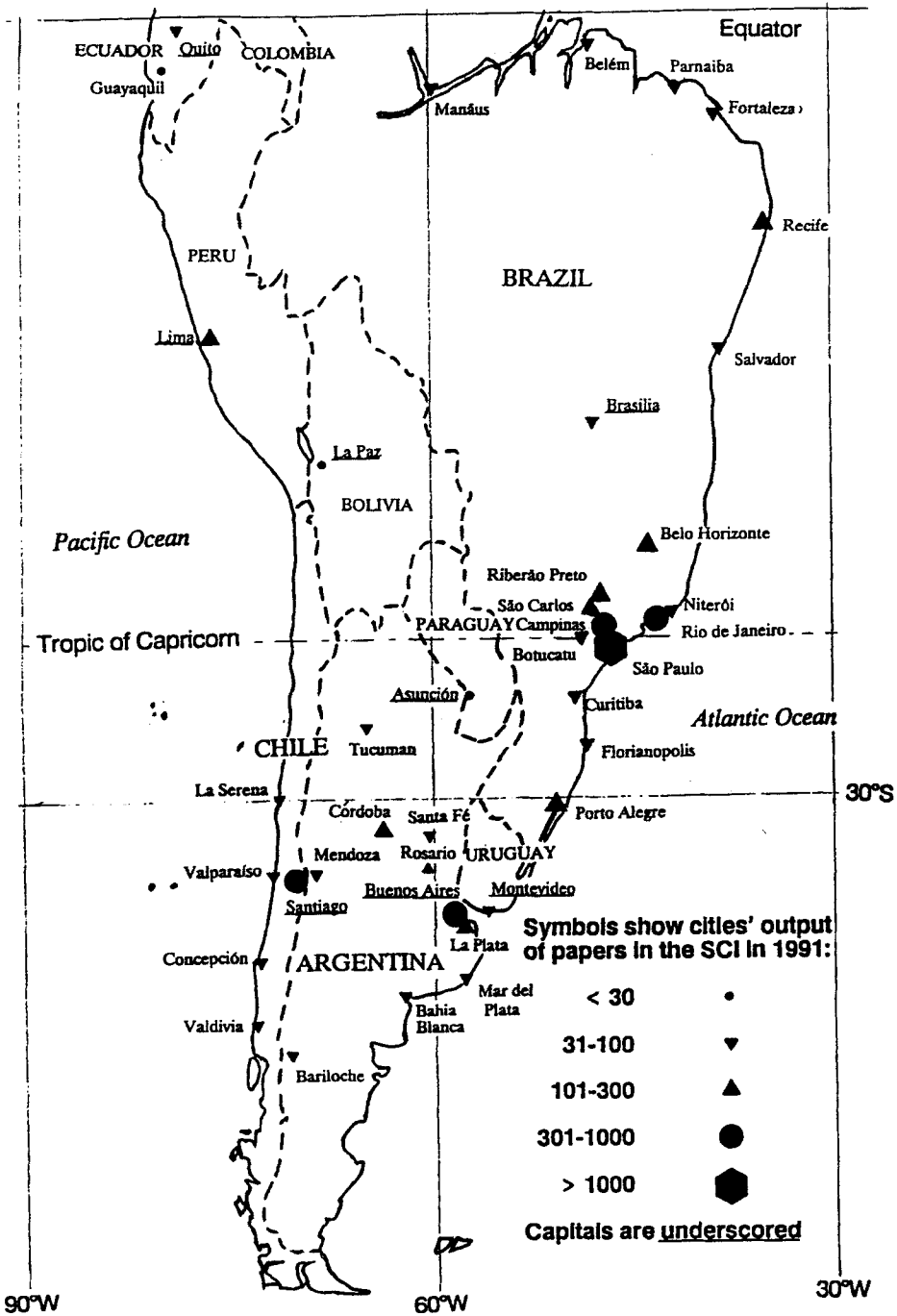


Fig. 3. Sketch map of Latin America, south of the equator, showing the output of papers in the *Science Citation Index* in 1991 for major cities. (National boundaries are for illustrative purposes only and have no political significance)

The geographical distribution of scientific output within each country was determined for the most recent year, 1991, and it has been recorded in the form of symbols on the maps shown in Figs 2 and 3 for cities with more than 30 papers per year. (Major cities and national capitals with lesser output are also shown for locational purposes). There are five major scientific centres with over 700 papers per year, see Table 3. This shows their output in comparison with some major scientific cities in Spain and Portugal.

Table 3

Leading scientific centres in Latin America, with output of papers in the SCI in 1991, and some cities in Spain and Portugal compared on the same basis

City	Country	Papers
São Paulo	BR	1070
México D. F.	MX	986
Buenos Aires	AR	980
Santiago	CL	827
Rio de Janeiro	BR	738
Caracas	VE	328
Campinas	BR	307
Madrid	ES	2943
Barcelona	ES	1907
Valencia	ES	452
Lisboa	PT	418
Porto	PT	195

The maps show Latin America north and south of the equator and reveal that there are several clusters of scientific output, largely, but not entirely, based on the local population concentrations.

Results - regional co-operation

The next analysis performed was of Latin American scientific co-authorship between nations within the region. This was calculated as the difference, M , between the sum of the individual national totals in each year and the regional total, or the number of papers with an author from *any* of the 20 nations. A paper with authors from two L.A. nations would contribute unity, a paper with authors from three L.A. nations would contribute two, and so on. The "index of co-authorship" was then

defined as the ratio of this difference to the regional total. A similar calculation has been conducted for the 12 Member States of the E.C., and the results are shown in Table 4.

Table 4
"Index of co-authorship" for 20 Latin American nations and 12 E.C. Member States in 1986-91.
M = multi-national papers, see text

Year	Regional total, R.T. (thousands)	Latin America		European Community		
		M	M/R.T., %	Regional total, R.T. (thousands)	M	M/R.T., %
1986	9.33	139	1.5	170.0	6838	4.0
1987	9.14	130	1.4	171.7	7591	4.4
1988	8.03	130	1.6	170.5	8003	4.7
1989	7.80	157	2.0	159.3	8658	5.4
1990	8.46	216	2.5	164.5	9838	6.0
1991	8.97	256	2.8	167.7	10624	6.3

This shows that inter-regional scientific co-operation has been increasing quite rapidly within Latin America - it has doubled during the six years - but it is still quite small compared with that occurring in the E.C.

An examination was made of patterns of trans-national co-authorship within the LA region where there are several sub-regional groupings of nations which seek to promote LA co-operation including joint scientific work. The Andean Pact covers Bolivia, Colombia, Ecuador, Peru and Venezuela. The "index of co-authorship" has been very small, averaging only 0.7% over the six-year period, see Table 5. The six small republics of Central America, however, have shown an increase in scientific co-publication, the index rising from 1.0% in 1986-8 to 2.8% in 1989-91.

For the comparison of co-operation between individual pairs of countries, it is helpful to use a different index, attributed to *Salton*,¹⁷ in which the number of joint papers is divided by the square-root of the product of the numbers of the individual country totals. Symbolically,

$$S_{ik} = N_{ik}/(N_i \cdot N_k)^{0.5}$$

Table 5

"Index of co-authorship" for two LA sub-regions in 1986-91. M = multi-national papers, see text

Year	Sub-reg. total	Andean Pact (BO, CO, EC, PE, VE)		Sub-reg. total	Central America (CR, GT, HN, NI, PA, SV)	
		M	M/SRT %		M	M/SRT %
1986	747	4	0.5	182	3	1.7
1987	755	2	0.3	211	0	0.0
1988	714	5	0.7	203	3	1.5
1989	728	7	1.0	189	6	3.3
1990	797	11	1.4	225	8	3.7
1991	853	4	0.5	245	4	1.7

The Salton index of co-authorship is shown graphically in Fig. 4 for five leading LA nations, Portugal and Spain. Individual national mean SCI outputs in 1986-91 are shown by the areas of the circles, and the Salton indexes are shown by the thicknesses of the connecting lines. Most trans-national links are at about the 0.005 level, but those for Brazil with Argentina (0.016) and with Chile (0.012) are substantially higher, comparable with the index for Spain with Portugal in 1989-91, which had nearly doubled from its value in 1986-8, probably as a result of their participation in E.C. research programmes following their accession to the Community in 1986. The relatively high values of the indexes for Brazil with other LA nations suggest that the difference in language is not an impediment to scientific co-operation.

Further evidence for this statement comes from Table 6, in which the numbers of LA trans-national papers with and without Brazilian co-authors are shown, together with the use of languages other than English. The mean proportion of such papers involving Brazil was 57%, which is almost double the percentage of papers in the LA total with a Brazilian author or co-author, namely 34%. This is what would be expected if Brazil were neither more nor less likely to co-operate scientifically than any other nation, and suggests that this is indeed the case, and that the effects of language are insignificant with respect to the science published in SCI journals.

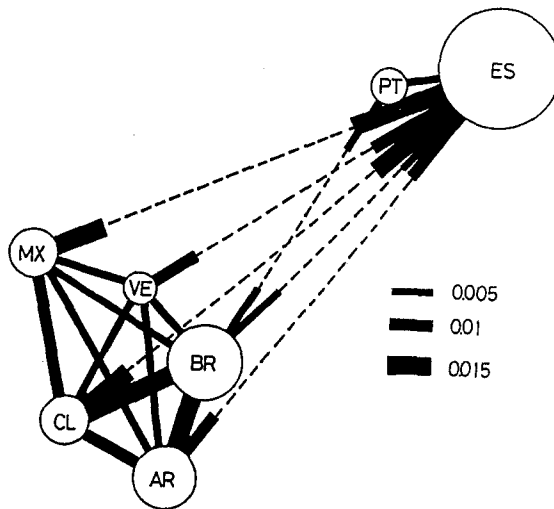


Fig. 4. Salton index of trans-national co-operation between five L.A. nations, Portugal and Spain (shown as line thickness). Areas of circles are proportional to national output in SCI. Yearly averages, 1986-91

Table 6
The use of Spanish and Portuguese in trans-national LA publications in the SCI in 1986-91

Year	BR-LA	Other LA co-op.	Total papers	% BR	Span. lang.	Port. lang.
1986	83	52	136	61	11	5
1987	62	53	115	54	5	3
1988	67	57	124	54	5	3
1989	74	63	137	54	1	1
1990	104	89	193	54	5	0
1991	141	92	233	61	2	1
Total	531	406	938	57	29	13

The low level of inter-LA co-authorship is, perhaps, surprising given the common problems that exist in, for example, medical, agricultural, ecological or geophysical research, and the various regional initiatives in science and technology. This suggests that either the scientists have not perceived the benefits to be derived from the joint approach or they are prevented by financial, political or logistical constraints.

Language cannot be a reason in 19 out of the 20 countries and this study shows that it does not seem to hinder co-authorship with Brazil. Some contact among LA scientists takes place in regional or international research laboratories in LA but this is not the same as co-operation between independent national centres.

Table 7

Latin American nations' output of papers in the SCI in 1986-91 co-authored with scientists from the European Community (E.C.), USA and Canada (CA). All figures are annualised

Nation	With E.C.	With USA	With CA	Leading E.C.M.S.
BR	361	327	51	FR-117; GB-91; DE-84; IT-47; ES-19; BE-17; NL-13.2; PT-7.3; DK-6.5; IE-2.0; GR-1.3
AR	146	132	13	FR-51; DE-35; ES-25; IT-24; GB-14; BE-5.3; NL-3.7; DK-3.3; GR-1.0
MX	132	204	29	FR-38; ES-31; GB, DE-28; IT-10.8; BE-3.8; DK, NL-3.2; GR-1.0
CL	129	143	21	DE-35; ES-32; FR-27; GB-22; IT-12.8; BE-10.3; NL-6.0; DK-2.5
VE	59	87	7	GB-18; FR-15; ES-12.3; IT-6.8; DE-6.7; BE-1.2
CO	22	48	4	GB-6.0; DE-5.5; FR-3.7; ES-3.5; IT-2.0; NL-1.3
PE	21	48	2	GB-7.2; FR-5.7; DE-5.2; BE-2.0; IT-1.8; ES-1.2
CU	19	3	1	DE-12.2; IT-8.5; ES-4.3; FR-3.7; GB-1.0
BO	12	3.5	0.3	FR-8.7; GB-2.0; BE-1.5; IT-1.0
UY	11	6	1	FR-4.2; ES-3.3; DE-1.5; GB-1.2
CR	10	33	3	DE-5.5; GB-1.5; FR-1.3; ES, NL-1.0
EC	7.2	11	0.2	GB-3.0; FR-2.0; DE-1.2; IT-1.0
GT	3.2	13	1	GB-1.5; DE-1.3
NI	3.0	1.3	0	GB-1.5
PY	2.7	2.2	0	DE-2.0
PA	2.3	31	4.7	GB-1.3
HT	2.0	6.8	0.5	FR-2.0
DO	1.8	8.2	0.3	
HN	0.8	4.8	0.2	
SV	0	0.8	0	

Results – international co-authorship with third countries

An analysis was made of the numbers of papers in the SCI co-authored by scientists with corporate addresses in each of the 20 Latin American nations listed in Table 1 and scientists from the European Community (taken, for the sake of continuity, to include the former German Democratic Republic in the years 1986-90), from the United States and from Canada.

The results for all six years combined are presented on an annualised basis in Table 7, with the nations ordered by the numbers of papers co-authored with the E.C.

The last column gives the leading E.C. Member States in terms of their scientific co-authorship with each Latin American nation. Member states are listed if and only if they have co-authored, on average, at least one paper per year with the L.A. nation.

Table 8 examines the same situation from the point of view of the E.C. Member States and lists their overall output and the number and percentage of papers co-authored with Latin America.

Table 8
E.C. Member States' output of papers in the SCI in 1986-91 co-authored with scientists from Latin America (L.A.); figures annualised

Member State	ISO Code	Total Pubs.	With L.A.	%	Leading L.A. nations
France	FR	30217	281	0.93	BR-117, AR-51, MX-38, CL-35
Germany	DE	40504	219	0.54	BR-84, AR-35, CL-35, MX-28
UK	GB	54538	200	0.37	BR-91, MX-28, CL-22
Spain	ES	7648	133	1.74	CL-32, MX-30, AR-25
Italy	IT	16125	119	0.74	BR-47, AR-25, CL-13
Belgium	BE	5673	42	0.75	BR-17
Netherlands	NL	12263	31	0.25	BR-13
Denmark	DK	5209	18	0.35	
Portugal	PT	699	9	1.30	BR-7
Greece	GR	1775	4	0.21	
Ireland	IE	1277	3	0.25	
Luxembourg	LU	48	0	-	
E.C.		167283	946	0.57	
USA	US	226375	1107	0.49	
Canada	CA	27202	138	0.51	

This table also shows the amount of co-operation with scientists from the USA and Canada. On average, half of one percent of the scientific output of the USA and Canada, and a slightly higher proportion (0.57%) for the E.C., is co-authored with scientists from Latin America, although it is much higher for a few E.C. Member States, notably Spain, Portugal and France, and somewhat higher for Belgium and Italy.

These figures are all averages over the six years, and some changes have occurred between the first and second three-year periods. All E.C. Member States except Ireland and Luxembourg have increased their number of joint publications between 1986-8 and 1989-91, see Table 9, in which the Member States are ordered by the increase in this number.

Table 9
Increases in EC Member States' co-publications in the SCI between 1986-8 and 1989-91 with Latin America. Papers per year

M.S.	1986-8	1989-91	Increase
FR	231.0	331.3	100.3
ES	95.0	170.3	75.3
DE	192.7	257.0	64.3
IT	90.7	147.7	57.0
GB	171.7	228.7	57.0
DK	9.3	26.7	17.3
BE	35.7	45.7	10.0
NL	27.3	34.0	6.7
PT	6.7	11.7	5.0
GR	2.3	5.3	3.0
LU	0.0	0.0	0.0
IE	4.0	2.3	-1.7

The notable increase in Spanish joint publications is probably attributable to the support for co-operative research projects by the Spanish National Research Council and described by *Fernández et al.*¹⁸ Almost all the projects were in five nations: Argentina (21), Brazil (13), Chile (20), Cuba (26), and Mexico (13). In the four large countries, the Spanish programme, whose major effort was between 1986-89, is hard to distinguish from the overall increase in joint publications (although must have contributed to it), but in Cuba there was a sudden jump in joint publications from only 1 in 1986-8 to 25 in 1989-91.

Figure 5 shows, for nearly all the LA nations, the numbers of co-authorships with the E.C. plotted against those with the USA, at log scale. The circles for each country

show the situation in 1989-91 compared with 1986-88: for nearly all countries the line between them points north east, showing that both forms of co-operation have increased. The line at 45° represents equality of co-authorship between the E.C. and the USA; the chain-dotted lines with slopes of 2 and 0.5 represent the E.C. having ten times the number of co-authorships that the USA has, and *vice versa*, respectively. In the former category lie Bolivia, Cuba and Nicaragua; in the latter there are the Dominican Republic, Guatemala, Haiti and Panama.

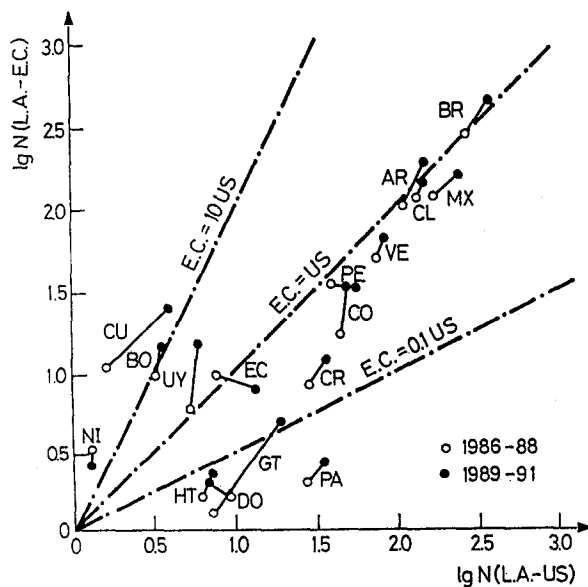


Fig. 5. Log-log plot of numbers of papers per year from Latin American nations co-authored with the E.C. against the numbers co-authored with the US, for 1986-88 and 1989-91

Finally, an examination was made of the possibility that the participation of a third country (from the E.C. or the US or both) might lead to a greater tendency for LA nations to work together. The results are shown in Figure 6 in the form of part of a Venn diagram of intersecting circles. (The circles have areas in correct proportion to the numbers of SCI papers they represent but the overlap areas are slightly distorted.)

The overall proportion of LA papers co-authored internationally within the region is 158/8595 or 1.8%. If an E.C. author participates, the proportion is 23/936 or 2.5% and if a US author does, the proportion is similar at 28/1093 or 2.6%. However if both an E.C. and a US author take part, the proportion rises to 5/95 or

5.3%. (All figures are in SCI papers per year.) The pattern is remarkably consistent from year to year over the six years 1986-91, although most forms of collaboration have doubled in proportion to output over the period. The evidence suggests that LA regional collaboration is enhanced if an E.C. or US scientist is a co-author ($P < 0.1\%$) and noticeably enhanced if both are present ($P < 0.01\%$).

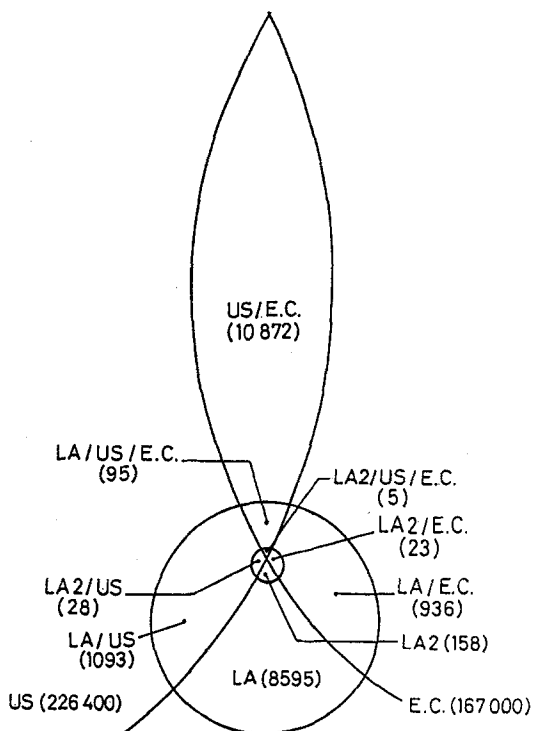


Fig. 6. Venn diagram of the effect of E.C. and U.S. co-authorship on the transnationality of L.A. papers in the SCI within the region. Yearly average for 1986-91

The patterns of scientific co-operation between the USA and the E.C. and Latin America follow closely the cultural and political ties - or absence thereof. In fact the statistics on co-authorship reflect political realities to a remarkable degree, as witness the relative lack of co-operation between the UK and Argentina, and between the US and Cuba and Nicaragua. Cuba's links have primarily been with Russia/USSR and the countries of eastern Europe. The six small countries of Central America, and

Mexico, remain very clearly within the US sphere of influence (except, of course, for Nicaragua).

Within the E.C., France has clearly been making a major effort to provide opportunities for her scientists to co-operate with Latin America, and she is the leading Member State in the three largest L.A. nations in terms of joint scientific output. Germany is relatively strong in Chile, Costa Rica and Paraguay; the UK in Venezuela, Peru, Colombia and Ecuador; and Italy in Cuba and Argentina. The patterns of co-authorship shown here are quite similar to those shown by *Narvaez-Berthelemot et al.*² for 1981–6 except in Argentina where the links with Spain are now relatively stronger and those with the UK, weaker.

Overall, the E.C. has strengthened its position in the region relative to that of the US, and in two thirds of the L.A. nations including the five largest (Brazil, Argentina, Mexico, Chile, and Venezuela) its number of co-authored papers has increased faster than has the number co-authored with the US. This is probably due to the efforts in recent years in some E.C. Member States, notably France and Spain, and by the CEC through the ISC programme, to support joint scientific work with Latin America.

An attempt was made to assess to what extent the ISC programme, which has operated in nine of the 20 nations, can be considered to have contributed to the rise in the number of joint L.A.–E.C. publications in the SCI. One might expect that the influence would be greater than that occasioned by the projects actually financed by the CEC as many others will have been submitted unsuccessfully. The mere act of preparing them will have created an opportunity for the scientists to learn more about each others' work and, perhaps, to have worked together under different sponsorship.

In order to see the effects of the ISC programme in context, the numbers of man-years (often, in fact, women-years) of L.A.–E.C. contact through a fellowship or a joint research project during the three years 1988–90 were determined for each of the nine nations. This is the operative period to have had a plausible influence on the differences between the numbers of joint L.A.–E.C. publications between 1986–8 and 1989–91. There is a small ($r = 0.37$) but positive correlation between the increase in the numbers of such publications and the ISC man-years, which suggests that the ISC programme may account for about one third of the observed variation in output of joint papers. A modifying factor will be the subjects chosen for the scientific work: in some, such as biology, medicine and physics, there is a much greater propensity to publish in SCI journals than in others, such as agriculture and engineering. There is, in fact, a general increase in the amount of trans-national scientific co-operation and against this background it is often difficult to perceive the effects of particular initiatives.

Conclusions

This paper has sought to show that patterns of international collaboration in science can be traced among the nations of Latin America from an analysis of Science Citation Index publications. Trans-national co-authorship, both within the region and with third countries, is increasing fairly rapidly but is still not very high. Several E.C. Member States, notably France and Spain, have increased their co-operative programmes with Latin America and these, and the E.C.'s own International Scientific Co-operation programme, have borne a harvest of joint scientific publications. However it must be remembered that the SCI only shows the publications in selected international journals and these may well not reveal the whole picture of such international co-operation.

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