INTERNATIONAL SCIENTIFIC COLLABORATION IN LATIN AMERICA

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ABSTRACT

This study attempts to analyse the extend of the usability of international databases such as the Science Citation Index (SCI) for the observation of the international collaboration in lesser-developed countries. We have examined the adequacy of this data source (the SCI) in perceiving the international scientific activities of nine Latin American countries. We have studied the relationships of these countries with their main foreign partners in the large fields of science. It has been observed that some of these relationships are not covered by the data source under study. The creation of an information system storing complementary data suited for the identification of existing international collaborative projects is recommended. In the long-range future such a system would provide more appropriate information for the analyses of international collaboration.

RESUME

Cette étude tente d'analyser les limites de l'utilisation des bases de données internationales telle que Science Citation Index (SCI) pour l'observation des collaborations internationales dans les pays les moins développés. Nous avons examiné la pertinence de cette base (SCI) en prenant en compte l'activité scientifique internationale de neuf pays d'Amérique Latine. Nous avons étudié les relations de ces pays avec leurs principaux partenaires étrangers dans les grands domaine de la science. Nous avons ainsi observé que certaines de ces relations n'étaient pas couvertes par la base de données étudiée. C'est pourquoi la création d'un système d'information pour le stockage de données complémentaires permettant l'identification des projets menés dans le cadre de collaborations internationales nous paraît nécessaire. A long terme, un tel système fournirait des informations plus appropriées pour l'analyse des collaborations internationales.

INTRODUCTION

Many mesures of the scientific activities of a country have been employed, including counts of publications, author productivity, or collaborative projects. Measuring scientific production is relatively recent. One of the first studies on this subject counted and classified publications country by country (1).

Bibliometric indicators such as links between authors (reference coupling); study impact (citation analysis); source impact (impact factor, immediacy index, journal influence); subject relationship (co-references, co-citations and co-word analysis); (2,3) and coauthorship (4) have been developed .

In international collaboration, as shown by Frame and Carpenter (5), coauthorship is more frequent in fundamental science than in applied science. Geographical, political, and cultural factors also strongly influence international collaboration, as does the scientific status of a country.

Analyzing international collaboration in science using bibliometric indicators is becoming more and more frequent due to the fact that scientific activities are more internationalized than ever. Better facilities for study and training, increased financing by national and international organizations, and improved ways of communication enable scientific international relations between researchers, laboratories, and large organizations to develop.

Most of the bibliometric studies mentioned are comprised of quantitative information extracted from an international database, usually the Science Citation Index (SCI) of the Institute for Scientific Information (ISI).

Indicators for the measure of international collaboration are presently being developed by the Laboratoire d'Evaluation et de Prospective Internationales (LEPI) of the Centre National de la Recherche Scientifique (CNRS). Two databases developed at LEPI-CNRS, "BADIN" and "MEV-MAC", have been chosen for this study. The objectives of this study are to observe:

(a) the participation of nine Latin American countries in mainstream scientific journals;

(b) the collaboration between Brazil and other Latin American countries;

(c) the collaboration between six Latin American countries (Mexico, Chile, Argentina, Venezuela, Colombia and Peru) and France. For this third observation the BADIN and MEV-MAC database are compared with each other to determine their respective abilities in covering the collaboration in general and the selectivity of projects between France and its Latin American partners.

The work conducted at LEPI shows that interpretation of data from the SCI database can be useful for the analysis of international activities in developed countries (DCs). The question of analyzing these activities in lesser-developed countries (LDCs) is still under discussion and merits further study. However, by using the SCI's database, it is possible to obtain a views of the development of the scientific activities of a country in a specific field and of the scientific relationships between countries. We attempt to compare selective and non-selective databases and to analyze the effect of the "selectivity" in observing Latin American international activities.

METHODOLOGY

The question of the "visibility" of science in the LDCs (6) could be reconsidered by using "non selective" data bases such as BADIN. This database is an inventory which identifies the international projects between the CNRS and its partners throughout the world. The BADIN data has no selectivity criteria.

The MEV-MAC matrix is made up of projects having produced publications in mainstream journals and therefore shows selective scientific activities between countries. This database is derived from the Science Citation Index (SCI) produced by the Institute for Scientific Information (ISI, Philadelphia, PA, USA). The SCI data contains the number of publications and the number of internationally co-authored articles, notes and reviews in over 3,000 journals. In the present study we have used the 1981's fixed journal set processed by Computer Horizons Inc. (CHI). SCI's main advantage is its coverage of data in fundamental science. The SCI database also includes the affiliations of all of the authors for each article. This detailed information enables quantitative studies of international collaboration in the eight large divisions of the sciences.

In this study we show data concerning the nine most scientifically productive countries in Latin American: Brazil, Mexico, Argentina, Venezuela, Chile, Colombia, Peru, Cuba, and Jamaica.

We use Carpenter's classification of eight scientific fields (7), accepted by the National Science Foundation (NSF). These fields, represented by the following abreviations, are: MAT (Mathematics), PHY (Physics), CHM (Chemistry), ENT (Engineering & Technology), EAS (Earth & Space Sciences), BIO (Biology), BIM (Biomedicine), and CLI (Clinical Medicine). The countries are identified using the ISO codes, e.g.: Brazil=BRA, Peru=PER. The data corresponds to the six-year period from 1981 to 1986. The count represents the number of international co-authorships for each country.

RESULTS

During the period 1981-1986 the nine Latin American countries under study produced a total of approximately 30,000 articles in the fields considered: 17,602 in the Life Sciences (Biology, Biomedicine and Clinical Medicine), 4,805 in Physics, 3,961 in Chemistry, 1,677 in Earth & Space sciences, 1,141 in Engineering & Technology, and 746 in Mathematics.

International activities varied widely in the nine Latin American countries studied (Table 1).[1] Observing the percentage of internationally co-authored articles in the total scientific production in these countries, during the period 1981-1986 in the eight fields combined, we see that some countries produced

[1]Tables and figures are presented at the end of the paper.

more locally than internationally: Brazil (26% internationally), Chile (23%), Mexico (31%), and Argentina (13%). In Cuba (50%), Colombia (48%), and Jamaica (41%), these two forms of production were almost equally represented. Peru had the highest proportion of international coauthorship (61%). In Table 1 we see that the three Life Sciences fields had the largest percentages of the total coauthorship activities in each country, varying from 10 to 30%, except in Clinical Medicine which was even higher in Colombia and Jamaica. Physics also had high rates but only in three countries: Brazil, Argentina, and Mexico. These countries had similar proportions in almost all fields. Cuba should be noted for its rate of 24.9% in Chemistry. Chile should be noted for its rate of 27.4% in Earth & Space science. Activities of the European Spatial Observatory (ESO), at La Silla, and of the Cerro Tololo Inter-American Observatory, at La Serena make up a large part of this rate. Colombia was more active in Biology (31.2%) than were the other eight countries. Neither Engineering & Technology nor Mathematics had rates greater than 6.2% in any of the nine countries.

1) Participation of eight Latin American countries in mainstream journals: MEXICO, ARGENTINA, VENEZUELA, CHILE, COLOMBIA, PERU, CUBA, JAMAICA

Figure 1 shows the principal partners of the four Latin American countries, Mexico, Argentina, Venezuela, and Chile. The order of representation of the 12 largest partners was somewhat similar in Mexico, Venezuela, and Chile. During the period 1981-1986, Mexico produced 878 co-authored articles with the USA, whereas the three other countries, Argentina, Venezuela, and Chile, produced less than half this quantity with the USA. The remaining 11 partners co-authored less than 150 articles each with each of the four countries. Argentina collaborated actively with Brazil, in second place after the USA.

Representation field by field of collaboration between these four countries and the USA can be seen in Figure 2. For three of the countries, the Life Sciences, especially Clinical Medecine, were the most active fields and were followed by Physics. In Chile, Earth & Space was the most active field.

A series of charts are in annexe (Charts 1-4) in which partners are classified by the number of their coauthorships with the four Latin American countries under study. In each chart the number of partners listed in the "ALL" column corresponds to the number of partners in the most diversively collaborating field of the country under study. We define here "the most diversively collaborating field" as the field which had the largest number of partner countries producing at least 5 co-publications with the country under study. For instance, for Mexico (chart 1), 13 countries are listed in the "ALL" column because there were 13 partners producing at least 5 co-publications in the Physics column, Mexico's most diversively collaborating field. That is why all of the partners in the Physics column are printed in upper case characters. The number of co-authored articles

(COAs) for each partner in the "ALL" column is given. The total number of coauthorships for each field (COA-WORLD, horizontal row) is given, as is the total number of partners with at least 4 coauthorship during the period, for each field (PARTNERS-WORLD, horizontal row). In each field column, countries with 2 to 5 articles in the period are listed in lower case characters for general information.

Mexico had 28 partners in the world having at least 5 co-authored articles, notes, or reviews in the six-year period, all fields combined. Five out of the thirteen largest partners listed in chart 1 were in the highest positions. FRA, CAN, GBR and DEU followed the USA in different orders in the different fields. France was well situated in the second horizontal row in 4 fields, notedly in Chemistry and Physics, and Great Britain, the second partner in Clinical Medicine, was well placed in the third row in the Life Sciences and Engineering & Technology. Canada was the second largest partner in Engineering & Technology and Mathematics. Germany was second in Biomedicine. Spain, the sixth partner in the ALL column, was fourth in Physics. Brazil, the seventh partner in the ALL column, was the fourth in Biomedicine. In the fifth row partners were more diversively represented: ESP (Engineering & Technology, Biology), SWE (Clinical Medicine) and ITA (Earth & Space Sciences). From the sixth to the eighth row Latin America (BRA, VEN, COL, CHL) and Spain were more visible. Poland was linked with Mexico through Chemistry (7th row) and Mathematics (3rd row). Switzerland, Belgium, and India should be noted in Physics. Sweden in Clinical Medicine had its only field attachment with Mexico. Life Sciences had 12 partners represented in its fields' columns: 7 in Biology, 7 in Biomedicine, and 8 in Clinical Medicine. However, the largest number of partners having published at least 5 co-authored articles with Mexico was found in Physics. Physics in Mexico was the country-field producing the largest number of co-authored articles in all of the 4 countries under study (391 papers). Clinical Medecine was the second largest having 368 papers co-authored by Mexico.

Argentina had 20 partners with which it produced at least 5 papers during the six-year period, all fields combined. In chart 2, we see that five countries were placed in the first and second rows in most of the fields (USA, BRA, FRA, DEU, GBR). France replaced the USA in the first row in Chemistry. Brazil was Argentina's second largest partner in Physics, Biomedicine, and Mathematics, and its third largest partner in Chemistry and Clinical Medicine, but there were no articles with Brazil in Engineering & Technology. Two other Latin American countries, Venezuela and Chile, appeared in medium positions. Germany was well placed in four fields as the second (Engineering & Technology, Biology) and the third (Earth & Space Sciences, Biomedicine) partner. As in Mexico, Great Britain was the second partner in Clinical Medicine, and France was second in Earth & Space Sciences. Italy, Spain, and Canada co-authored in several fields (rows 5 to 10). The Netherlands in Earth & Space Sciences, Sweden in Physics, and Belgium and Switzerland in Clinical Medicine and

Biomedicine, all had links in a few fields with Argentina. Clinical Medecine and Physics both had the largest number of partners having produced at least 5 co-authored articles with Argentina: 10 countries are listed in upper case characters in these columns. Biomedicine, Earth & Space Sciences and Chemistry followed as the most diversively collaborating fields.

Venezuela had 16 partners with which it produced at least 5 coauthorships during the period, all fields combined. In chart 3, we see that three countries were in the highest positions in several fields (USA, GBR, FRA). Great Britain replaced the USA in first place in Chemistry, and as was the case for its collaboration with Mexico and Argentina, it was well placed in Life Sciences. France was situated in the second horizontal row in Physics and Japan was second in Clinical Medicine and Engineering & Technology. Venezuela's links with Spain were visible in Chemistry, and links with other Latin American countries were most significant in Biomedicine (ARG, BRA, MEX). Canada was present in various rows and in five fields. Venezuela had its greatest number of partners in Biomedicine (7).

With 25 partners having produced at least 5 coauthorships during the period of study, 38% of Chile's links was with the USA, in first place all fields. In chart 4 it should be noted the second place in Chemistry occupied by Spain, because it published with Chile nearly as much as did the USA (33 and 35 articles respectively) and was Chile's second partner in Biology. Chile was linked with Belgium in Physics (11 articles) and with other European countries. Germany (37 articles), Great Britain (37 articles), France (28 articles), and Canada (26 articles) were very active in Earth & Space Sciences, owing to the ESO and to the Cerro Tololo activities mentioned above. France came second in Biomedicine and third after Brazil in Clinical Medicine. Only Brazil and Argentina (the third partner in Biomedicine) were significant partners in Latin America. Earth & Space Sciences and Clinical Medicine had the largest number of partners. Earth & Space Sciences in Chile was the country-field producing the third largest number of co-authored articles (358) in all of the four countries.

Figures 3, 4, 5 and 6 show the largest partners and the breakdown of fields for coauthorships between Colombia, Peru, Cuba and Jamaica and the world during the period 1981-1986. In figures 4 and 6, concerning Peru and Jamaica only eight partners are shown as there were only eight which produced at least 5 co-authored articles with these countries. Except for Cuba, the USA was the first partner for this group of countries. The Life Sciences were the most active fields and were followed by Chemistry and Physics (in Colombia, Cuba, and Jamaica) or Earth & Space Sciences (Peru). The relative positions of the partners field by field is not shown because the number of papers co-authored was often less than 5.

Nevertheless, some of the links seem to be of particular interest: the USA represented 47% of the links involving Colombia, and had hight rates in the Life Sciences: 151 articles out of 160 articles were made in these fields. Brazil, the fouth partner in all fields combined (Figure 3), co-authored 10 articles in Biology

with Colombia, where it was in second position after the USA. Spain was Colombia's first partner in Chemistry (5 articles). In collaborating with Peru (Figure 4), the USA obtained the highest percentage of links for this group of countries (51%). Japan was an active second partner in Earth & Space Sciences (8 articles), following the USA (20 articles). France was Peru's first partner in Chemistry (5 articles) and Clinical Medicine (7 articles). Germany was specially linked with Peru in the Life Sciences: 17 articles out of 22 were made in these fields.

For the period in reference, the Soviet Union and the Eastern European countries were Cubas's most active partners (figure 5), making up 66% of the links in all fields combined and 24,5% for the Soviet Union alone. It is also notable that after the Life Sciences, Chemistry was the other important field of interest for collaboration, as is often the case in collaboration with Eastern European countries. Italy was the first western partner having produced five articles with Cuba in Clinical Medicine and six in Physics, and was followed by the USA. Cuba's Latin American partners were under-represented in the SCI database: Argentina, Chile, Colombia and Mexico, produced one co-authored article each, and Costa Rica produced two during the six-year period.

In Jamaica (Figure 6), the first positions were shared by the USA (32,5%) and Great Britain (28,7%). Great Britain was first in Clinical Medicine (45 articles) and Biomedecine (8 articles). The USA was second in Clinical Medicine (28 articles), in Biomedicine (7 articles) and the first in Biology (22 articles).

2) Collaboration between BRAZIL and its Latin American partners

In chart 5, all of the links between Brazil and its Latin American partners are given, and those with at least 2 co-authored articles are listed in the ALL column. We see that three Latin American countries, Argentina, Chile, and Mexico were particularly linked with Brazil. Nevertheless, Colombia was Brazil's largest partner in Biology, representing 50% of the links, but Venezuela's collaborative activities with Brazil were more diversified in Mathematics, Clinical Medicine, and Biomedicine. Engineering & Technology, Earth & Space Sciences and Mathematics were not active fields among these partners. Only the 5 largest Latin American partners are represented in figure 7, which summarizes Brazil's collaboration with these countries for the period in reference, in five significant fields (Physics, Chemistry, Biology, Biomedicine, and Clinical Medicine).

It can be observed that in the MEV-MAC matrix, which itself is based on the SCI database, some relationships were not present. For example, in MEV-MAC, in Engineering & Technology Brazil registers only 2 articles with its Latin American neighbors during the six-year period. In Chemistry, Argentina registers no coauthorship with Chile and Venezuela registers none with Mexico. In Mathematics, Peru and Cuba register no international partners, Jamaica registers

only a total of two articles, and Colombia registers 3 articles all of them with the USA. This same situation of under-representation is similar in Earth & Space Sciences and in Engineering & Technology.

3) Collaboration of six Latin American countries with France

At LEPI-CNRS, analyses of international activities include studies on the mobility of researchers (9), and studies on spontaneous collaborative projects between scientists from the CNRS and from other laboratories throughout the world (10). For "macro" analysis, LEPI-CNRS also uses indicators to analyze relationships and trends between countries (11). For such analysis the SCI database is used.

Figure 8, derived from data in MEV-MAC, shows the number of co-authored articles between France and each of six countries (Mexico, Argentina, Venezuela, Chile, Colombia, and Peru) for the years 1982, 1984, and 1986. In 1982, 58 articles were written, compared to 71 in 1984, and 89 in 1986. Collaboration between the six countries combined and France grew by 35%.

The BADIN database, which identifies all projects between the CNRS and its partners throughout the world, stems from the spontaneous participation of CNRS researchers. This means that no sure numbers are obtained but a general appreciation can be determined of tendencies in fields and of the amounts of collaboration of different countries working with the CNRS.

Figure 9 shows that the 91 collaborative projects between the six Latin American countries under study and the CRNS teams identified in 1989 in BADIN produced 153 publications, 18 theses, and 12 instrument developments.

Figures from BADIN can also be correlated with the number of exchange visits by PhDs or post-doctorates. Exchanges between LDCs and DCs are often associated with graduate and postgraduate studies and with instrument development (technological transfer), as observed by LOMNITZ:

"The percentage of papers co-authored with foreigners ... reached a peak in 1969, owing to the return to Mexico of the first important group of PhDs who published papers co-authored by their thesis advisers. This collaboration reflects the most important entry of Mexican scientists into international networks, as contacts with foreign professors and colleagues are likely to be maintained for life." (12)

However, these activities are not always "seen" through SCI data, especially if the data is stored during the time the collaborative work is at an early stage.

Of the 153 publications in the 1989 BADIN study (Figure 9), we had enough information to cross-check 132, and it was found that 100 (75%) of these 132 publications were co-authored and published in high-quality journals, most of them in the mainstream category.

If we examine the typical process of publishing, we observe that it begins with the training of a researcher coming from a LDC for a PhD thesis.

Communications are prepared by one of the partner countries in that partner country's language. These communications are not always co-authored. Later, the co-authored articles are drawn-up, usually in English, in an international journal, usually in the mainstream category. It should be noted that of the 50 co-authored articles in the "selective journals" only one was in French and one in Spanish, while of the 22 co-authored communications, 7 were in English, 4 in French and 11 in Spanish.

Some evidence has been brought forward that a large part of LDC production is of a "high selectivity" nature when international collaborative works are performed (13).

CONCLUSION

MEV-MAC, based on the SCI database, enables useful interpretations and observations of the international activities between lesser developed countries and developed countries in fundamental science. For certain cases it could also be useful to observe the development of selective international projects between Lesser Developed Countries and the links between countries for a long period of time.

However, more appropriate indicators are necessary for identifying the output of LDCs not found in mainstream journals.

For a regular follow-up of results using adequate databases, the question of the criteria for selection of collaborative works remains under discussion.

National, regional, or institutional databases are necessary to the follow up of the activities of each collaborative project. Such databases would enable both the identification of the works being conducted and the future analyses of selected results.

LDCs would be able, not only to identify joint projects, but also to obtain more detailed and useful information. By using compatible formats for identifying collaborative projects, a more realistic and complete image of the activities involved could be achieved.

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Annex

TABLE 1

Scientific activity of Latin America (1981-1986)
Total number of articles (PROD)
Number of international coauthorships (COA) and percentage of 8 fields

	PROD	COA	MAT	PHY	CHM	ENT	EAS	BIO	BIM	CLI
BRA	9997	2628	5.9	23.0	9.0	5.8	7.7	14.1	16.5	18.0
ARG	7081	922	1.8	22.3	9.9	5.5	10.7	12.1	18.7	19.0
MEX	4899	1525	3.3	22.0	12.1	6.2	10.4	14.2	11.7	20.1
CHL	3982	930	2.7	6.6	13.0	3.3	27.4	14.6	14.9	17.5
VEN	2154	679	6.0	16.6	11.6	4.4	4.8	13.4	17.3	25.9
COL	594	288	1.0	3.1	4.5	1.3	3.1	31.2	14.9	40.9
CUB	472	236	0	9.3	24.9	0	5.0	19.4	19.4	22.0
JAM	408	168	1.1	7.7	12.5	2.3	1.1	21.0	11.3	43.0
PER	345	221	0	1.0	3.6	2.2	13.1	23.5	28.0	28.6
WORLD	2265438	150877	4.0	19.6	12.1	6.0	8.0	8.1.	18.0	24.2

CHART 1

MEXICO'S PARTNERS IN EIGHT FIELDS (1981-1986) CLASSIFIED IN ORDER OF NUMBER OF COAUTHORSHIPS

	MAT	PHY	CHM	ENT	EAS	BIO	BIM	CLI		ALL	COAs
	USA	USA	USA	USA	USA	USA	USA	USA	1	USA	878
	CAN	FRA	FRA	CAN	FRA	FRA	DEU	GBR	2	FRA	136
	pol	DEU	CAN	GBR	DEU	GBR	GBR	FRA	3	CAN	103
	che	ESP	GBR	FRA	GBR	DEU	BRA	CAN	4	GBR	97
	deu	CAN	DEU	ESP	ITA	ESP	FRA	SWE	5	DEU	81
	gbr	BRA	ESP	jpn	CAN	ITA	CAN	CHE	6	ESP	64
	esp	CHE	POL	ind	ESP	CAN	VEN	VEN	7	BRA	40
		IND	bra	bel	ven	chl	che	COL	8	ITA	36
		GBR	jpn	deu	yug	isr	chl	bel	9	CHE	29
		ITA	dnk	chl	arg	bra	dnk	bra	10	IND	21
		BEL	arg	aus	sun	ven	yug	zaf	11	VEN	19
		DDR		ven	ind	arg	esp	arg	12	ARG	19
		ARG			pol	per	swe	ita	13	POL	19
COAs	58	391	195	109	184	229	216	368		WORLD	1750
PARTNERS	2	13	7	5	7	7	7	8	28	WORLD	

Column each field -> Upper case : 5 or more coauthorships
-> Lower case : 2 to 4 "

COAs WORLD Row = Total of coauthorships in the field
PARTNERS Row = Total of Mexico's partners with 5 COAs in the field

CHART 2

ARGENTINA'S PARTNERS IN EIGHT FIELDS (1981-1986) CLASSIFIED IN ORDER OF NUMBER OF COAUTHORSHIPS

	MAT	PHY	CHM	ENT	EAS	BIO	BIM	CLI		ALL	COAs
	USA	USA	FRA	USA	USA	USA	USA	USA	1	USA	371
	bra	BRA	USA	DEU	FRA	DEU	BRA	GBR	2	BRA	117
		FRA	BRA	FRA	DEU	CHL	DEU	BRA	3	FRA	101
		DEU	DEU	GBR	NLD	FRA	GBR	FRA	4	DEU	100
		ITA	GBR	esp	CAN	bra	VEN	ITA	5	GBR	75
		GBR	ESP	ita	GBR	ita	CHL	DEU	6	ITA	48
		SWE	can	chl	CHL	nld	FRA	BEL	7	CHL	33
		VEN	ita	swe	bra	esp	ITA	SWE	8	VEN	30
		MEX	mex	che	ita	can	CHE	CHE	9	CAN	29
		ESP	aus		mex	aus	bel	CAN	10	ESP	27
COAs	19	248	97	53	123	127	216	231		WORLD	1114
PARTNERS	1	10	6	4	7	4	9	10	20	WORLD	

Column each field -> Upper case : 5 or more coauthorships
-> Lower case : 2 to 4 "

COAs WORLD Row = Total of coauthorships in the field
PARTNERS Row = Total of Argentina's partners with 5 COAs in the field

CHART 3

VENEZUELA'S PARTNERS IN EIGHT FIELDS (1981-1986) CLASSIFIED IN ORDER OF NUMBER OF COAUTHORSHIPS

	MAT	PHY	CHM	ENT	EAS	BIO	BIM	CLI		ALL	COAs
	USA	USA	GBR	USA	USA	USA	USA	USA	1	USA	382
	CAN	FRA	USA	jpn	gbr	GBR	GBR	JPN	2	GBR	73
	FRA	GBR	FRA	aus	mex	CAN	ARG	GBR	3	FRA	48
	gbr	CAN	ESP	can	fra	fra	FRA	ITA	4	CAN	33
	chl	ARG	DEU	fra		col	BRA	MEX	5	ARG	30
		ITA	ITA	gbr		deu	ITA	FRA	6	ITA	29
		bra	can	mex		arg	MEX	esp	7	MEX	19
COAs	44	132	83	33	37	96	135	191		WORLD	751
PARTNERS	3	6	6	1	1	3	7	6	16	WORLD	

Column each field -> Upper case : 5 or more coauthorships
-> Lower case : 2 to 4 "

COAs WORLD Row = Total of coauthorships in the field
PARTNERS Row = Total of Venezuela's partners with 5 COAs in the field

CHART 4

CHILE'S PARTNERS IN EIGHT FIELDS (1981-1986) CLASSIFIED IN ORDER OF NUMBER OF COAUTHORSHIPS

	MAT	PHY	CHM	ENT	EAS	BIO	BIM	CLI		ALL	COAs
	USA	USA	USA	USA	USA	USA	USA	USA	1	USA	436
	FRA	BEL	ESP	GBR	DEU	ESP	FRA	BRA	2	DEU	92
	deu	GBR	BRA	can	GBR	DEU	ARG	FRA	3	FRA	86
	bra	FRA	FRA	deu	FRA	ITA	DEU	GBR	4	GBR	79
	ven	deu	DEU	arg	CAN	ARG	CAN	CAN	5	ESP	75
		ita	NOR	mex	AUS	fra	ESP	DEU	6	CAN	60
		esp	can		NLD	gbr	GBR	SWE	7	BRA	49
		arg	gbr		ITA	can	BRA	CHE	8	ARG	33
		che	ita		DNK	mex	mex	COL	9	ITA	31
		mex	bel		JPN	per	ita	THA	10	AUS	27
			ven		ESP		aus	NGA	11	BEL	19
			sau		ARG		bel	aus	12	CHE	17
					CHE		jpn	ind	13	NLD	17
COAs	27	69	130	34	358	146	159	236		WORLD	1159
PARTNERS	2	4	6	2	13	5	8	11	25	WORLD	

Column each field -> Upper case : 5 or more coauthorships
-> Lower case : 2 to 4 "

COAs WORLD Row = Total of coauthorships in the field
PARTNERS Row = Total of Chile's partners with 5 COAs in the field

CHART 5

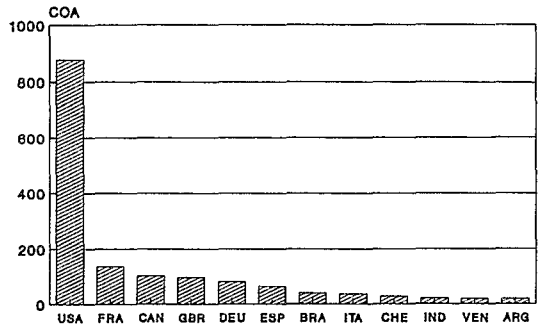
BRAZIL'S LATIN AMERICAN PARTNERS IN EIGHT FIELDS (1981-1986) CLASSIFIED IN ORDER OF NUMBER OF COAUTHORSHIPS

MAT	PHY	CHM	ENT	EAS	BIO	BIM	CLI		ALL	COA
arg	ARG	ARG		arg	COL	ARG	CHL	1	ARG	117
chl	MEX	CHL		chl	arg	MEX	ARG	2	CHL	49
	ven	mex			ury	VEN	URY	3	MEX	40
					mex	CHL	mex	4	VEN	18
						col	ven	5	COL	18
						cri	col	6	URY	9
							cri	7	CRI	6
							per	8	PER	5

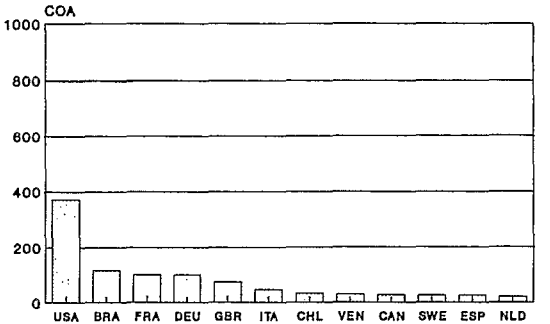
Column each field -> Upper case : 5 or more coauthorships
-> Lower case : 2 to 4 "

Figure 1. Coauthorship number (COA), Latin America & their 12 largest partners, ALL fields, 1981-1986

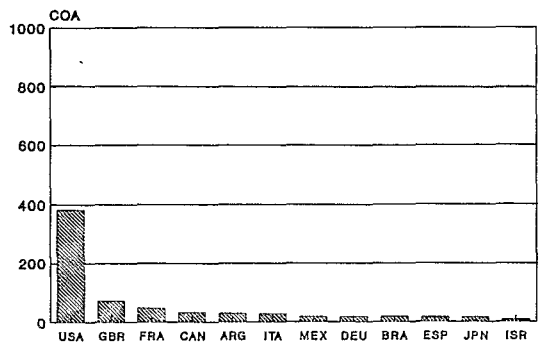
MEXICO



ARGENTINA



VENEZUELA



CHILE

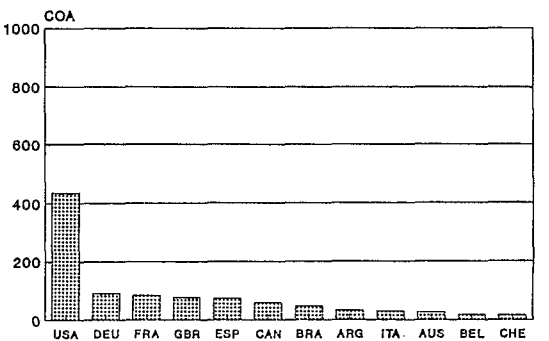


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Fig. 2 Coauthorship number (COA), 4 Latin America countries and the USA, field by field, 1981-1986

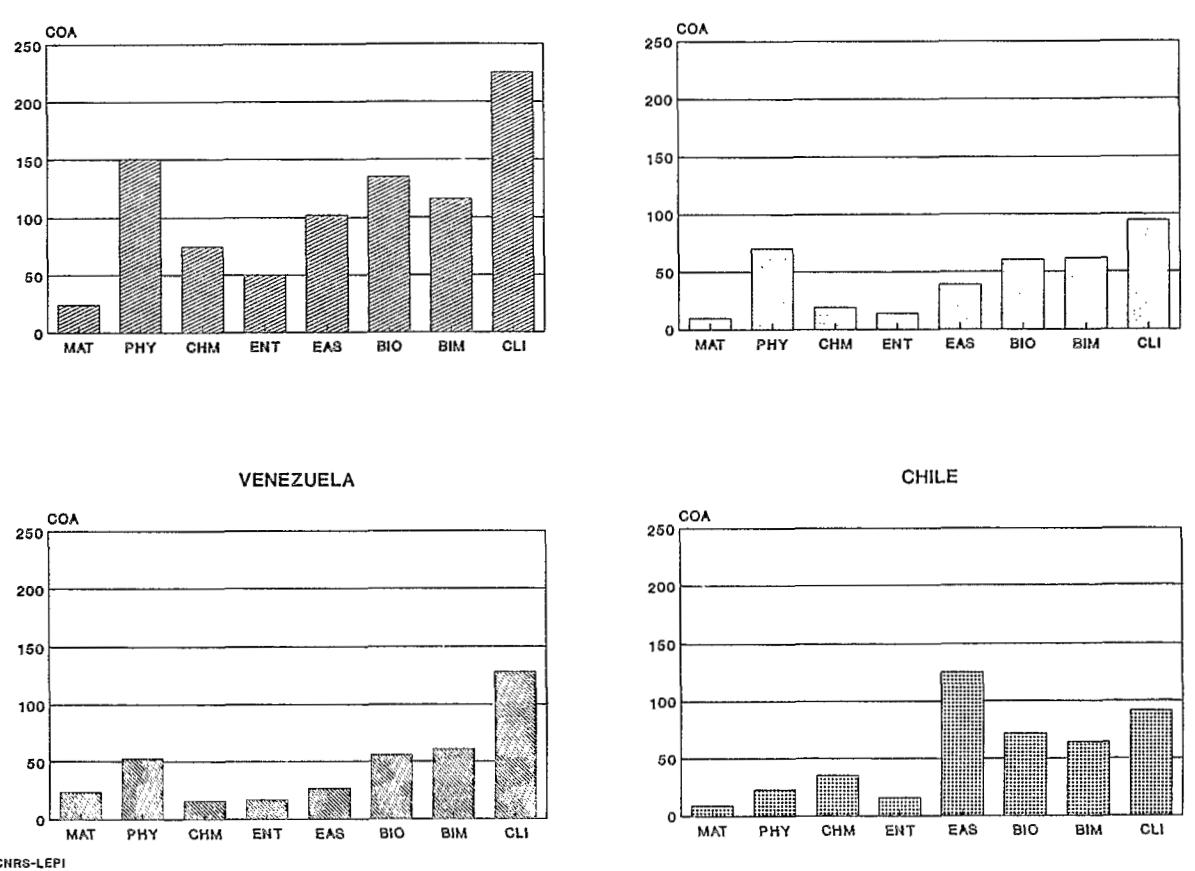

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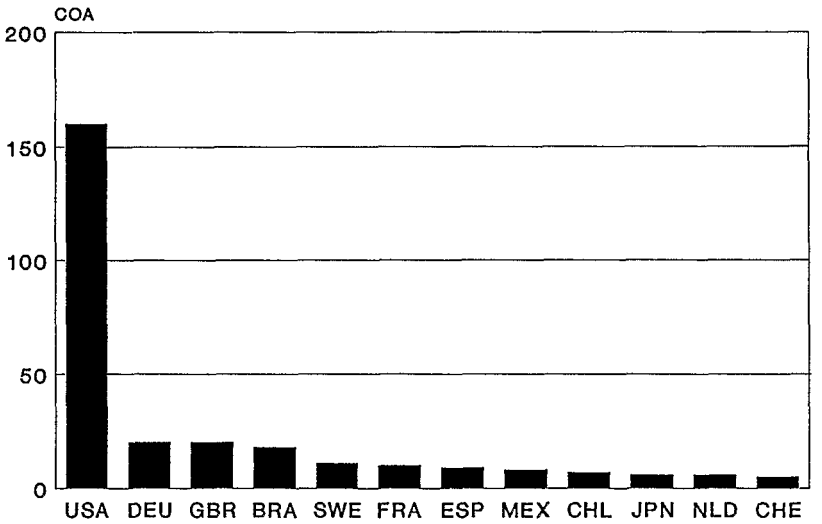
Fig. 3 Coauthorship number (COA), COLOMBIA

a) LARGEST PARTNERS, ALL FIELDS, 1981-86



COLOMBIA & THE WORLD
b) IN EIGHT FIELDS (1981-1986)

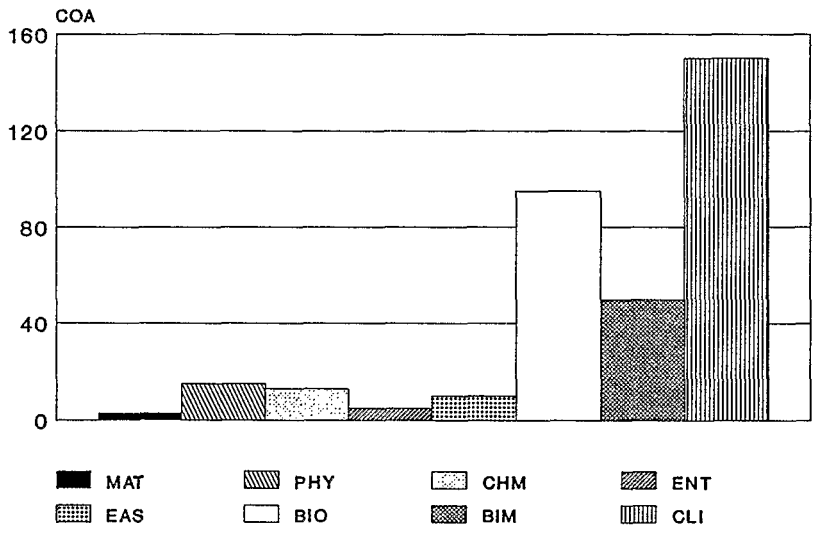


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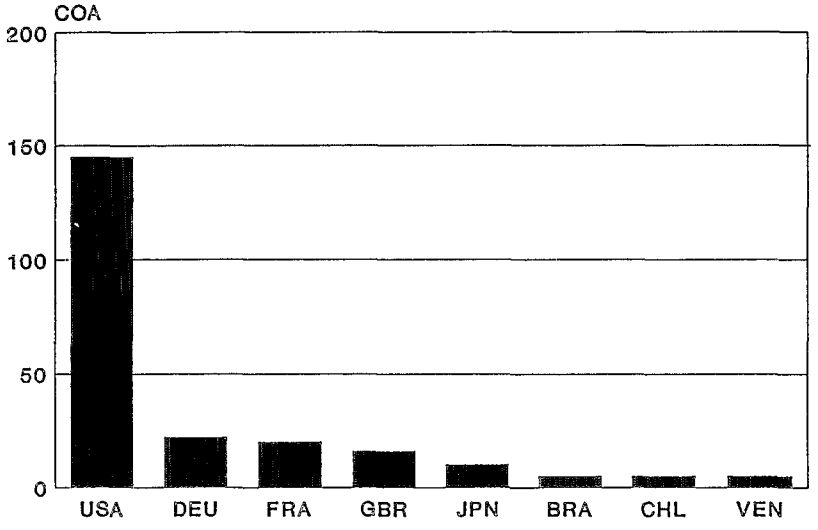
Fig. 4 Coauthorship number (COA), PERU

a) LARGEST PARTNERS, ALL FIELDS, 1981-86



PERU & THE WORLD
b) IN EIGHT FIELDS (1981-1986)

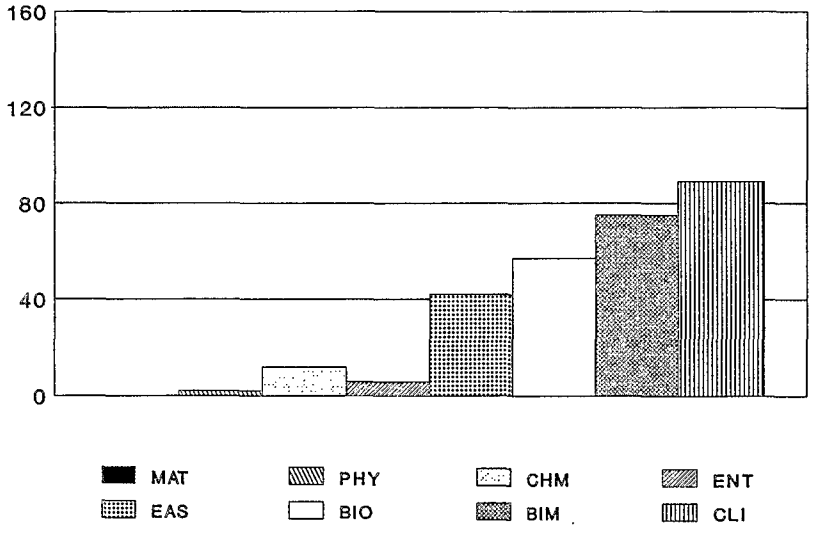


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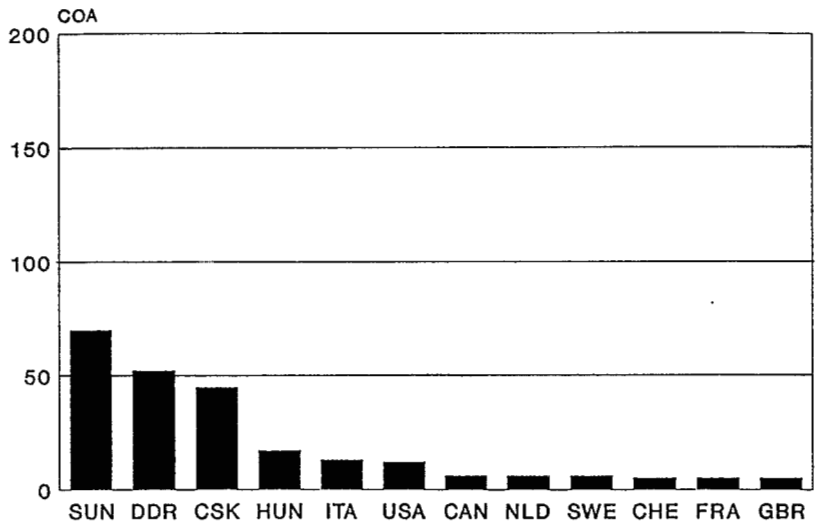
Fig. 5 Coauthorship number (COA), CUBA

a) LARGEST PARTNERS, ALL FIELDS, 1981-86



CUBA & THE WORLD
b) IN EIGHT FIELDS (1981-1986)

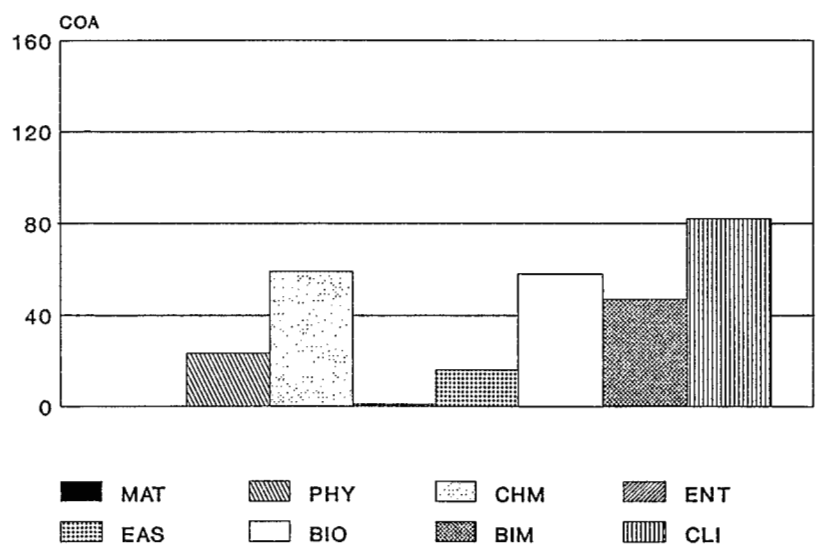


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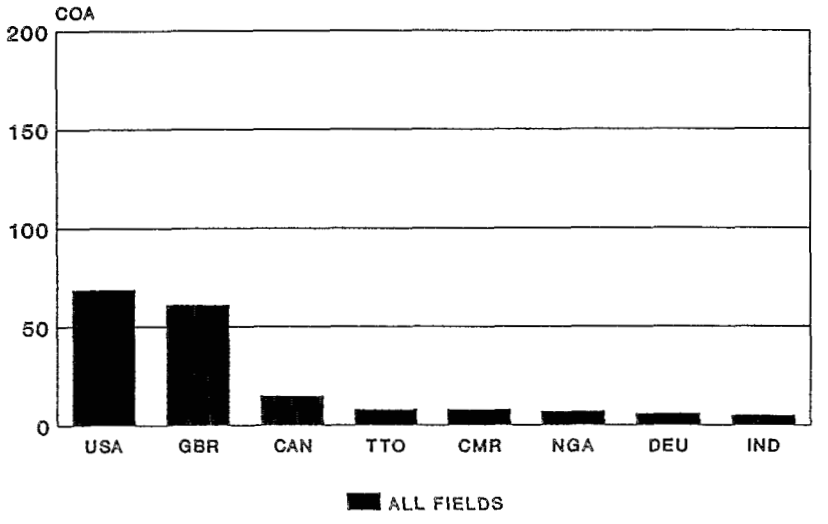
Fig.6 Coauthorship number (COA), JAMAICA

a) LARGEST PARTNERS, ALL FIELDS, 1981-86



JAMAICA & THE WORLD
b) IN EIGHT FIELDS (1981-1986)

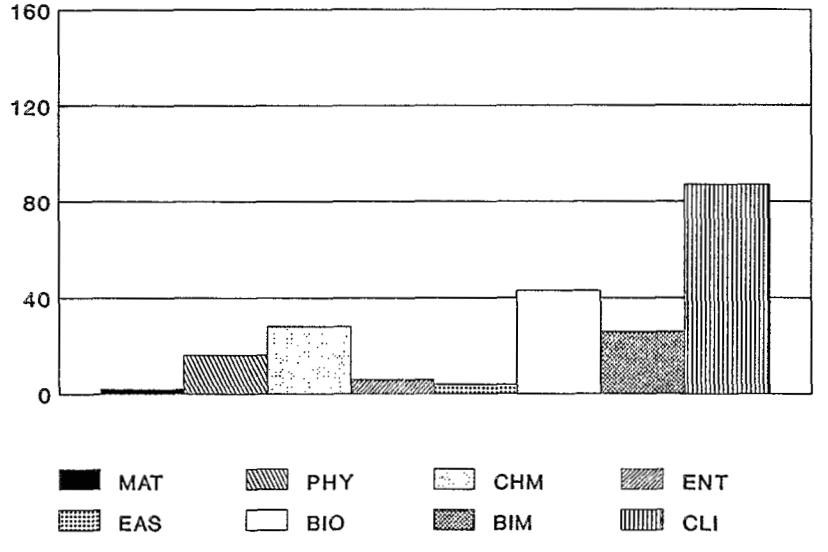


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Fig.7 BRAZIL & OTHER LATIN AMERICAN COUNTRIES IN FIVE FIELDS 1981-1986

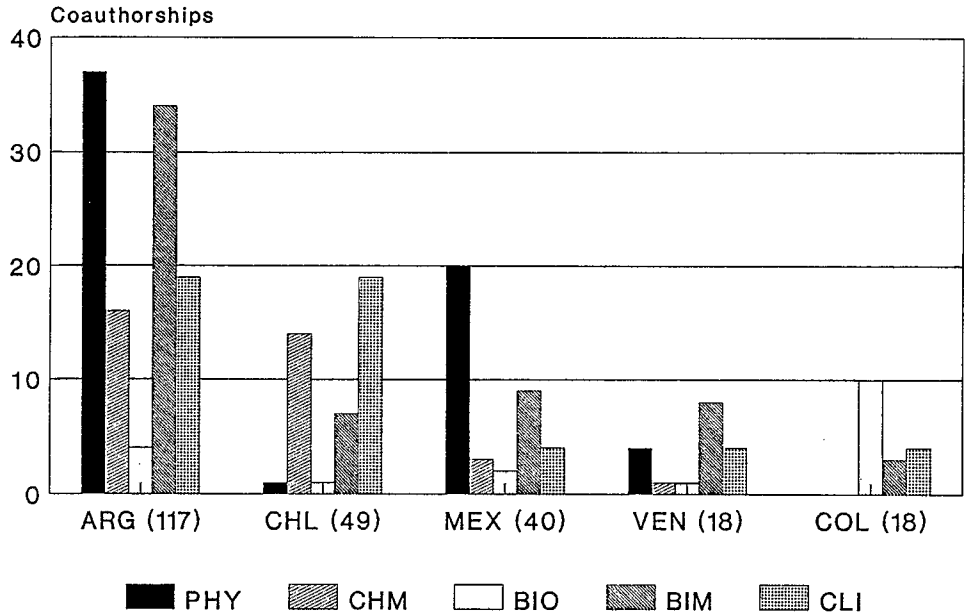

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FIG. 8
FRANCE & LATIN AMERICAN COUNTRIES
ALL FIELDS

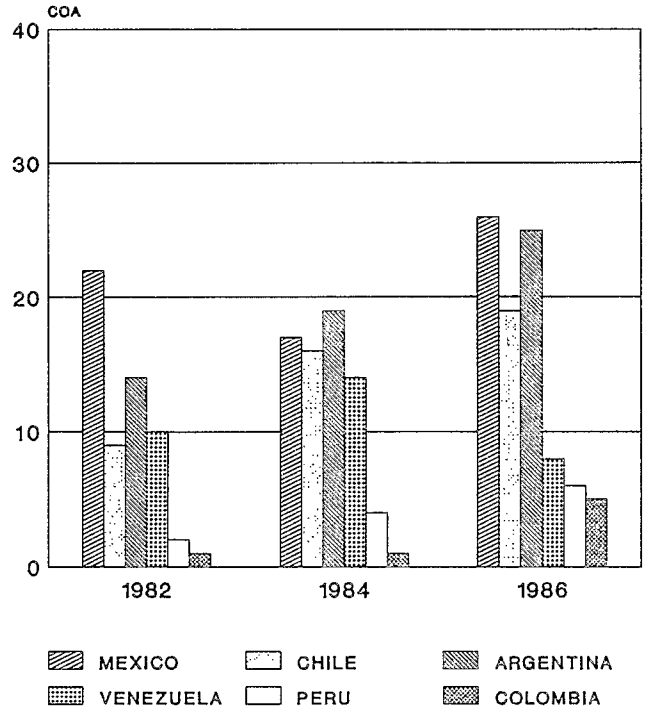

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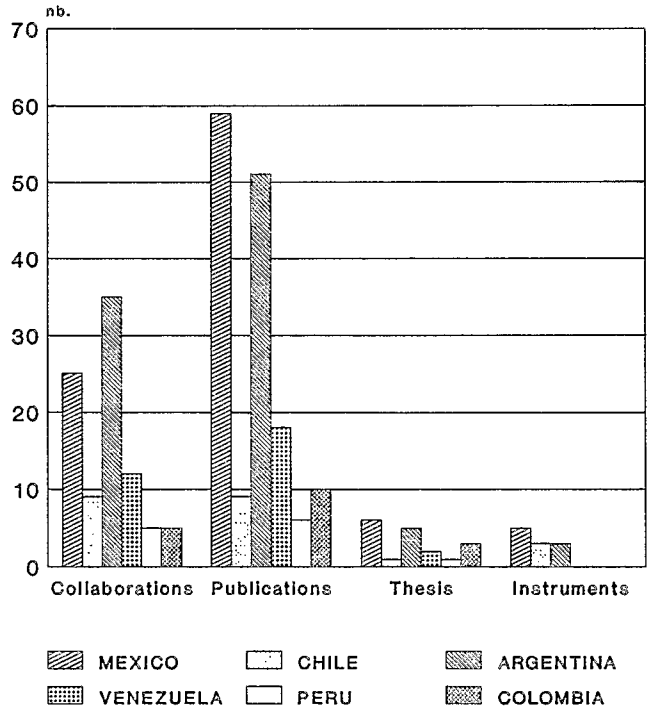
Fig. 9
CNRS AND LATIN AMERICA
RESULTS IN 1989 (ALL FIELDS)



CNRS-LEPI BADIN