Research Collaboration between Europe and Latin America

Mapping and Understanding partnership

Scientific editors

Jacques Gaillard
Rigas Arvanitis

éditions des archives contemporaines

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Edited by

Jacques Gaillard

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Chapter 1

Science and technology collaboration between Europe and Latin America: towards a more equal partnership?

Jacques GAILLARD and Rigas ARVANITIS

Introduction

Latin America countries (LAC) and Europe are linked by historical ties dating back to the Spanish conquest. These ties continued over the centuries. As a result, the two continents share very close cultural affinities and common views on many issues (Eeuven 2005). As the first colonial outpost of the early-modern European world, Latin America has long witnessed complex processes of cultural cross-pollination, suppression, and adaptation. This leads Latin American authors to argue that it cannot be labelled non-Western without serious qualifications (Cueto & Cañizares Esguerra 2008). LAC have indeed developed S&T collaborations with Europe since the rise of their scientific development. These relationships became institutionalized at the beginning of the 20th century. Between the 1940s and the mid-1970s, LAC witnessed an accelerated process of institutionalization and professionalization of research. Scientific cooperation was first based on hiring foreign research to training or granting scholarships for training abroad, a process that was supported by international technical assistance to Latin American universities and research centres. As illustrated in this book, the notion of international cooperation became more visible in the 1980s and a new type of cooperation was accepted that supported the "theory of mutual benefit" over that of "technical assistance" (cf. chapter 2). In this way, LAC joined a trend that existed at a more global level in the explicit and implicit notions on the role and modalities of cooperation, that we have analyzed earlier (Gaillard 1999). Drawing on the results presented in this book, we will argue that the asymmetry of relations, which was often reported in the 1970s and 1980s, has turned into a more equal partnership between the two continents. The book will also try to decipher some of the reasons behind this more balanced cooperation.

In the early 1980s, the European Union began a political dialogue and encouraged parallel agreements with a few LAC. The first European Framework Programme EU-STD1 "Science, Technology and Development" (1984), contributed to strengthening international collaboration between scientists from Europe and from Argentina and Mexico, which were among the first LAC countries to benefit from this initiative. The 1986-1990 Consolidated Activities Report defines the aims of international scientific cooperation between the Europe and the scientific communities in the lesser developed parts of the world as the development of strong and durable links that enable work to be carried out at the international level, but with the advantage of scientists remaining in their home institutions. The benefit for the European scientists is described as the access provided to new intellectual environments and the opportunity to apply their skills to a different range of conditions and problems (European Commission 1992). The EC's Seventh Research Framework Programme emphasises new opportunities for scientific cooperation between Europe and LAC, with focus on "innovation and technology for sustainable development and social inclusion" using an integrated approach that embraces the environmental, economic and social dimensions and a balanced involvement of research teams and relevant stakeholders from Europe and the LAC region in the consortia (European Commission, 2011).

The European Union - Latin American Research and Innovation NETwork (EULARINET) reflects this policy. EULARINET is a 4-year project started in 2008 to establish a co-ordination platform composed of leading EU and LAC policymakers, programme managers, eminent researchers and representatives of research entities, universities, the private sector, and civil society. Its purpose is to contribute to the identification of S&T policies and priorities, to define specific activities to promote, support and stimulate participation of LAC researchers in FP7 and to strengthen international S&T cooperation (EULARINET 2011). EULARINET recognises and takes into account the achievements of past and current co-operation with multilateral programmes such as CYTED (*Ciencia y Tecnología para el Desarrollo*) involving Spain and Portugal and 19 LAC countries and national programmes implemented by institutes such as the German *Deutsche Forschungsgemeinschaft* (DFG) and the French *Institut de Recherche pour le Développement* (IRD).

However, not all international scientific partnerships occur under the umbrella of cooperation programmes. According to several authors (e.g. Wagner 2008), the decision to work together is essentially a personal one based on mutual interests and complementary skills, and international collaboration functions as a global self-organising system through collective action at the level of researchers themselves (Leydesdorff & Wagner 2008). The latter views of scientific collaboration stressing and focusing on the individual researcher alone need to be qualified. The researcher is presented as the hero of international collaboration taking decisions where individual interests would be the main driver; the pitch of this explanation is based on the idea that the individual recognizes potentially interesting collaborators and is able to evaluate and size the expected outcomes of the planned collaborations. This could probably be the case for experienced and relatively senior researchers who enjoy world repute. It does not reflect the case of younger researchers who usually do not have access to all potential choices for initiating successful and fruitful collaboration. Moreover, for an individual to be able to objectively "choose" his collaborations, he/she needs to be embedded in his/her local environment, institutionally, politically and economically. The existence of a local scientific community as well as the institutionalization of scientific activity play a very important role here since it is through the participation in local training and local scientific teams that the young individual scientist can become increasingly involved in international collaborations. Personal decisions are important but choices are also influenced by other factors that go far beyond what we are usually ready to accept when assuming that international scientific collaborations are beneficial. A possible way to examine what constrains and influences decisions to collaborate would be to scale the issue at different levels:

- the national policy environment (and more recently the policy environment and instruments at the researchers' institution, which are usually related to the national level) that directly affects the decision to collaborate on the basis of the tools and instruments available for the scientific collaborations but also, indirectly, on the basis of the national political and economic context;

- the international level involving wider networks of collaborations through which scientists can find opportunities for international collaborations. This level should include global issues as well as actors that are very active at an international level (e.g., the large pharmas);
- finally, the individual level, choice of discipline, career pattern and personal contacts.

By using these different levels and the multiplicity of roles scientists can play, we can go beyond the limits of the above-mentioned 'heroic' and individualistic vision of international collaboration. As we will argue here, this heroic vision is related to a situation of research that is not valid in most Latin American countries.

1. Brief literature review

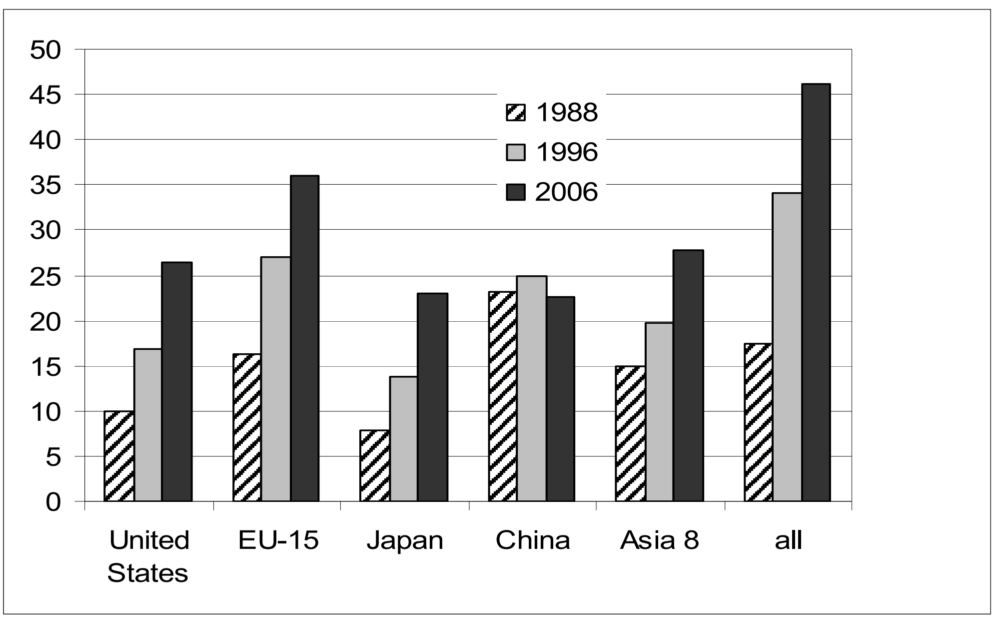
International cooperation and mobility has almost become an essential element of academic career and impact. But despite a long history of cross-border cooperation between researchers worldwide, there are very few large empirical studies on the main drivers of international collaboration in science and technology (S&T).

The determining factors of international collaboration in S&T are based on a wide range of rationales that go beyond the sole S&T rationales and objectives (Gaillard 2001; Wagner 2008). International co-authorships, for example, occur along clearly discernible geographic lines, suggesting that extra-scientific factors (for example, geography, politics, language) play a strong role in determining who collaborates with whom in the international scientific community (Frame & Carpenter 1979). Luukkonen *et alii* (1992) identify social, historical, geopolitical and economic factors as potential drivers of international collaboration in S&T. In a book published some ten years ago, we argued that S&T cooperation policies for development (as part of development aid policies) are based on a variety of complex factors that are often interdependent, including political, diplomatic military, economic humanitarian and scientific factors (Gaillard 1999:272). When analysing the rationales behind international research collaboration, a more recent study published by the European Commission distinguishes between "the narrow Science, Technology and Innovation (STI) cooperation paradigm" and the "broad research cooperation paradigm" (Boekholt, Edler, Cunningham & Flanagan 2009). In the former paradigm, the purpose of the drivers is mainly "to improve the quality, scope and critical mass in research by linking national resources and knowledge in other countries". In the later paradigm, other non-science policy objectives interact with the "intrinsic" science-oriented objectives. For example, the urgency of tackling global societal challenges has led to discussion on more global research programmes. Other drivers such as diplomacy and historical cultural ties between countries and development or bilateral aid have long influenced the choice of partners and may still constitute a backstage influence.

As a result of the growing complexity of science, the ease of face-to-face contact, the Internet, and government incentives, S&T activities are being conducted in an increasingly international manner (Figure 1 below). The indicator most often used to capture the scale or intensity of international collaboration in S&T is co-publications of authors from two different countries. Co-publication analysis can tell us something about the relative importance of international collaboration that leads to tangible outputs (publications) and the nature of the cooperation in terms of countries and disciplines (e.g. Adams, Gurney & Marshall 2007; Edler, Fierb & Grimpe 2011; Edler & Flanagan 2009; Glänzel 2001; Mattsson, Laget, Nilsson & Sundberg 2008; Schmoch & Schubert 2008).

In 2006, for instance, 30% of the world's scientific and technical articles had authors from two or more countries, compared to slightly more than 10% in 1988. One-quarter (26.6%) of articles with U.S. authors had one or more non-U.S. co-authors in 2006; the percentage is more or less similar in the Asia-8[1] and slightly lower for China and Japan (NSF and OST 2008). Between 2001 and 2006, international co-publications increased in all countries except China, Turkey and Brazil. The higher EU-15 level (36% in 2006) partly reflects the EU's emphasis on collaboration among the member countries as well as the relatively small science base of some EU members. Other countries' high levels of collaboration (46% in 2006) reflect science establishments that may be small (e.g. developing countries) or that may be in the process of being rebuilt (e.g. Eastern European countries).

Figure 1. Share of scientific publications with international co-authorship, by country/region (1988, 1996 and 2006)



Source: Thomson ISI and SCI, NSF and OST computing 2008 (Gaillard, 2010)

[1] Asia-8 is composed of South Korea, India, Indonesia, Malaysia, Philippines, Singapore, Taiwan and Thailand.

LAC international collaboration has been the subject of several studies over the last two decades. Narvaez-Berthelemot *et al.* and Lewison and co-authors were among the first to study the international co-production of knowledge of the (Lewison, Fawcett-Jones & Kessler 1993; Narváez-Berthelemot, Frigoletto & Miquel 1992), followed by Fernández and co-workers (Fernández, Gómez & Sebastián 1998). In more recent years Lemarchand has looked at the co-author networking of Ibero-American countries for the period 1973-2006 (Lemarchand 2008). The co-production of Spain with LAC has received special attention (De Filippo, Morillo & Fernández 2008; Fernández, Agis, Martin, Cabrero & Gómez 1992) as has the intraregional collaboration of LAC institutions (Russell, Ainsworth, del Río, Narváez-Berthelemot & Cortés 2007; Sancho, Morillo, de Filippo, Gómez & Fernández 2006). Other studies have included international co-authorship patterns as part of a general analysis of scientific production within the LAC region (Santa & Herrero-Solana 2010).

Figures two and three illustrate the relative growth of the share of publications co-signed with foreign authors in the LAC countries in 1985 and 2010-2012 respectively. They indicate a rapid and tangible increase in internationalisation of science in all countries. In general, with the exception of Guyana, the larger the country and the national scientific community, the smaller the share of publications signed with foreign co-authors.

Thus, Brazil, the LAC country with the largest scientific community and highest scientific production, has the lowest share of scientific publications in international co-authorship (co-signed with foreign co-authors), although this share rose from less than 20% in 1985 to 33.5% in 1995, but it then fell to 26.5% in 2011-2012. As mentioned earlier, Brazil is one of the very few countries (with China and Turkey) that experienced a relative decrease of its share of scientific publications co-signed with foreign co-authors during the last decade.

All other LAC countries continued to increase their share of scientific publications co-signed with foreign co-authors during the last 20 years although the top scientific producers (including also Chile, Argentina and Mexico) have been experiencing a downturn during the last few years (cf. chapter 3).

Further, within this increasingly globalised scientific literature, the internationally co-authored papers receive a higher citation impact than papers written by national authors (Glänzel, Debackere & Meyer 2008)[2].

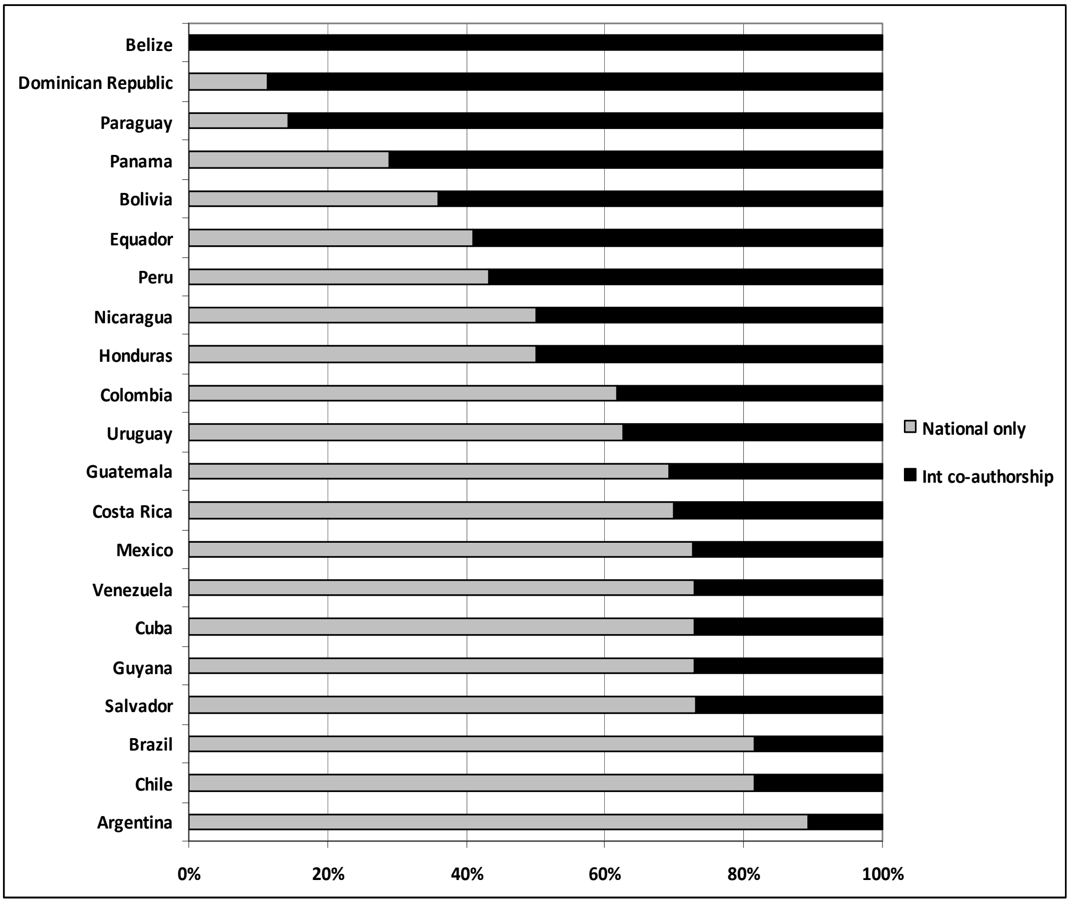
Other patterns of international scientific co-operation are worth considering:

- the more basic the field of research, the greater the proportion of international co-authorships (Frame & Carpenter 1979);
- the larger the national scientific enterprise, the smaller the proportion of international co-authorship (Frame & Carpenter 1979);
- humanities and social sciences remain rather less internationalised than natural sciences (Hogan, Zippel, Frehill & Kramer 2010);

[2] More recently Schmoch and Schubert (2008) have raised doubts as to whether the higher citation counts observed for international co-publications are a strong and unambiguous indicator of higher quality, given that higher citation can also be a result of the larger size of a community and the international nature of its work.

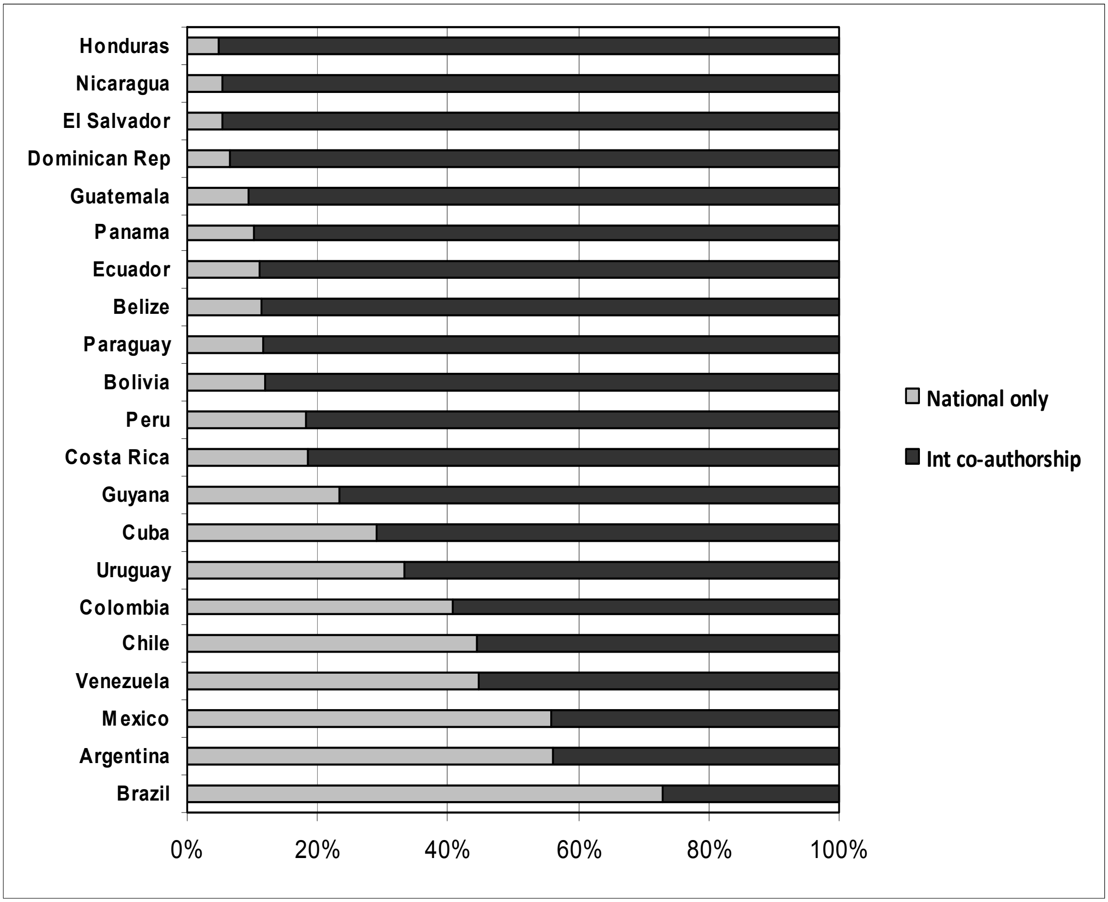
- scientists from non-English speaking and less developed countries experience particular difficulties in "breaking into" international journals covered by WoS/SCI (Arvanitis & Gaillard 1992; Gibbs 1995).

Figure 2. Share of scientific publications with national and international co-authorship in LAC countries in 1985



Source: WOS and UNAM computing, 2010

Figure 3. Share of scientific publications with national and international co-authorship in LAC countries in 2011-2012



Source: WOS and UNAM computing, 2013

There are many reasons for researchers to want to engage in international collaboration. The following list compiled by Edler and Flanagan (2009) attempts to convey what broad consensus exists in the literature on international collaboration about motivations and drivers although the relative importance attributed to these motivations by different authors may vary. Amongst the motivations and drivers emphasised in the recent literature (e.g. Archibugi & Iammarino 1999; Beaver 2001; Bozeman & Corley 2004; Edler, Fierb & Grimpe 2011; Edler & Flanagan 2009; UNCTAD 2005; Wagner 2006; Wagner 2008) include:

- access to and acquisition of cutting-edge and complementary know-how,
- access to foreign technology markets

- the sharing of costs and risks with international partners, especially when large infrastructures are needed for basic science (e.g., particle accelerators) or product development (e.g., international telecommunication networks),
- a combination of skills and data located in different countries to tackle issues too complex for researchers from one location,
- the identification of solutions to complex scientific and technical problems that could not be solved with domestic resources alone,
- access to funds from foreign institutions and/or programmes,
- access to skilled individuals who might have an interest in pursuing opportunities for research in another country (recruiting),
- access to endemic research subjects, such as natural or social phenomena, etc. which are limited geographically,
- a desire to influence regulatory regimes or standards,
- improvement of the impact and visibility of one's research (see above).
- fun and pleasure.

A longitudinal survey that follows recipients of research doctorates from U.S. institutions until age 76, NSF found out that 30% of the recipients collaborate internationally, (23% of the female and 33% of the male recipients) (NSF 2009). This rare dataset on international collaboration derive of the National Science Foundation's 2006 Survey of Doctorate Recipients (SDR), analysed by sex, research/teaching faculty status, sector of employment (industry, government, academia), minority status, citizenship, presence of children in household, field of study of doctorate, and year of doctorate receipt. Selected results of the data indicate that:

- research faculty have a higher rate of international collaboration than teaching faculty;
- doctorates employed in business/industry are more likely to collaborate internationally than those employed in government or academia;
- female doctorates are less likely to collaborate internationally than male doctorates;
- the presence of children in the household does not deter female doctorates from international collaboration but their presence appears to be associated with increased international collaboration among male doctorates;
- there is little difference in international collaboration between doctorates that are U.S. citizens and doctorates that are not U.S. citizens;
- doctorates with degrees in engineering and the physical sciences are more likely to collaborate internationally than doctorates with degrees in other sciences;
- doctorates that are in mid-career stages are more likely to collaborate internationally than doctorates that are in early or late career stages.

- in an international collaboration, foreign collaborators are more likely to travel to the Unites States than for U.S. collaborators to travel abroad.

The cross-border movement of researchers constitutes another factor contributing to the growing internationalisation of science and technology. Whilst the migratory flow of researchers is as old as science itself, there is convincing evidence that the mobility of highly educated people has increased during the last (Dumont, Spielvogel & Widmaier 2010). The impact of the international mobility of highly educated people in non-OECD countries may vary from country to country. The most developed countries do not seem to be significantly affected and may indeed benefit from the direct or indirect outcomes of the emigration of their elite (in terms of remittances, return, transfers of technology and scientific watch) (Docquier & Rapoport 2007). On the contrary, in small countries like Caribbean and small African countries that suffer a critical shortage of skills, the emigration of highly educated people severely affects the countries given the fact, well documented now, that the smaller the national resource base of highly skilled people, the higher the percentage of highly skilled expatriates (Docquier & Marfouk 2006).

The conclusion to this brief literature review is that there is no single factor driving S&T international cooperation and/or collaboration. In most cases, there is a cumulative set of factors and/or actions by multiple actors that shape the geographical, institutional and thematic focus of international partnerships in S&T.

2. Contents of the book: summary of the main results

The chapters compiled in this volume are tacking stock of several complementary studies developed within the framework of an EC-funded coordination and support action programme called EULAKS (Connecting Economic Research on the Dynamics of the Knowledge Society in the European Union and Latin American and Caribbean Countries (EULAKS) to map, analyse and understand the main trends and characteristics of S&T Collaboration between Europe and Latin America.

These studies include a survey of policies and programmes developed by Latin American countries to promote international cooperation (1960 to today), a bibliometric analysis of co-authorships between Europe and Latin America (1984-2007), a review of FP6 and FP7 projects involving Latin American countries as well as the results of a questionnaire survey and in depth interviews of Latin American scientists. These studies are summarized below.

2.1. Policies and programmes developed by Latin American countries

The second chapter authored by Feld, Casas, López, and Vessuri compares the cooperation policies and strategies of several countries of the region i.e. Argentina, Brazil, Mexico and Venezuela, starting with the institutionalization of science and technology policies from the 1940s to the 1970s and continuing with a selection of priority areas to form a common strategy in the 1970s and 1980s.

Between the 1940s and the mid-1970s, Latin America underwent a reconfiguration of research activities, during what was called the "golden era" of national science. This implied, on the one hand, an accelerated process of institutionalization and professionalization of research and, on the other, the consolidation of science and technology policy through the creation of new government agencies, such as the national research councils (first in Brazil and Argentina, and later in Mexico and Venezuela). To a large extent, the scientific cooperation policy of these new institutions was based on hiring foreign researchers to train national scientists or allocate scholarships for training abroad. The "golden era" of national science coincided with the "golden age" of international technical assistance to Latin American universities and research centres, led by several national public organisms and American foundations, and also overseen by international agencies such as the International Council of Scientific Unions (ICSU)[3], the United Nations Educational, Scientific and Cultural Organization (UNESCO), and somewhat later the Organization of American States (OAS).

After the 1970s some of the changes occurred in the paradigm of science policy and in the notion of international cooperation; they became more visible in the 1980s. While cooperation aimed at increasing the "critical mass" of human resources and the infrastructure sustaining research activities, the new paradigm, spread by international organisms and adopted locally in the 1970s/1980s, implied the integration of international cooperation into the national science and technology policy and priorities. Progressively, cooperation was redirected to be of "mutual benefit" rather than of "technical assistance". This trend coincides with the changes in cooperation modalities at a more global level (Gaillard 1999): until the 1970s the international cooperation was characterized as "technical assistance", between 1970 and 1980 as "Problem solving" and since 1980 it was based on a principle of "mutual benefit. In Latin America, the "technical assistance" mode fostered some cooperation projects, initiated by the countries themselves, between Argentina and Brazil without intervention of other foreign / international agencies. Substantial changes took also place in the 1990s, within the frame of globalization processes, and research internationalization that led to new forms of collaboration, both with North America and the European Union, in the framework of large international networks and the internationalization of higher education.

Since the mid 1990s, responding to European policies, several Latin American countries set up collaborative funds with the framework programs to support initiatives of collective projects proposed by Latin American research teams in consortium with several European groups. Examples are the *Fund for Scientific and Technological Research* (FONCyT), in Argentina, or in Mexico the European Union *Fund of International Cooperation in Science and Technology European Union-Mexico* (FONCICYT). These initiatives reinforce the tendency of Latin America to cooperate with developed countries as shown by bibliometric studies of co-publication in the next section. However, during recent years, some countries of the region have also begun to establish bilateral agreements with developed and developing countries thus strengthening also south-south cooperation. In a more complex scheme, Argentina and Brazil have also diversified the scope of their international relationships: scientific and technological agreements have been signed with China, Angola, Mozambique, Israel, Russia, Cuba, and various other African countries.

Another major trend focused on the reconnection and use of the diaspora of national scientists living abroad. In 2003, Mexico launched the Networks of Talents for Innovation aimed at integrating the Mexican diaspora and creating business opportunities based on innovation, and the *Raices* Program (Network of Argentine Researchers and Scientists

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[3] In 1998 the name was changed to International Council for Science but the acronym, ICSU, remained the same.

Abroad) was created in Argentina in the mid-2000s. Among the older such experience is the Caldas network set-up in the nineties but the national council of science of Colombia.

Finally a third trend stems from the need for in-depth transformation in the region to achieve social inclusion. Following this trend, new strategies to orient scientific cooperation are being developed to achieve not only social inclusion, but also to alleviate poverty, and confront local and regional social problems.

2.2. Bibliometric analysis of co-authorship (1984-2007)

The objective of the third chapter authored by Russell and Ainsworth is to map the characteristics and trends in collaborations between Europe and the countries of Latin America and the Caribbean (LAC) through the co-publication of original scientific papers validated by a process of peer review and highly visible to the international scientific community. The analysis covers a 24-year period starting in 1984, the year of the first European Framework Programme STD1 "Science, Technology and Development".

As shown in this chapter, Latin America and the Caribbean (LAC) increased their mainstream scientific production in all knowledge areas from 9,641 papers in 1984 to 54,807 in 2007. This represents a steady increase in overall production of mainstream papers and in the LAC region's rank, expressed as a percentage of world output. With the growth of overall production, the percentage of the world share of publications (science areas only), from the LAC region rose in recent years, from 1.5% in 1990 to 4.29% in 2008 indicating a small but increasing presence on the world stage.

Brazil is by far the regional leader in number of papers published throughout the whole period of study increasing its dominance from 34% (3,312) of the total of LAC papers in 1984 to 52% (28,479) in 2007. Mexico took second position from Argentina at the beginning of the 1990s and increased its lead from the turn of the new century onwards. Both Argentina and Chile significantly decreased their percentage of contribution, Argentina from 21-13% (2,020-7,001) and Chile from 13-8% (1,279-4,319).

With regard to international co-authorship patterns all regions and the top four producers showed a similar trend. As could be expected, the less productive regions and countries showed increasing reliability on international co-authorship to sustain or boost output. Brazil on the other hand, increased its percentage of internationally co-authored papers from 18% in 1984 to 34% by 1994, after which the role of foreign collaborators decreased. By 2007, only 26% of total production was in international co-authorship. The percentage for Mexico rose from its 1984 level (26%) until 1998 when it levelled off at 40% while Argentina showed a steep rise from a mere 10% at the beginning of the study period reaching percentages similar to Mexico by 2007.

The top four LAC producers which contributed 80% of the total output of 182,941 papers in international collaboration (excluding social sciences), followed similar overall patterns with respect to their scientific disciplinary focus for the period as a whole. Medicine, Physics and Biology are the main areas of collaboration with Medicine taking top priority in Brazil (23% of all papers) Physics in Chile (25%), Mexico (22%) and Argentina (22%). Biology is an important area of collaboration in all four countries (Argentina, 19%; Mexico (16%); Brazil, 16%; Chile, 15%). Engineering is given more weight by Mexico (12%) than by the other countries (Brazil, 10%; Argentina, 8%; Chile; 7%).

Taking the period as a whole we see more LAC papers co-authored with European partners (98,155) than with the US and Canada (87,540). However, regional differences exist, while the Southern Cone favours European counterparts, (54% of its internationally co-authored papers as opposed to 44% with the US and Canada), Mexico and Central America look more to North American partnership, (53% of papers compared to 45% with Europe) suggesting that geographical proximity could be a determining factor in this case. For the Caribbean we see a different trend, 55% collaboration with Europe and just 31% with North America, pointing towards the possibility of colonial ties influencing the choice of international partners. In 1984, the US and Canada were more frequent co-authors of LAC internationally co-authored papers than Europe: North America, 56% and Europe, 40%. By 1993, the number of papers co-authored with Europe had overtaken that with the US and Canada and in 2007, Europe had a 53% share and North America 46%.

The partnership with the EU-15[4] is dominant with respect to the four regions and the four most productive countries. In all instances EU-15 countries account for more than 80% of internationally co-authored papers except in the specific case of Mexico where non EU European countries assume a greater importance, a situation also reflected in the Central America and Mexico region. Brazil not surprisingly had the largest volume of papers published with the EU-15 countries, 33,389, followed by Mexico with 15,520, Argentina with 14,951 and Chile with 10,632. All other countries accounted for 4,000 or less papers.

France is the leading collaborating country of the EU-27[5] with 10.3%, followed by Great Britain and Spain, both with 9%. Of the newer members of EU, Poland and the Czech Republic are the most frequent partners of LAC with 2,386 and 1,428 papers, respectively, small in comparison with the US total of 79,568 papers, France with 22,529, Great Britain with 19,756 and Spain 19,744. Germany has 17,506, Canada and Italy trail with 11,037 and 10,544, respectively. All other countries have less than 5,000 collaborations with LAC, including the non-EU countries of Russia and Switzerland with 4,238 and 4,200 papers, respectively. However, the relative weight of the four main European partners changed over time. While in 1984 Spain occupied the fourth position with only 62 publications with LAC (compared to 197 for France, 177 for Great Britain and for 149 for Germany) in 2007 Spain had the most publications, 2,387 compared to 2,045 for France, 2,014 for Great Britain and 1905 for Germany.

2.3. A review of Framework Programme 6 and 7 projects involving Latin American countries

In this third study and fourth chapter, all projects funded by FP6 and FP7 up to April 2010 in which Latin American groups and institutions participated were considered and analyzed. Basic statistics such as total number of projects and the magnitude and distribution of the funds involved, as well as specific features such as thematic distribution and the concentration of projects in specific geographical areas -such as the capital cities-and the existence of dominant elites or institutions in each field were considered.

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[4] EU-15: Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, the Netherlands, Portugal, Spain, Sweden and the United Kingdom

[5] EU-27 (*from 1 January 2007*): EU-15 + Poland, Czech Republic, Cyprus, Latvia, Lithuania, Slovenia, Estonia, Slovakia, Hungary, Malta, Bulgaria, Romania.

The results show that the participation of the leading Latin American countries is far from being marginal: considered together, Argentina, Brazil and Mexico are involved in as many projects as Germany and France, two of the leaders (along with United Kingdom) in European research. Measured by their participation in number of projects, Brazil would rank as the 6th most important participating country and Argentina or Mexico 7th.

Not surprisingly, the participation is far from homogeneous throughout time, by country and by scientific disciplines. On the one hand, the more scientifically developed countries are the most active in their scientific collaborations in European projects: both in FP6 and in FP7 the four largest countries (Argentina, Brazil, Chile and Mexico) accounted for 75% of the Latin American share. On the other hand, the disciplinary pattern shows an important increase in SHS (almost double) and in Engineering as disciplinary fields. These two disciplines account for half of the Latin American participation in European projects. The basic disciplines (Chemistry, Biology, Physics) are also increasing and, together, represent almost a quarter (with a steeper increase in Physics). The most noticeable decrease is in Agricultural Research and Earth Sciences. This, according to the authors Kremer and Levin, seems to contradict the “local advantage”, centred around the use of the special conditions obtaining in developing countries, in terms of plant or animal species, soils, privileged vantage points, and so on. On the contrary, with the exception of the social sciences, research seems to be directed more towards "universal themes" in which Latin American groups make a contribution to the general cognitive objectives of the projects.

The situation described above needs to be explained more completely: besides the increase in Engineering, most of the themes are naturally and strongly oriented towards European priorities, which are increasingly geared to very specific and applied purposes defined by European scientific communities, governments, and – last but not least – the firms that industrialize the knowledge derived from these projects. Thus, the authors argue that the Latin American groups would be producing knowledge whose industrial application will benefit European societies.

One should also remember that contributions from Latin American countries to European projects increased from 5% (FP6) to 12% (FP7), while European contributions remained more or less constant. A continent-wide impact study based on well-documented case studies would be welcome to confirm or refute the observation that the LACs produce knowledge that only benefits European countries. The outcomes of such a study may be more complex and less one-sided than the authors suggest.

The unit costs per project are decreasing, along with the average number of groups per project, which dropped from 18 to 11 from FP6 to FP7. This means, for example, in Agriculture, Biology or Earth Sciences projects, whose average costs are the highest, (around 4.5 million euros), that each group received an average amount of around 400,000 euros. And in the Social and Human Sciences, which have the lowest cost per project, the per-project cost was around 180,000 euros. The figures are significant for a local group, but not enough to explain the strong desire of Latin American groups to participate. Besides the potential economic benefits, the continued participation of Latin American groups can be explained by referring to the social and cognitive integration strategies, which are designed to increase visibility, and improve interchange opportunities and access to information and data, and, indeed, such participations offers the best chance to publish in international journals. All of these outcomes are highly valued achievements in all local contexts.

2.4. The questionnaire survey

This chapter is based on the results of a questionnaire survey sent out in 2010 and aimed at understanding the main determining factors for initiating, promoting and enhancing international collaboration in S&T among the individual researchers in Latin American and Caribbean (LAC) countries and the European Union countries (EU). Answers were received from a huge number of scientists (4425) representing almost 36% of the Latin American researchers (2250 individuals) and 22% of their European colleagues (1875 individuals) invited to participate. The most likely reason for these unbalanced rates is related to the fact that LAC scientists were more interested in the survey since their LAC-EU collaboration was much more important than to their scientific careers than it was for their EU colleagues'. This assumption was confirmed by the results themselves: scientists working in LAC demonstrated higher levels of motivation and satisfaction regarding their international collaboration.

This survey tends to prove that the asymmetrical relations in the main sectors of international scientific collaboration, which was highlighted as a burning issue in the 1970s and 1980s, have turned into a more equal partnership between the two continents. This has been clearly demonstrated in several sections of this chapter 5 on the various facets of collaborative scientific activities, e.g., decisions about the distribution of roles, budgets and tasks in international projects. This also appears throughout the survey in the way scientific activities and interests in cooperation as well as advantages and disadvantages of such collaborative schemes are perceived in the two regions.

Some other important findings of this survey indicate that:

1. international collaboration correlates with increasing international mobility;
2. international collaboration is a win-win process that benefits all the partners;
3. international collaboration, once established, is a longstanding activity;
4. the more scientists collaborate internationally, the more opportunities they have to meet new colleagues, exchange ideas, write new projects, and access previously unsolicited funding schemes;
5. the motivations and expectations related to participation in international calls for proposals involving scientific collaboration are very high, and the declared derived outcomes are very significant in both continents;
6. the motivations, expectations and benefits of collaboration but also the difficulties of collaboration are higher in the scientifically less developed LAC countries than in the four major LAC scientific countries (Argentina, Brazil, Chile and Mexico);
7. the diaspora plays a very insignificant role in the decision to undertake extended stays abroad for scientific studies and a limited role in the decision to collaborate and in the choice of scientific partners;
8. international collaboration addresses and involves very dedicated and goal-oriented individual scientists in all countries, scientists who seek to increase and improve their scientific capacities and develop greater international recognition.

2.5. Interviews of Latin American biologists and agriculturists

This fifth study and sixth chapter are based on 74 interviews of Latin American scientists conducted in 2009 and 2010 in Argentina, Costa Rica, Chile, Mexico and Uruguay. All interviewed scientists were working in the field of biology applied to agriculture (or agriculture-related sciences) with a particular emphasis on animal and aquatic resources production and reproduction. They all have (or had) scientific relations with Europe at some stage of their career.

The study aims at analysing and gaining a better understanding of the importance of S&T collaboration at the level of the individual researchers in Latin America through the reconstruction of their personal scientific trajectories. In particular, it seeks to understand the main determining factors initiating, promoting and enhancing international collaboration in S&T. It also intends to illustrate the extent to which their mobility boosted the internationalisation of their activities and contributed to placing their institution (sometimes their country) in the global stream of knowledge circulation.

To sum up the major findings of this study, we are presenting (see below) the main initiating factors and derived consequences of international collaboration from the point of view of the Latin American researchers we interviewed.

A large majority of the scientists interviewed (except for Argentinean) went abroad for further studies. Reasons to expatriate for studies are mainly twofold: the search for excellence, and opportunity. The “search for excellence” factor is linked to the fact that a more advanced scientific environment provides greater stimulation and more opportunity to learn. The “opportunity” factor may be linked to a professor, a visiting researcher, a diplomatic representation, etc. It can also emerge in the course of a scientific workshop or a conference. The same reasons explain the choice of the post-doctoral students abroad. The search of excellence is probably the main reason and “opportunity” is also linked to a desire for excellence.

One of the main outcomes of these early expatriations is the networking effect. The majority of interviewed people kept contact with their PhD supervisor and continued to collaborate with this person and/or colleagues from the same institution as long as they continued to share common scientific interests. The relationship is not only longstanding and fruitful but may also open other paths and give rise to other collaborations. It is not uncommon that international collaborations started with colleagues known when studying abroad grow into inter-university agreements. This is even stronger among post-doctoral students abroad: the feeling of belonging to a group which operates as a network of excellence, the mutual recognition of the members and the perpetuation of the links through generations (by the students) reinforce the rewarding effects of networking.

Other stays abroad like sabbaticals and trainings (training sessions/courses…) are oriented more towards answering limited research issues: training workshops in the frame of a cooperation project, analysis of endogenous samples, acquisition of a new technique not available locally, etc. These stays do not apparently mobilize the same expectations from the researchers. They usually happen once the careers are designed and are perceived more as pleasant and stimulating ways to cope with research problems, learn new techniques and advance in the making of science. Although they may be great “sources of inspiration”; they do not have the same networking effect.

International collaboration is not the only privilege enjoyed by scientists trained abroad. Some determinants of such collaborations were clarified in the interviews. Developing scientific activism is one of them. Among the interviewed biologists those who worked with a militant commitment (environment preservation for example) belonged to international scientific active networks. The same applied to researchers working on topics of strong commercial interest, like salmon diseases. Other scientists happened to be at the right place at the right moment (working in marine biology in the Strait of Magellan at the time of the oil spill for example). A few others worked on relevant research topics in very specific environments (effects of altitude, endogenous fauna for example). Another important way to be associated with international collaboration without spending long stays abroad is to be noticed at international conferences.

All interviewed researchers agreed that participating in conferences was a very important and stimulating scientific activity, even critical for some of them in order to compensate for the narrowness of their scientific discipline locally. Many collaborations start among the conference participants, even with people never met before. The networking power of conferences has to be acknowledged since the collaborations initiated or enhanced there, according to the interviewed researchers, are usually long lasting.

The researchers who respond to international tenders (and sometimes succeed) have their own "alert" systems or are informed by foreign colleagues or learn about the tender at an international conference. Their laboratories compete at the international level not only for funding but also for visibility on the international scientific stage. The availability of national funding programmes for science in the five countries where the interviews were conducted reduces the interest of participating in big calls of tender (too much time for too little reward). For several interviewees, the scientific interest of such programmes was not even evident. The majority of the interviewed researchers give priority to small-scale bilateral collaboration based on personal relationships (the inter-university agreements deriving from lasting relationships nurtured by networking). The interviewed researchers also emphasized the fact that often their international collaborations take place outside official frameworks.

The researchers unanimously acknowledged the paramount importance of the human factor in collaborations. "You collaborate with friends", "we became friends", "we got along very well" were the most recurring types of sentences on this subject. When they talked about their scientific partners coming to visit they said "I invite them to my home and vice versa". One researcher said: "*The rewards of international collaboration have been tremendous in my opinion... If I am asked 'what is the main reward I've had from my career' I would say that it is the people I've met*."

The outcomes of international collaboration are not only on the human side, at the individual level they are, obviously and above all of a professional nature: learning new techniques, publishing in high impact journals, learning to compete at international level, enhanced networking activities, better access to funding, international (as well as national) recognition, etc. At the country level, the benefits are also major. Some reference laboratories have been funded in Latin America by young expatriates who returned home with foreign funding to enhance research and international partnership in their disciplines. The international networking gave rise to many inter-institutional partnerships; the exchange of professors and of students, PhD sandwich programmes, training abroad are just some of the results of this tremendous networking. For the less scientifically developed countries of the region, international collaboration at the individual or institutional level made it possible for scientists to perform sophisticated research. Without this opportunity they perhaps would not have returned to their country to work in science.

The analysis of the interviews concludes that there is no single factor driving S&T international cooperation activities. In most cases, there is a cumulative set of factors and/or actions by multiple actors or situations that shapes the geographical, institutional and thematic focus of international cooperation in S&T. Yet, the most powerful drivers are scientific excellence and mobility and the capacity of networking. The networking power of conferences and post-doc stays abroad are particularly important in initiating long-lasting scientific collaborations. A good personal relationship is also of paramount importance in scientific collaborations. Ultimately, “You collaborate with friends”, and meeting people through collaboration is also acknowledged as a very important reward.

3. Conclusion: Towards a more equal partnership?

The different studies presented in this book confirm the multiplicity and interdependency of the range of reasons that determine international scientific collaborations. It demonstrates, however that, contrary to the most commonly accepted postulate, the researchers’ individual interest is not solely at stake when he or she engages in international collaboration activities. The fact that, very often, collaborations “relate to individual’s own resource stock which can be used to gain a competitive advantage” (Rijnsoever (van), Hessels & Vandeberg 2008) is not sufficient to conclude that the dynamic of collaborations is strictly individually driven. The individual researchers who seem to be at the heart of the collaborations need additional factors at least as important as their individual commitment to be able to engage in collaboration. These conditions relate to their professional and institutional environment: level of equipment, status of researcher, the promotion and evaluation systems, the institutional base to collaborate widely, etc. Thus the individual researcher who is the heart of international collaborations should be seen as someone who is embedded into his/her local environment.

Results of the questionnaire survey seem to depict scientists as a relatively homogeneous group both in EU and in LAC. They tend to value the same motivations and to expect to reap the same types of benefits from the international cooperation: more publication, more projects, more resources, better recognition at international level. This can also be explained by the fact that Latin American countries have considerably upgraded their research institutions by creating better research centres, giving more funding to research and paying more attention to the uses of research and the tools and instruments of international cooperation. The institutionalization process, at least in the larger countries of LAC, has been gradually creating larger (if not better) institutions, doctoral degree programmes, and opportunities for post-docs who in turn become clients for international funding, which are sources for more funding and for collaborations with renowned scientists from other countries. Apparently, in this context, a strategy of connecting to the worldwide scientific networks seems to be a fruitful strategy. Nonetheless, we should insist that it only makes sense when there is a solid institutional basis. This radical change of scenario at the national level has, thus, profound consequences on international collaborations giving rise among other things to many inter-institutional partnerships; the exchange of professors and of students, PhD sandwich programmes, training abroad to mention only some of the results of this tremendous networking connecting individuals and institutions.

The policies have also changed at the international level. Richer countries, or “donors” as they used to be known, had a focus on research for development. The aim was to support the creation and strengthening of research capabilities in developing countries. Capacity building was the main aim and this was thought of as part of a larger strategy for collaboration with unequal partners who asked for this help (Gaillard 1994). This does not seem to be the dominant paradigm anymore, and although the “science for development” has not totally disappeared, it now very commonly coexists with support programmes that consider international collaborations as partnerships between equals. In this new policy context, funding for research and international collaboration is no more than an additional opportunity for funding research *tout court.* Even between Europe and African countries, there are policy documents that focus on the ‘co-ownership’, ‘co-design’, ‘co-funding’ of research projects.[6]

With this perspective, the results of the online survey are not surprising and can explain the way scientists portray their place on the chessboard of collaborations and the role they play in projects obtained in response to international calls for proposals. Analysing the scientists’ participation in calls for proposals clearly indicates that the level of commitment and responsibility for all-important decisions in the project is the same on both continents. They also feel very much involved in the projects and express a very high level of satisfaction in both regions.

Does that mean that the previously well-known dissymmetry between the rich developed countries and the developing world do not exist anymore? L. Busch had already claimed that the “Third World” makes no more sense when funding flows to biotechnology firms instead of agricultural research (Busch & Gunter 1996). What happens is we now find a much larger variety of research contexts and policy instruments and no more this policy specialization where research was meant for the rich and “research for development” was aimed for the developing world. The net result of international collaborations is not a collection of cooperative actions that aimed at providing input to development; it is rather a large international network of scientists that share common research practices, similar evaluation patterns, and quasi-identical legitimating discourses vis-à-vis their mother institutions. This large network is a network of equals and global issues are best tackled inside this world net. Kreimer and Zabala (2008) have claimed that the researchers from the periphery are entering this network in a foot of inequality: they would become voluntarily dependent and subordinated to the large centres of research that regulate the flow of science and structure the international network. Local legitimacy, support for research, access to sophisticated equipment, would depend on entering this worldwide network of research.

We partly agree but it very much depends upon the science fields and areas of activity. The survey partially supports the claim that access to more material aspects seem to be more important to LAC scientists than to the Europeans, who enter into collaborations with LAC scientist for less tangible benefits. What the latter seek is to participate in the knowledge

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[6] See for example the documents discussed by the Monitoring Committee (MoCo) for “Euro-Mediterranean Cooperation in Research, Technology and Demonstration”, a policy forum that was created between European countries and the South and East Mediterranean countries (Morini, Rodriguez, Arvanitis & Chaabouni 2013).

accumulation of LAC. LAC scientists no doubt seek to enter in scientific collaborations also to get local recognition. In many areas, there seems to be competition between international and local recognition, or, as Sari Hanafi (2011) has put it bluntly: 'publish internationally and perish locally or publish locally and perish internationally'. International collaborations, when they rely on local capabilities do not seem to lead to this terrible alternative. Rather, domains where capacity building has been strong are also those where LAC scientists no longer tend to be subordinates of the Europeans but are also drivers of mainstream themes and topics.

On the other hand, international collaboration being strongly correlated with geographical mobility, scientists having spend periods of time working outside their national frontiers are familiar with the working culture of their counterparts. These scientists usually join international networks as soon as they start studying or do their post-doc abroad. The ties established then are active and longstanding. The derived advantages of these early links are depicted as: reinforced feeling of being a member of a network (often considered as a network of excellence), enhanced capacity to compete at the international level, better ability to start new relationship while being in conference or other connecting situation. Furthermore, the scientists recognize that the more they collaborate internationally, the more opportunities they have to meet new colleagues, exchange ideas, write new projects, and access previously unsolicited funding schemes.

It is essential to take into account the fact that working conditions of scientists in the larger countries of Latin America (Argentina, Brazil, Chile and Mexico), responsible for 80% of international co-authored papers between Europe and LAC and 75% of the FP projects, have improved in a tangible manner compared to a decade ago. And not only are the career prospects better; the capacity of the local scientific community to judge on the value of their national fellows in areas that once were scarcely populated makes a great difference. It is thus not only a matter of being well connected to the outside: it also a matter of being able to gather sufficient interest around one's professional area. As F. Beigel (2010) has very convincingly argued that "peripheral academic circuits" in LAC have not had lesser international impact because of an incapability to reflect upon their own reality, but rather because their scientific communities have been obliged to manage political and organizational difficulties incurred by their own academic systems.

In brief, we have seen that both at the national level, as well as at the international level, it is the very meaning of international collaboration that changed for the scientists in countries where once there were only few researchers, fewer institutions and universities or academic institutions were barely interested into carrying out supporting research activities; where once research was possible because of the support of foreign donors; in these non-hegemonic countries, the fundamental changes have also obliged to reflect on a new perspective: how is it possible to integrate the knowledge that exists locally, and not only the scientific knowledge, into the perspective of research? Latin America has recently rediscovered its own knowledge resources (Arellano Hernández, Arvanitis & Vinck 2012) not only because of the international scene, where indigenous knowledge has become a new and fashionable topic, but also because of local health, agriculture and food security considerations. It can be easily argued that the new research areas have been occupied by Latin American scientists not only as a response to external pressure[7] but also because of

[7] see the case of GMOs in Mexico studied by Jean Foyer (2008), or the protection of biodiversity (Aubertin & Vivien 2006)

their own capacity to enter these debates. International collaborations have always played an important role in the creation of this analytical capacity, sometimes as a resource and sometimes as a constraint.

Finally, the existence of multiple funds that support collaboration, which are reviewed in this book, is posing a governance issue that is not related to programme management but to the way these programmes are articulated with other considerations, such as the usefulness and pertinence of the research topics to local social, economic and politically-sensitive problems. In fact, this very central issue, that has always been at the forefront of policy consideration in LAC (see for example in Venezuela, Arvanitis 1996)), is now becoming part of the large international projects and is being taken into consideration in the design of research projects. Obviously, these issues merit more attention in the future. All those past and ongoing transformations at national and international levels contribute to postulate that the asymmetry of relations, which was highlighted as a burning issue in the 1970s and 1980s, is definitely been turning today into a more equal scientific partnership between the two continents.

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Chapter 2

Policies to Promote International Scientific Cooperation in Latin America: Evolution and Current Situation

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Abstract

International scientific cooperation has been instrumented through a large variety of support schemes that were actively promoted by Latin American governments since well before the second half of the 20th century. This article analyses the evolution of these policies and programs, which underwent profound transformations.

From the 1940s until the 1980s, Latin American countries based their cooperation strategies on promoting graduate education offered to Latin American students by developed countries by means of bilateral and multilateral agreements.

A second line of argument relates to the decentralized nature of cooperation policies in the countries of the region. Until the 1980s, cooperation instruments were not centralized in science councils and ministries since universities and other public and private research institutes also granted external scholarships and established research collaboration agreements.

The cooperation policies of Argentina, Brazil, Mexico and Venezuela are examined in this article since the institutionalization of science and technology in the 1940s through the 1980s, when priority setting became a common strategy. We then consider the substantial changes in the 1990s within the frame of globalization processes; the modalities of research internationalization that led to new forms of collaboration, both with North America and the European Union, fostered the creation of international networks and the internationalization of higher education. The final section of the article explores some new schemes of international cooperation in Latin America and the challenges of social inclusion as undertaken by some of the region's governments in connection to scientific collaboration.

Introduction

Latin American international scientific cooperation has been instrumented through a large variety of support schemes that were actively promoted by governments since well before the second half of the 20th century. This article analyzes the evolution of these policies.

We argue that from the 1940s until the 1980s Latin American countries based their cooperation strategies on promoting graduate education offered to Latin American students by developed countries, by means of bilateral and multilateral agreements. Emphasis was on "technical assistance," which meant the mobilization of human and financial resources from developed countries. We argue further that since the 1990s, the central features have no longer been of “assistance” but, rather, collaboration tends to be framed through jointly defined activities in research programs. The programs promote shared laboratories, reciprocal mobility of researchers and professors as well as of students, shared budgets and activities.

A second line of argument relates to the uncoordinated nature of cooperation policies in the countries of the region. Until the 1980s, the science councils and ministries did not centralize cooperation instruments. Universities and other public and private research institutes also granted external scholarships and established research collaboration agreements. For various reasons, a systematic and effective role of policy organs with regard to international collaboration has been lacking.

The cooperation policies of Argentina, Brazil, Mexico and Venezuela are examined from the institutionalization of science and technology in the 1940s through the 1980s when priority setting became a common strategy. We then consider the substantial changes in the 1990s within the frame of globalization processes; the modalities of research internationalization that led to new forms of collaboration, both with North America and the European Union, fostered the creation of international networks and the internationalization of higher education. The final section of the article explores some new schemes of international cooperation in Latin America and the challenges of social inclusion as undertaken by some of the region’s governments in connection to scientific collaboration.

The Institutionalization of Science and Technology Policies and External “Aid": from World War II to the 1970s

a) Cooperation and Institutionalization of Science Policy

Since the 1940s, many countries in the region experienced an accelerated process of industrialization supported by an imports' substitution policy, a growing external demand for consumer goods and the expansion of the domestic market. This substitutive industrialization strategy --favoured by World War II-- fostered the development of the manufacturing industry, the diversification of local productive activities and the broadening of urban employment, which together with a set of tariff, fiscal, credit and public expenditure policies promoted by the State resulted in the sustained growth of the economy. During the post-war period, governments, with varying nuances, showed an interest in generating a domestic science base (Casas, 1985).

Thus, between the 1940s and the mid-1970s, Latin America underwent a reconfiguration of research activities, which has been identified by academic literature and the protagonists’ imagination as the “golden era” of national science.[1] This implied, on the one hand, an accelerated process of institutionalization and professionalization of research and, on the other, the consolidation of science and technology policy through the creation of new government agencies, such as the National Research Councils (first in Brazil and Argentina,

[1] Some expressions of this *imaginario* can be read in the testimonies compiled by Rotunno and Díaz de Guijarro (2003). For a global account of institutional growth within the moulds of national science in the non-OECD world, see Vessuri (1994b).

and later in Mexico and Venezuela). To a large extent, the policy of scientific cooperation of the new organs was based on the training of human resources through hiring foreign researchers or granting scholarships for training abroad. Even if usually emphasis is placed on these specific institutions, it is to be noted that the instruments mentioned were not centralized by the respective Councils; universities and other public and private research institutes also granted external scholarships or relied on foreign collaboration depending on the negotiating capacity or international prestige of some local scientific leaders.

The most significant evolution in the region has been that of Brazil. In this country, the creation in 1951 of the National Council for Scientific and Technological Development (CNPq) and of CAPES (Coordenação de Aperfeiçoamento do Pessoal de Nível Superior, of the Ministry of Education) was crucial in consolidating the country's research infrastructure. Since their early days, these institutions have awarded scholarships for graduate training in the United States and Europe. This policy was reinforced in 1961 with the establishment of the Ford Foundation program in Brazil, and in 1964, with the National Bank for Economic Development's fund for training master's and doctoral degree candidates in physics, chemistry, chemical engineering, metallurgical and electrical engineering. To give an idea of the gradual development of human resources abroad, a recent study shows that while between 1942 and 1962 an average of 130 students per year were trained in the United States, in 1965 that figure had reached 764 (Canêdo and Garcia, 2011) and the figures have continued to grow.

In Argentina, since 1955 the main decentralized research agencies have been created, reorganized or re-founded; these were the National Institute of Industrial Technology (INTI), the National Agricultural Technology Institute (INTA), the National Commission of Atomic Energy (CNEA) and National Council of Scientific and Technological Research (CONICET)[2]. Also, national universities started to change their professional profile, by creating new careers, renewing the teaching staff, setting up research institutes and increasing the number of full-time posts (Caldelari and Funes, 1997; Sigal, 2002). In CONICET, scholarship programs (domestic and abroad) and subsidies, as well as the establishment of a pay scale and experience level program for researchers, complemented the universities' effort at institutionalization and professionalization by establishing evaluation parameters based on shared international criteria. The implementation of these tools made evident a certain "liberalism" in CONICET policies that privileged criteria based on academic excellence over those based on regional, sector, social or disciplinary priorities (Feld, 2011). Between 1958 and 1966 CONICET granted 536 external scholarships (38% of the total), part of which were paid with funds from the Ford Foundation (Ford Foundation, 1966). Additionally, between 1958 and 1971, CONICET collaborated, either through subsidies or bilateral exchange and cooperation agreements that it started to sign by the mid-1960s, with the visit of 271 foreign scientists: 96 from the United States, 40 from France, 24 from Great Britain, 20 from Germany. Latin America was less represented with 12 visiting scientists from Brazil and 6 from Chile. A slighter higher figure for international cooperation was registered by CONICET a decade later (CONICET, 1972: 31).

Similar steps at institutionalization took place in Venezuela. In the 1940s and 1950s, scholarships were granted to study abroad: 43% in the United States, Canada and the

[2] Regarding these institutions see Oteiza (1992) and Hurtado (2010).

Panama Canal Zone, and 27% in Europe. During this period the largest number of scholarships were awarded by different ministries, but also by foreign agencies and foundations such as the Rockefeller Foundation and the Creole Petroleum Corporation of Venezuela, among others. The collaboration of the North American private foundations had a particularly significant role in the development of basic agricultural science, public health research and training, and the social sciences (Vessuri, 1996; Ruiz Calderon, 1990); such collaboration was resumed in the 1960s after being interrupted for political reasons from the end of the 1940s. The Venezuelan Institute of Scientific Research (IVIC) came into being at the end of the 1950s to produce science of the highest international standard.

In 1968, CONICIT (later FONACIT) was created as a researchers' initiative under the inspiration of UNESCO, mirroring other agencies in Latin America, while the majority of researchers belonged to the Venezuelan Association for the Advancement of Science (AsoVAC), the most important corporate association founded a couple of decades earlier. CONICIT was born as part of a "*scientistic*" institutionality, trying to emulate as much as possible what was being done in industrialized countries. The tacit terms of the social contract regulating relations between the State and scientists was that scientists did research and CONICIT facilitated the means to do it, usually through subsidies. Social accountability was understood as occurring within the scientific community through peer review, although no broader concerns were posed. Indeed it was a policy by and for scientists with the support and good will of the State (Avalos, 2007; Vessuri, 2004).

In 1975, Gran Mariscal de Ayacucho Foundation (FUNDAYACUCHO) was instituted to contribute to the formation of professionals envisaged in the development plans of the country. During more than 35 years through its fellowship program, the foundation enabled more than 135,000 Venezuelans to be trained in domestic higher institutions and abroad. From 1970 to 1985 CONICIT and FUNDAYACUCHO granted 13,311 scholarships in the field of science of which 73% were to study abroad, mainly in the United States, the United Kingdom, France and Spain (De la Vega, 2003).

By the end of the 1960s, Mexico had already established important public research institutions, such as the National University of Mexico, the National Polytechnic Institute, and the Research and Advanced Studies Centre (CINVESTAV). In 1959 the National Scientific Research Academy was created, and important governmental institutions, such as the National Observatory, the National Institute on Agricultural Research, the National Cardiology Institute and the National Oil Institute, among others, were already contributing to scientific development in the country. The 1970s in Mexico were characterized by a renewal of the nationalist discourse by government, which aimed to reduce the economic dependence of the country from abroad (Casas & Ponce, 1986). One of the most important measures at this stage was the creation of the National Council of Science and Technology (CONACYT) in charge of planning, coordinating and assessing government's Science and Technology policy.

The creation of CONACYT also linked government policy to national development (DOF, 1970) under a notion that resembled the paradigm of science as an engine of progress. CONACYT's aim was to reverse scientific backwardness and achieve economic independence in a context characterized by the growing predominance of transnational capital and the loss of dynamism of the imports' substitution model. One of the main policies applied by CONACYT in the 1970s was the training of highly qualified personnel, mainly abroad. Towards the end of the 1970s, 30% of scholarship holders from CONACYT had gone abroad, mainly in the United States, United Kingdom, France and Japan[3], all destinations similar to those of Argentina, Brazil and Venezuela during 1958 to 1966, except for the cooperation between Mexico and Japan. In addition, scientific collaboration was fostered through bilateral cooperation agreements, mainly with France, Germany, Japan and Cuba, which promoted the exchange of researchers in both directions. Available information suggests that between 1970 and 1976 the training of human resources in engineering, agricultural sciences and social sciences was favoured.

The creation of these councils did not produce a discontinuity in the modalities of international cooperation: "international links continued to develop under a *laissez faire* regime, in which each researcher or laboratory head tried to establish links with prestigious colleagues from 'central' countries, with whom they exchanged information, and to whom they sent their students to spend some time" (Kreimer, 2010). However, the presence of new funding tools, like the grants and fellowships awarded by the councils, led to increasing institutionalization and formalization. On the other hand, in many cases, foreign researchers' visits were crucial in establishing disciplinary fields, restructuring study plans, installing certain research lines, coordinating between referent and local institutions, articulating international networks and acquiring policy and management tools.[4]

b) The Role of International Agencies and Foreign Foundations

The "golden era" of national science coincided with what was also called the "golden age" of international technical assistance to Latin American universities and research centres, led by several national public agencies and North American foundations and also overseen by international organs such as ICSU, UNESCO and somewhat later OAS.[5] In the four countries studied here the domestic public sector has historically been perceived as the primary source of science funding. However, there was also significant funding originated in the "donor" countries that was accepted by the "recipient" ones with emphasis on "technical aid," which meant the mobilization of human and financial resources from developed countries (Gaillard, 1996; Cetto and Vessuri, 2005).

A study by Levy (2005) shows, for example, the ample support given to the region by the United States through different institutions, principally the Ford Foundation (FF), the Agency for International Development (AID) and the Inter- American Development Bank (IADB). The funds from these institutions were oriented to both training (scholarships and visiting professorships) and research infrastructure (equipment, libraries, etc.). These funds participated in the institutionalization and professionalization process, and, hence, they also helped consolidate international links.

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[3] Note that what is traditionally conceived as the "golden age" of science in Argentina extended for only a decade until the 1966 *coup d'état*. That is why we have presented here the data for that period. In Mexico the total number of international scholarships granted from 1972 to1981 increased significantly less than the domestic ones, barely reaching 11.33% of the total. Also, the flow of funds from North American foundations stopped.

[4] An exemplary case is the Physics Department of the Faculty of Exact and Natural Sciences of Buenos Aires University; see Romero and Buschini (2010).

[5] ICSU: International Council for Science. OAS: Organization of American States. According to Levy (2005), the period from approximately the Alliance for Progress (around 1959) until 1975 has been considered the most ambitious, organized and nonmilitary effort in history, aimed at exporting progress where progress was understood in a broad sense as being political, economic, social and cultural, through the development of universities and other research centres in the region.

Multilateral agencies participated in south-south (and intra-regional) cooperation aiming at training human resources, as well as participating in large projects or international scientific events. In the 1960s, UNESCO's Centre for Scientific Cooperation for Latin America (CCCUAL) fostered the creation of regional research centres and laboratories principally focused on the training of human resources in the basic sciences. As a response to this policy, the Latin American Physics Centre in Río de Janeiro, the Latin American Mathematics Centre in Buenos Aires, the Latin American Chemistry Centre in Mexico, and the Latin American Biological Sciences Centre in Caracas (Barreiro and Davyt, 1999) were created. Not all these initiatives generated the desired effects; the Latin American Physics Centre was the most active among them.[6]

Additionally, towards the end of the 1960s, OAS started the Regional Program of Scientific and Technological Development (PRDCyT in its Spanish acronym)[7], which was implemented through a set of projects of technical assistance (mostly scholarships, visiting professorships, equipment, seminars, colloquia, short courses and publications). Each project was integrated by centres from several countries of the region and was proposed by a national centre designated by the respective government, which performed contextual research to make sure that the project fitted the national development plan (Haas, 1980). The CCCUAL strove to cover important deficits in human resources in the region, and the OAS program implied a shift in the notion of cooperation geared to link it to national policies.

The Latin American participation in large international projects driven by "Northern countries" generally did not solve the priority problems of "Southern countries," although it was expected that the projects might turn out to be useful to the latter (Barré and Chabbal, 1996). Latin American evidence confirms Elzinga's claim that during the post-war years the modalities of international cooperation transcended the traditional information exchange through conferences and symposia (such as those organized by the international scientific unions). International cooperation incurred in the design of large-scale research programs involving numerous countries, because of either the need to share costs or the inherent requirements for the study of large planetary systems (meteorology, oceanography, hydrology, biosphere, etc.). This presupposes data collection and the elaboration of resource inventories (Elzinga, 1996).

ICSU and UNESCO, as the largest intergovernmental and nongovernmental international agencies, were very active in organizing and promoting large research programs such as the International Geophysical Year (1957-1958), the International Year of the Calm Sun (1964-1965), the International Biological Program (1964-1974), the Hydrological Program (1965-1974), the International Geological Correlation Program (started in 1974) and the Global Program of Atmospheric Research (initiated in 1970 together with the World Meteorological Organization). Participation in some of these programs involved setting up national committees in charge of coordination of activities in each country.[8] In Argentina, the national science policy institution CONICET oversaw the creation of the national committees (CONICET, 1983). Similar mechanisms were adopted in other countries in the region.

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[6] For example, the Latin American Center for Biological Sciences only came into fruition as BIOLAC-UNU in 1988.

[7] In 1967, the *Declaration of the Presidents of the Americas* (Punta del Este) announced the launching of the PRDCyT as part of the Central Program for the development of the hemisphere. Such a program was defined in 1968 in the Fifth Meeting of the Inter-American Council for Education, Science and Culture in Maracay, Venezuela (Plaza, 1970: 282).

[8] See the example of the national committees of the International Hydrological Decade (Barreiro and Davyt, 1999).

Cooperation in the 1970s to the 1980s: Research, Technology and Priority areas

While during the 1960s and early 1970s, science policies were characterized by instruments aimed at increasing the "critical mass" of human resources and the infrastructure sustaining research activities, a new paradigm emerged in the 1980s, mainly spread by international organisations, that proposed the integration of science-technology policies in the general planning of the development and the setting up of priority areas. Thus appeared a new discourse, parallel to the dominant "scientific" one, that emphasized the need to regulate technology imports to increase the endogenous capacities that would enable generating "technologies that are in agreement with local conditions" towards a "national independence project." To some extent, the design of national plans became a common practice in Latin America. In addition, some countries approved a series of regulations for foreign investments and technology transfer.

In line with these changes, new policies for international cooperation became common. The first S&T plan in Argentina claimed that external assistance must "be the complement of the national effort, be oriented by the country and respond to its priority needs" (SUBCyT, 1972). It announced that cooperation should be guided by a "principle of mutual benefit" rather than being perceived as "technical assistance" (SECyT, 1985).[9] Under this principle, some cooperation projects were started by some Latin American countries, for example that between Argentina and Brazil, without other foreign funding.

In an attempt to favour not only scientific development but also technological research and its integration to the national productive sector, the Venezuelan CONICIT's Unit of Technology Transfer (begun in 1977) was raised in 1983 to the level of Directorate of Technology Promotion. However, by comparison with the Directorate of Scientific Promotion, its funding was considerably lower. Also, in the second half of the 1970s, Venezuela started a cooperation program in petroleum science and technology with centres and programs of the United States, Europe and the Ibero-American network CYTED, which focused on training in fields associated with core sectors of the national oil industry: production and refining (Engineering, Chemistry and Geology, among others). Venezuela created the Superintendence of Foreign Investments (SIEX) as the organ in charge of this mission, following the recommendations of the Andean Pact; however, it inefficiently fulfilled its aims since it ran against the prevailing economic logic of imports' substitution.

In Mexico, during the 1970s, research programs were established related to food, mineral and marine resources, agricultural and forest sectors, ecology, demography and health, basic and educational sciences. In addition, the *National Indicative Plan of Science and Technology* was elaborated at the end of 1976, a planning exercise that involved some 250 scientists, technologists, consumers and CONACYT officials. This was the first exercise in which actors from social and economic sectors participated, leading to a dialogue between different cultures: academic, bureaucratic and economic.

[9] Gaillard (1996: 10) produced a classification of the implicit (and explicit) notions in cooperation modalities at different times: "technical assistance" (until the 1970s), the "generation of endogenous capacities," "problem solution" (between 1970 and 1970) and "mutual benefit" (since 1980).

By the mid-1980s, the Mexican Secretariat of Foreign Relations[10] developed a project called the "International Technical Cooperation System." Started in 1985 with the support of the United Nations Development Program (UNDP) the project established a set of priority areas: engineering; metallurgy; agro-industrial technology; vegetables, grains and fruit production; housing technologies; hydraulic resources; health; refining and petrochemistry, among others. The document was made public in 1987, a year before the end of the De La Madrid presidency; as frequently occurs in Mexico, this strategy was not followed by the new president who took office in 1988 (Gonzalez, 1995). This Secretariat has been since then the main monitoring governmental office for scientific and technical cooperation, approving bilateral agreements and emitting visas to foreign experts.

Brazil experienced significant changes in its institutional structure of science and technology. Beginning in 1968, there was a university reform that resulted in the creation of academic departments, research institutes and a large number of graduate programs managed by CAPES. In 1975, the former National Research Council (CNPq) was transformed into the new and broader National Council for Science and Technology, also under the Ministry of Planning. In 1973, and again in 1975, a national biannual plan for science and technology was promulgated. Planning in the field of science and graduate education intensified technological orientations at the expense of basic science. The fund established by the National Development Bank was transferred to the National Innovation Agency (FINEP), created in 1967 under the Ministry of Planning to foster innovation in both the academic and the productive sector (Schwartzman, 2001). Also, the nationalist ideal of turning Brazil into a world power – widely supported at the height of the military regime in the early 1970s – led the government to align its efforts with those of the scientific community in order to modernize the Brazilian university system and the national scientific and technological sector. Large resources were made available for the university system to train and professionalize the full-time teaching staff as well as by implementing a consistent graduate policy directly associated with the development of the National Graduate Programs (PNPG) adopted in 1974 (Hostins, 2006).[11] Since the 1980s, major efforts were made to provide grants for study abroad at different academic levels and in numerous knowledge fields.

The 1970s also witnessed the strengthening of international academic cooperation through agreements such as the *Capes-Cofecub* Agreement, USAID programs, the Fulbright Commission, cooperation with Germany in the development of nuclear energy and the ensuing construction of reactors, as well as cases involving the installation of state firms in basic industry; Brazil and the United States cooperating to expand the steel and oil industries is one example (Volta Redonda and Petrobrás). These programs had a clear assistance connotation and tried to supply Brazil with human resources for the development of higher education institutions.

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[10] In Mexico, ministries are called "secretariats."

[11] The emphasis on quality of higher education and the expansionist goals of the second National Plan (PNPG 1982-1985) gave way to the institutionalization of the monitoring and evaluation system. In the third PNPG (1986-1989) graduate programs came to be considered integrally linked to academic research activities. Specific measures were directed at strengthening the ties between the academic community, the national ST&I system and the productive sector. Brazilian policy concerning funding for the development of research capacities was not restricted to training through domestic programs.

A significant case of cooperation in human resource training to solve the unequal development of different regions of the country was the *Acordo Capes-Cofecub,* signed with France in 1978. The initial aim of the agreement was to foster the development of universities in Northeastern Brazil that presented greater academic deficiencies. While recognizing limitations in the traditional scholarship programs, the agreement concentrated on individual spontaneous applications for pursuing courses in foreign countries. It also aimed at attracting graduate teachers in Northeastern Brazil (Schmidt & Martins, 2005). By the early 1980s, the agreement was broadened to also cover other regions as a result of the pressure from universities in the southeast and south of the country that wanted to participate in the cooperation process. Better established institutions along with new and emerging ones also integrated the agreement; this opened the way to more symmetric partnerships between Brazilian and French teams in equivalent stages of development. As time went by, in addition to full doctoral programs and the “sandwich” modality (short-term doctoral stays along with graduation in both countries), postdoctoral projects were also developed. The changes signalled the maturity of the national graduate system that began offering the possibility of carrying out master's and doctoral degrees within Brazil. A joint commission (called “mixed commission”) in 1995 approved a proposal to subsidize two types of projects called type I and type II. The first category involved teams in unequal degrees of academic consolidation and attempted to strengthen new teaching and research groups. The second category involved consolidated groups on equal footing in projects, aimed at intensifying the joint scientific production.

In Argentina, CONICET created by the mid-1980s the Office of Technology Transfer and the Advisory Commission of Technology Development, with the function of advising the Directorate in the evaluation of technology-linking activity.[12] Additionally, CONICET received a second Inter-American Development Bank loan to execute four programs, among them one for technology linking and another for human resource training (funding external scholarships, short stays and trips abroad) (SECyT, 1989).

Also, the Secretariat of Science and Technology (SECyT) underwent important changes. SECYT, which was created in 1968, was in charge of the earliest S&T Plans and a number of national programs in priority areas (Gargiulo and Melul, 1992),[13] but its action had been rather weak (Amadeo, 1978). At the beginning of the 80´s, SECYT restructured its national programs, prioritizing biotechnology and informatics, emphasizing the participation of government representatives along with research groups and firms in the concerned areas. It also included training and international cooperation policies (SECyT, 1989). [14]

In 1986, the Argentine government launched a project of regional scope: the Latin American Advanced School of Informatics (ESLAI). The project was agreed upon by several countries of the region and directed at producing (at the undergraduate level) well-trained students that

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[12] A National Registry of License Contracts and Technology Transfer had been created in Argentina in the early 1970s.

[13] Regarding the plans see SECONACyT (1971) and SUBCyT (1972).

[14] The choice of these two privileged areas responded to the belief, common in the 1970s, in the emergence of a “third industrial revolution,” a new techno-economic paradigm based on the development of the electronic-informatics complex, biotechnology and new materials (Aguirre & Carnota, 2007). A similar trend is observed in Venezuela, where in the 1980s an Inter-American Development Bank loan was also obtained (the first IDB/CONICIT program) for the development of new technologies and research in five fields with potential for their technological transfer to the productive sector: biotechnology, fine chemistry, informatics, electronics and telecommunications, as well as new materials.

would pursue their graduate studies abroad in order to later join the local academic and productive systems.[15] In a simultaneous move, the Argentine and Brazilian governments started a rapprochement and cooperation policy in some areas of science and technology. Early in 1985 they laid the foundations of what came to be the “Argentine-Brazilian Program of Research and Advanced Studies in Computer Science," or PABI, envisaging summer schools, the creation of a binational research group and the exchange of researchers and students between the two countries. Between 1986 and 1993, six summer schools took place together with meetings of researchers in a joint research project called ETHOS (Workstation of Heuristics Aimed at Software Engineering). Both ESLAI and ESBAIs contributed to the training of human resources, the institutionalization of the discipline in the region’s academic domains and the shaping of a vast exchange and cooperation network (Aguirre & Carnota, 2007). However, these programs were less successful in the promotion of cooperation links between firms than was originally expected (Marí et al., 2001).

Cooperation in biotechnology was also one of the fields of greatest Latin American interaction. An early precedent can be traced to 1984 when discussions began about the Latin American Biotechnology Network which would become the Regional Biotechnology Program for Latin America and the Caribbean (1986), sponsored by UNDP, UNESCO and ONUDI (SECyT, 1987). The Argentine-Brazilian Biotechnology Centre (CABBIO) was launched in November 1985 after the Biotechnology Argentine-Brazilian Meeting in Foz de Iguazu. This was complemented by the integration between universities, research institutes and firms through the Argentine-Brazilian Biotechnology School (Siñeriz, 2008/2009). The fate of the two cooperation projects between Brazil and Argentina was quite dissimilar. PABI and ESLAI, as well as CABBIO, were weakened by the 1980 debt crisis and the 1989 change of government in Argentina. [16] However, CABBIO endured until the present, and today is considered a successful case of cooperation (Siñeriz, 2008/2009). More recently, in 2005, both countries signed a protocol for the creation of the Argentine-Brazilian Centre of Nanotechnology (CABN), which has similar features to those of CABBIO.

The shaping of MERCOSUR in the 1990s seemed to augur a deepening of south-south cooperation links. However, although bibliometric studies show some strengthening of cooperation mainly between Brazil and Argentina, MERCOSUR has not systematically nurtured S&T regional programs. A good portion of the cooperation links established throughout the 1990s continued to have their origin in national policies, individual contacts from meetings and congresses, graduate courses or multilateral programs driven by the European Commission, such as CYTED and ALFA (Marí et al., 2001; Velho, 2000; Cetto and Vessuri, 2005).

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[15] To avoid the effects of potential political fluctuation, ESLAI was placed under the Informatics Foundation, an *ad hoc* institution integrated by members of UNESCO, SECYT, entrepreneurial and academic referents. The projects received funding from the Intergovernmental Bureau of Informatics, equipment donated by the Italian government, two subsidies from the European Economic Community (one for US$ 30,000 and another one for US$ 60,000) and the assistance of Italian and French teachers.

[16] To a further extent, the weakening of both initiatives was linked to the economic crisis that implied not only a budget cut for national programs but also an inflationary spiral that hindered estimates for them. Thus, for example, subsidies for the programs increased from US$ 900,000 in 1984 to US$ 8 million in 1985, diminishing to US$ 5 million in 1986, US$ 2.5 million in 1987 and US$ 1.4 million in 1988 (Gargiulo and Melul, 1992).

Internationalization of Higher Education

The internationalization of higher education is a clear trend observable in the cooperation policies of Latin American countries since the 1990s.[17] Universities with research capacities began by creating bureaus of international relations, and in some cases universities have opened offices abroad to foster their internationalization. However, it was not until the late 1990s that universities began to consider internationalization as a strategic objective, as a recent study on the international dimensions of higher education in Argentina indicates (Theiler, 2005).

In Argentina, the Spanish Agency for International Cooperation (AECI) (in particular the Interuniversity Cooperation Program) played an important role in structuring cooperation activities. The International Cooperation Network of National Universities, established in 1999, aimed at the standardization of practices among universities. However, the small size and limited budget of the universities' offices for international relations restricted their activities to the management of external programs, the signing of international agreements and, sometimes, a mere formal participation in regional and international networks. They acted as forums to discuss aspects of higher education and promote technical assistance in university management and organization.

Research activities mainly developed with European Union partners: 63% of Argentine universities conducted research activities with institutions located in the European Union, while only 21% were developed with Latin America and 14% with the United States. Generally, research funding has come from agreements signed between the Secretariat (now Ministry) of Science and Technology with foreign agencies such as the CNRS, NSF or CNPq (Theiler, 2005). On the contrary, most actions concerning student mobility have been based on participation in mobility programs established by multilateral agencies (Organization of Ibero-American States or OEI), bilateral agencies like AECI and university networks: Montevideo Group University Association, Council of University Presidents for the Integration of the Western-Central Subregion of South America and Latin American Universities' Union (UDUAL) (Theiler, 2005).

About half the universities (both public and private) offer undergraduate and (predominantly) graduate degree programs in collaboration with foreign universities, although primarily designed for the Argentine market. Additionally, in 2003 the Secretariat of University Policies created an international relations structure that developed the Graduate Program of Associate Centres. It is based on an Educational Cooperation Agreement between Argentina and Brazil to promote the association of master´s and doctoral degree programs in both countries (Theiler, 2005). Finally, European and North American universities have created branches in Argentina: University of Bologna, New York University and Harvard University). However, the activity of some of these centres (specifically NYU whose activities were

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[17] An early example was the COLUMBUS Project, established in 1987, as a nonprofit organization of the European Association of Universities (EAU) and the Latin American Association of Universities (AULA) to promote cooperation between European and Latin American universities while identifying and undertaking institutional strategies to respond to the challenges facing tertiary education.

cancelled) was affected by the severe political, economic and social crisis of 2001 (Theiler, 2005).

In Mexico, the internationalization trend was framed with the adherence of Mexico to GATT Free Trade Agreements and its admission into the OECD. Changes in higher education and research in 1989 through 2004 placed strong emphasis on the internationalization of the domain (Casas and Luna, 1997). The result has been an intensification of student mobility to pursue graduate studies abroad, supported by Mexican financial sources. However, despite the increase of scholarships for postgraduate studies abroad, mainly in the United States, Mexico is far from having integral collaboration schemes of student mobility (Ortega, 1997).[18]

The NAFTA agreement with the United States and Canada, since 1994 has promoted scientific collaboration by means of different mechanisms with working groups in energy, climate change and transport technologies, as well as in biotechnology, nanotechnology, genomics, cybernetic infrastructure and new materials (Antal, 2009). The Alliance for Security and Prosperity in North America (ASPAN) has also promoted scientific collaboration in agricultural biotechnology, electronic commerce, information and communication technologies, as well as in energy to promote the use of clean energies in the region. Collaboration promoted by foundations, such as the Mexican-American Science Foundation (FUMEC) created in 1992, is worth mentioning. This is a strategic alliance between government, universities and firms that integrates activities with an entrepreneurial base and three major objectives: technology-based economic development, technology-based firm accelerators and the System for Technical Firm Assistance, which supports small and medium firms (Antal, 2009) The Foundation has been very active in developing nanotechnologies and nanoscience in Mexico (Robles, 2011).

The ANUIES SUPERA programs, supported by CONACYT have aimed at the mobility of Mexican researchers and scientists to visit other countries for variable lengths of time and have an improved access to universal knowledge. Between 1989 and 1993, exchange actions envisaged in binational and multilateral agreements of cooperation increased by 140%.

Also the majority of the scientific cooperation fostered in the 1990s in Mexico took place with United States universities through specific agreements that involved Mexican universities or other higher education institutions. These took the form of consortia, as for example the Consortium of Universities from the Eastern Region of the United States, which promotes collaboration with Mexican universities or strategic alliances such as the one established by Texas A&M University, ITESM and Northern Telecom (Ortega, 1997). Other forms of cooperation established in the 1990s were through electronic networks such as the UNAM Network, Mexnet, ITESM Network, IPN Network and Profmexis, among others.

These actions have been accompanied by specific programs for the internationalization of higher education of some public universities in Mexico. Among others, the actions of UNAM may be recalled here: the Teaching Centre for foreigners, for example, has spurred internationalization through the teaching of Spanish, Mexican history, fine arts and literature and the professionalization of teachers trained in each of these academic areas, within and

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[18] A similar effect can be observed in Venezuela, where historically, because of its oil wealth, the State funded the bulk of student mobility programs.

outside the country. Currently UNAM has four sites or extension schools abroad: San Antonio, Los Angeles and Chicago in the United States and Gatineau in Canada.

Historically, exchanges and cooperation activities have been performed frequently with the United States and Europe (mainly Spain, Great Britain, France and Germany). However, in the last decade major changes have occurred with the generation of stronger links with countries in Latin America; this strategy is part of a growing south-south cooperation scheme, not yet fully realized.

In Venezuela in 2001, the National Nucleus for Cooperation and Inter-institutional Relations (NUCORI), which coordinates all directorates or offices of international cooperation in the country's universities, identified 345 international agreements signed by Venezuelan higher education institutions. Of these, 133 (38.5%) belonged to the Central University of Venezuela (OPSU, 2001).[19]

During the last decade, the Ministry of Education has developed policies to strengthen academic cooperation agreements with countries such as France, Spain, Germany and Great Britain. However, the ministry has also extended its action to include other less traditional partners; for example, under the Integral Cooperation Agreement between Cuba and Venezuela, since 2000, 51 graduate programs at the master's and doctoral level such as Pedagogical Sciences, Engineering, Information Technology, Renewable Energy, Energy Efficiency, Agriculture and Sustainable Agriculture were developed. In total, 19 Venezuelan institutions and 15 Cuban universities were involved with 691 graduates in January 2010 (MPPEU, 2010).

Some of the activities within the framework of the Andean Community of Nations (CAN) until Venezuela's withdrawal in 2006 were the adoption of an exchange schedule for the recognition of professional qualifications and diplomas,institutional self-assessment and the accreditation of academic programs of higher education. A community rule for border integration zones (ZIF in the Spanish acronym) was also adopted to facilitate academic mobility as well as S&T exchange between signatory countries.

Since 2006, the Alma Mater Mission has endeavoured to promote the transformation of the Venezuelan university education system through an institutional partnership framework to generate, transform and socially appropriate relevant knowledge, while promoting Latin American integration. Among the institutions in the process of creation or transformation within this framework is the Basic Science University, which is the transformation of the Centre for Advanced Study of the Venezuelan Institute of Scientific Research (IVIC) into a university with greater capacity to receive international students. Also included is the Peoples of the South University, conceived as a university with an international partnership profile to mobilize collaborations with other southern nations on the basis of the recognition of political pluralism and cultural diversity. In addition to other projects outside the realm of universities and science, such as Telesur, RadioSur, PetroSur and the South Bank, this

[19] These agreements include the participation of Venezuela in the following: the Alpha, Presta and Columbus Programs with the European Commission as well as the Mutis Scholarship, Intercampus and Ibercue Spanish programs. Other agreements involve the Redican network related to agriculture and various programs under international bodies such as UNESCO, UDUAL, Association of Amazonian Universities (UNAMAZ), Centre for Historical Research in Latin America and the Caribbean, United Nations Organization for Food and Agriculture Organization (FAO), International Atomic Energy Agency (AEA), Latin American Parliament, Inter-American University Organization (OUI) and Ibero-American University Graduate Association (AUIP).

university is one of the spearheads in the new geopolitics that is emerging from the processes of transformation of Latin America and the Caribbean (MPPEU, 2010).

A trend appears about having greater links within Latin American countries. In 2008 the Committee on Accreditation of Higher Education Programs and Institutions (CEAPI) was established as an advisory body to coordinate the processes of institutional evaluation and accreditation and to ensure, recognize and promote the quality of higher education. The efforts of this committee include the integration of Venezuela into the MERCOSUR Network of National Accreditation Agencies (RANA) and the Ibero-American Network for Accreditation and Evaluation of Higher Education (RIACES). Also under its responsibility is the coordination of assessment and accreditation processes of Agronomy and Architecture under the System for Assessment and Accreditation of University Programs (ARCUSUR) of MERCOSUR, as well as the establishment of the ALBA University Network. Similarly, government has developed plans and projects sponsored by international organizations such as the Andres Bello Agreement (CAB) and the Organization of American States (OAS), which both include teacher performance evaluation in the Andean countries, the teaching of history in the signatory countries to the Andrés Bello Chair and the “Living Classroom for Integration” Program.

Brazil today is in a third phase with regard to international academic cooperation. During the last two decades, human resources in science rose dramatically. The number of students in master's and doctoral programs in Brazilian universities increased more than tenfold (Gusmao, 2010). Whereas in the late 1980s the number of doctorates granted in Brazil was only 3% as compared to the United States, by 2005 they corresponded to 21%. In 2005, Brazil was among the 10 top countries in the world with regard to the number of PhDs awarded (Viotti, 2008). During the preparation of the fourth National program (PNPG), which for various reasons was never published (Hostins, 2006), discussions focused on the need to diversify the model and incorporate professional training courses. Finally, the fifth PNPG (2005-2010) proposed the expansion of the system along four lines: i) teacher training for all educational levels, including basic education; ii) training of staff and specialized professionals for nonacademic markets; iii) networking to offset regional unbalances in the supply of graduate courses and to meet the demands of new knowledge fields and iv) fostering university cooperation at the international level, including capturing resources from international agencies (CAPES, 2004). By 2008, the total number of master's and doctoral programs had risen to 2,568 of which 54% were from federal universities, 26% state or municipal and 20% private. From 1998 to 2008, the number of grants offered by the two agencies for master, doctoral and postdoctoral studies in all fields had increased an average 82% (from about 33,000 to around 60,000 per year).

Developments such as these clearly indicate that the central features today are no longer “assistance” but joint efforts in research programs (shared laboratories) and an exchange of teachers and students connected to such programs. Noticeable are also bi-national assessment committees to judge merit and priorities according to the themes and lines defined in official documentation and published in specific calls, permanent evaluation and monitoring. Binational financial resources with open and shared budgets, as well as a permanent exchange of information, visits, meetings and seminars between the national agencies involved, are also among today’s cooperation features.

The asymmetric logic of the integration into the international networks and research is giving way to a renewal of the south-south cooperation. A case in point is the IBAS Agreement (among Brazil, India, South Africa), which might become a useful instrument of mutual help given an effective integration of academic and scientific projects (Schmidt and Martins, 2005). Similarly, actions are being implemented through regional university networks, inside and outside MERCOSUR, such as the Montevideo Group University Association, the Council of University Presidents for the Integration of the West-Central Region of South America and ARCAM, a network of universities from MERCOSUR. The signature of the Gramado Agreement by the Ministers of Education of MERCOSUR has the purpose of promoting the following: a) student and faculty mobility; b) interinstitutional cooperation in graduate programs, faculty training and scientific research and c) accreditation of degrees (principally in agronomy, medicine and engineering). Until 2005, the latter was the only objective reached (Theiler, 2005: 82, 87).

A number of conditions need to be secured to develop this kind of cooperation: improvement of the mutual knowledge of the countries and their cultures; an exchange of information about curricular contents and teaching techniques and the diffusion of that information; and the formatting of research projects that might be developed until the phase of research products' marketing. The displacement of education from the field of social policy to that of economic policy in the World Trade Organization threatens to modify the process of internationalization of education, subjecting it more directly to the pressure of large multinational providers of "internationally certified educational services." The very essence of the concept of university would be radically altered.

New Trends of International Cooperation in Latin America and the Challenges of Social Inclusion

To conclude we would like to mention some recent trends in international cooperation. A first change concerns the geographical orientation of cooperation. During the last two decades, changes in S&T policies of developed countries implied, among other things, a growth and concentration of resources to create large "regional knowledge blocks," implemented through networks of excellence and projects including a large number of researchers from several countries and institutions (Kreimer, 2010). The Framework Programs from the European Union, for example, have opened research funding to "third countries" (among them, developing countries). The Third Framework Program (1990-1994) contained the STD program (Science and Technology for Development) and ISC (International Scientific Cooperation), which would later be followed by a specific entity inside the Directorate General for Research of the European Commission International Cooperation (INCO),[20] with a specific subprogram for developing countries: INCO-DC (International Cooperation with Developing Countries) since the Fourth Framework Program (1994-1998).[21] Throughout the

[20] Regarding international cooperation with Latin America from the Third to Fifth Framework Programs, see Gusmao (2000), and Bonfiglioli and Marí (2000).

[21] The INCO-DC Program was implemented through three kinds of action: research projects, coordination actions and measures of accompaniment or support. From a total of 3,277 proposals, 419 contracts materialized; the majority concerned R&D, concerted actions in vaccines for humans and animals, natural resource management and improvement of agricultural production. A lesser but considerable group corresponded to the ICT sector (Gusmao, 2000).

1990s, European cooperation with “developing countries” mobilized 25 Latin American countries, representing the participation of more than 800 laboratories.[22]

Responding to European policies, several Latin American countries created collaborative funds with EU Framework programs to support projects proposed by Latin American research teams in consortium with European groups. Since the mid-1990s in Argentina, the *Fund for Scientific and Technological Research* (FONCyT), a competitive fund oriented to national research projects, established a funding program for “S&T Research Projects” (PICT), which was also used as a facilitating tool of international cooperation with the European Projects. Since 1999 it enabled beneficiaries of such grants to use them as counterpart to participate in successive Framework Programs. In 2005, the Ministry for Science, Technology and Productive Innovation created the Argentine/European Union Link Office (ABEST) to encourage cooperation activities (Gusmao, 2000).

More recently this ministry has created several institutions (International Interdisciplinary Institutes for Innovation) in partnership with a leading international institution. Among them, between Germany and Argentina, the Institute for Biomedicine Research is co-organized with the Max Planck Society in Buenos Aires and devoted to current topics in the field of biosciences and biomedicine; between Argentina and Italy, there exists the Bilateral Centre for Industrial Design, which studies the relationship between industrial design and new technologies with the engagement of several Italian universities.[23] In addition, between Argentina and France, the Institute for Basic Informatics, Logics, Languages, Verification and Systems (INFINIS) is managed by CONICET along with CNRS (National Centre for Scientific Research) and University of Paris 7-Jussieu.

In Mexico, exchange with the European Union is one of CONACYT’s current priorities. Since the 7th Framework Program it has formalized projects with several European countries. Also the CONACYT / European Union Fund called the European Union-Mexico Fund of International Cooperation in Science and Technology (FONCICYT) and its application between 2008 and 2010, aimed to support joint research projects and networks, technological development and innovation between entities from Mexico and member states of the European Union. Through this program Mexican researchers participated in 59 projects within the 6th Framework Program (FP) and 89 within the 7th FP.[24]

These kinds of initiatives have reinforced traditional trends in Latin America to cooperate with developed countries, shown by bibliometric coauthorship studies. However, during recent years, some countries of the region have begun to establish non-traditional bilateral agreements. In Venezuela, for example, the Bolivarian Revolution proposes a political interaction at the international level with new bilateral relations, aimed at a development model that would differ (politically and ideologically) from traditional multilateral agreements or from those led by the highly industrialized nations.[25] “South-south cooperation,” a main element of this policy, is considered an option to support development from the resources

[22] The EU has increasingly opened practically all of its programs for research to all countries, including Latin American countries, and without any specific management procedures for developing countries.

[23] The Polytechnic Institute of Milan, the University of Bologna, the Venice IUAV and the University of Naples.

[24] See Kreimer and Levin in chapter 4 in this volume.

[25] Note that Venezuela is one of the few countries whose participation in FPs has decreased: from 11 projects within the EC’s 6th FP to only 3 projects in the 7th FP.

and expertise that each country can share with equally or less-developed neighbours, in a process of mutual cooperation. In practice, it appears as a form of cooperation not based on economic criteria and provides strategic partnerships between equals to achieve common goals (SEGIB, 2009). Since 2000, Venezuela has held bilateral agreements on S&T cooperation with the following nations: Cuba, 2000; Iran, 2001; China, 2001 and 2005; France, 2001; Russia 2003; Argentina, 2004; Brazil, 2004 and 2005; Chile, 2005 and India, 2005 (La Rosa, 2005, pp. 23-26). These agreements have ranged from information exchange through the training of human resources to performing joint research and technology projects.

In a more complex scheme, Argentina and Brazil have also diversified the scope of their international relationships: scientific and technological agreements have been signed between Brazil and India, China, Angola and Mozambique in recent years (Laus and Morosini, 2005). Similarly, Argentina is conducting joint research projects or has signed agreements and memoranda with countries like China, Israel, Russia, Cuba and various African countries.[26]

A second main trend focuses on the reversal of the historical problem of brain drain. In Mexico, some of the cooperation mechanisms set in place for that purpose are addressed to the technological and innovation domain (Dutrénit et al., 2010), such as the Networks of Talents for Innovation created by CONACYT in 2003 with the World Bank, several governmental agencies, and Nongovernmental Organizations (NGOs). It tries to integrate the Mexican diaspora and create business opportunities based on innovation. The program created a Network of Talents in the United States in 2005, as a joint initiative of the Mexicans Abroad Institute, CONACYT and the Mexico-United States Foundation for Science (FUMEC) in order to contact highly qualified Mexicans living in the United States to help Mexico in science and technology (Antal, 2009). In 2008 the network had nodes in large North American cities, such as San José, Boston, Chicago and Houston.

Brazil has just launched an ambitious mobility program in science, technology and industrial competitiveness called "Science without borders," funded by CNPq and CAPES (Mercadante, 2011; CNPq, 2011). Among the targets is the training of 75,000 scientists and technologists in four years, the recruiting of 1,200 researchers from abroad (either Brazilians or non-nationals) and 300 non-national scientific leaders to engage in research in Brazil. Industry may participate in this component in several ways, such as bearing the salary of the scientist equivalent to that of his home institution, allowing extended stays in Brazil and financing the project to be locally performed. By means of this program, Brazil expects to help redress some imbalances that still hinder further development in that country; for example, although it ranks number 13 among the countries with the greatest percentage of participation in scientific production, it figures in position 47 in terms of global ranking for innovation.[27]

In Argentina, since the mid-2000s, the PICT also served a broader program aiming at both fostering international cooperation links and reverting the characteristic *brain drain* problem: the *Raíces* Program (Network of Argentine Researchers and Scientists Abroad in the Spanish acronym), coordinated by the SECYT's Directorate of International Relations (currently the

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[26] However, several innovative collaborations have been established during recent years with "traditional" partners as in is the case of the joint institutes set up with the German Max Planck Institute or the French CNRS.

[27]Data correspond to the Institute of Scientific Information and the Global Innovation Index 2011, respectively.

Ministry of Science, Technology and Productive Innovation). A specific PICT-*Raíces* call was opened for projects that would include Argentine researchers residing abroad. This added to a previous scheme where funding was available for thematic networks that included Argentine researchers living abroad, and, later, the "Cesar Milstein" funding was established for short visits of emigrated researchers to support research, teaching and training of human resources, and to participate in seminars and workshops. Until 2010, the program had funded in total 46 PICT-*Raíces*, 32 networks and 130 short stays (MINCyT, 2010). The novelty of this fund is that it tried to capitalize on the presence of Argentine researchers abroad rather than perceiving their emigration as a loss in absolute terms (Menvielle, 2005). In addition, the *Raíces* Program contains a series of instruments devoted to the repatriation of researchers; according to the MINCyT, more than 850 scientists had returned between 2004 and 2011.

Finally, there is a third trend related to deeper transformations in the region. In the new century, Latin America has undergone changes that were unthinkable just a few years before. In public discourse, it is again the State and not the market that acts as the great protagonist, cornering in a defensive position the neo-liberal rhetoric. Movements with similar features have occurred in several Latin American countries such as Brazil, Venezuela, Bolivia, Ecuador, Paraguay, Uruguay, Argentina and Chile. In the current political climate, mere formal participation in the new globalized system of production and consumption seems to be no longer an option. As a result, there is a renewed engagement in public discourse on innovation. The need for social inclusion has burst forth in the political discourse, and more or less innovative programs have begun to be created (Vessuri et al., 2012; Dagnino, Olvera and Panfichi, 2006). Topics such as social inclusion, poverty, social inequality, social and economic regional differences and the high informality index of labour markets do not figure in advanced countries as they do in Latin America, exerting significant constraints upon the latter. The use of the potential of research and local development for the solution of social and environmental problems has not managed to become successfully integrated into the S&T agenda of either governments or researchers in the region. Venezuela, Brazil, Argentina, Bolivia and Ecuador have introduced within their S&T plans measures to fight poverty, social exclusion and inequality. Some of the ideas of the Latin American science policy literature of the 1970s (Varsavsky, 1969; Sábato and Botana, 1970; Herrera, 1971) have been re-discovered[28]. New strategies to orient scientific cooperation are being developed to achieve social inclusion, alleviate poverty and confront local or regional social problems.

In this context, new regional cooperation schemes have emerged where S&T has a place. Such is the case of the Bolivarian Alliance for the Peoples of Our America – the Peoples Trade Treaty (ALBA-TCP)[29]. This is a strategic political alliance to enhance the capabilities and strengths of member countries to produce a structural transformation, and the system of relations needed to achieve integral development through the rational use of the region's natural resources, the intensive training of human capital, and meeting peoples' needs and

[28] For instance, the Argentine MINCYT launched a program called "PLACTED," (Program to Study the Latin American Thought in S&T), whose objective is "to recover the historical memory on S&T thought in Argentina and Latin America."

[29] The ALBA proposal was formulated for the first time by Venezuelan President Chávez in the frame of the Third Summit of Head of States and Government of the Association of Caribbean States, celebrated in Margarita Island, December 11, 2001.

aspirations (ALBA V Summit, 2007). Through "Grand-National Projects" this regional cooperation scheme has generated some tools and organs such as the Alba Bank, the Grand-National Literacy and Post-Literacy Project and the Advanced School of Basic Sciences.

However, one might question whether these institutional changes –at least in the rhetoric and documents- constitute lasting transformations or whether they merely represent the entrance of electoral party politics in S&T policy, previously dominated by the scientocracy. This is precisely what is new in this process that occurred at a time when the concern for a policy specifically addressed to social development was emerging.

In Venezuela the Ministry for Science, Technology and Innovation came into being in 2001 to organize the National STI System as well as elaborate policies and plans in this domain, with much more money and power than the previous CONICIT; in addition the ministry sought to reinforce the role of the State relative to the corporate interests of scientists. In 2007 for the first time, the funds allocated for S&T in the Organic Law of Science, Technology and Innovation Law (LOCTI) approved in 2001 were collected. The funds were so huge that they posed a digestion problem to a society that had already suffered this problem in 1973, when following the "oil embargo" it experienced a significant increase in oil production profits. Between 1972 and 1974, Venezuelan revenues had quadrupled. The Venezuelan National Plan of Science, Technology and Innovation aims at social inclusion, a deeper participatory democracy and greater sovereignty (Ministry of Science, Technology and Innovation, 2005). The Science Mission, founded in 2006, was one of more than twenty different missions that have acted in parallel to the structure of a public administration considered to be too inefficient. It has three main objectives: the support of the small productive units, the training of human resources especially at the undergraduate level and the social appropriation of science, particularly technological literacy oriented to ICTs.

An agreement was signed between Venezuela and China in 2005 for building and orbiting the Venezuelan Simon Bolivar satellite (Venesat-1) with an investment of US$ 406 million. This agreement involves technology transfer and technical support for 15 years plus two guarantee years, as well as the training of Venezuelan staff to operate the satellite. The first phase was completed in 2005-2008 and included the training of qualified staff, the planning, building and the launching of the satellite from Xichang, China, as well as the creation of the Bolivarian Agency of Space Activities (ABAE). The second phase (2008-2013) is related to operational adjustment and connectivity. During these two phases, 90 Venezuelan professionals and technicians were incorporated as follows: 30 university professionals got their doctorates in several space fields linked to the manufacture of satellite platforms and 60 in orbit control and traffic management. The third phase (2013-2018) involves widening the service. The satellite is a platform for pursuing three strategic aims: technology appropriation and national development of aerospace research, and the integration to the National Network of Ground Telecommunications of the National Telephone Company of Venezuela (CANTV) to support social programs mainly concerned with the improvement of telecommunications, tele-education and telemedicine (ABAE, 2012).

An example of nontraditional relations is the Cooperation Framework Agreement between Venezuela and the Islamic Republic of Iran, signed in 2004, which implies several ventures in terms of trade, military, oil, petrochemistry, gas, mining, nuclear energy, education and S&T. The agreement includes building in Venezuela 15,000 houses, six milk-production plants, a mixed firm for oil exploration, the installation of six petrochemical complexes, a general agreement for cooperation in nuclear energy and the recognition of academic degrees from 47 Venezuelan and Iranian universities (Torres, 2010). Recently, a memorandum of understanding was signed with Iran for the training and exchange of information in nanotechnology.

Another initiative in international collaboration is the Foreign Students' Program in Venezuela carried out by the Ministry of Science and Technology through FUNDAYACUCHO in connection with ALBA, by which students from different regions of the world can study in Venezuelan universities. Until 2011, 2,743 scholarships had been granted of which 52% were in health, followed by 18.5% in engineering, architecture and technology; the rest were distributed between agricultural and marine sciences (10.6%), social sciences (10%), educational sciences (8.5%), basic sciences (0.2%) and one scholarship in humanities, letters and fine arts. The largest number of scholarships has gone to students from South American countries (56.2%), mainly from Bolivia and Ecuador, followed by Central American countries (20.5%) such as Nicaragua and El Salvador. Additional recipients include Africans (11.2%) from Gambia and Nigeria, Caribbean students (10.2%), North Americans (1.2%) and students from Asia and the Middle East (0.6%) (FUNDAYACUCHO, 2011a).

By April 2010, FUNDAYACUCHO reported 406 Venezuelan students abroad, of whom 31% were studying in France, 25% in Chile and 24% in Argentina, followed in lesser proportion by Germany, Russia, Spain, United States, Uruguay, Nicaragua, Brazil, Hungary and Poland (FUNDAYACUCHO, 2011b).

Mexico has also introduced changes in S&T and higher education policies to alleviate social problems. Currently, CONACYT has numerous calls of support for research and exchange: the Program of Bilateral and Multilateral Cooperation and the one on Bilateral Scientific and Technical Cooperation with countries from North America, Europe and Asia supporting joint research projects, academic exchange, academic meetings, seminars and workshops. Mexico participates in the Latin America and Caribbean Energy Innovation Contest (IDEAS), through Mexico's Energy Secretariat (SENER), the National Council on Science and Technology (CONACYT), and the Inter-American Development Bank (IDB), supported by the Government of South Korea for applied research and technological development projects on sustainable energy. The contest's total prize is $2.5 million and is intended to focus on ideas with local or regional impact, while supporting the development of sustainable economies and reducing poverty.

In Argentina during the last decade, the increasing resources for S&T and the creation of the Ministry of Science, Technology and Productive Innovation in 2007 gave fresh impetus to the sector. Social inclusion and "local innovation" are among the main priority areas along with Nano, Bio and ICTs. The Ministry of Science and Technology created a special program to attend to "social demand": the PROCODAS (Program-Council for the Demand of Social Actors). Its objective is to "coordinate the capacities coming from the scientific and technological sector and orient them to solving social problems." Even if this program has more symbolic than real consequences for "social needs" and for orienting scientific research, its creation is one of the innovative elements included in an important change in S&T policies.

Policies for innovation have been encouraged since 2004 with, for example, the creation of two specific funds: the Fonsoft (the development of software) and Fonarsec (the generation of competitiveness of several economic sectors and the resolution of social problems). The priority areas are far from new: biotechnology, ICTs, nanotechnology, agro-industry, energy and health. Social development, the environment and climate change are among the newer priorities. In recent years, some initiatives were directed at establishing cooperation relations for innovation. For example, in 2006 an agreement was signed with the Ministry of Industry, Trade and Work of Israel to finance R&D projects performed by research centres in association with Argentine or Israeli enterprises. In 2008, a protocol was signed for the creation of a Chinese-Argentine Centre in the area of food technology. However, relations between innovation policies and international cooperation policies are still weak.

Brazil has also introduced some changes in its S&T policy for social development, although as has often been the case with the other countries considered, it has not managed to produce adequate knowledge for making viable the policies aimed at social inclusion formulated in the same political juncture. Despite some efforts in this direction, this is not a prevailing logic. Fonseca (2010) analyses evidence showing how the decisions' agenda is occupied by electoral party interests that determine the contents of policy and the fate of resources. His argument is that the domain of science and technology policy was always fulfilled in accordance with political parties; however, the introduction of political contents linked to immediate political interests inaugurated a new modality of relationship in this field of public policy and politicians.

The emergence of a specific segment of policy driven to promote S&T for social inclusion, among the four priorities of the 2007-2010 Strategic Plan (MCT, 2003), was an important novelty. Its mere existence posed the need to face the debate –always delayed -- about which ones and how many are the beneficiaries of the results of S&T policy, as opposed to the idea of the neutrality of S&T and the freedom of research (Viotti, 2007, quoted by Fonseca, 2010). The Secretariat of Science and Technology for Social Inclusion (SECIS) created in 2003 is an interesting innovation, but it never managed to improve its small budget, reflecting its scarce weight within the sector. The high execution of resources coming from parliamentary amendments reveals precisely this electoral party use of it, in actions more identified with immediate and localized party-electoral aims, delinked from a more structured transformation project associated with social inclusion policies.

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As we endeavoured to show, the diversity of international relations is very rich and, indeed, difficult to summarize in a few pages. However, we intended to draw a general frame to perceive the major trends and, particularly, outline the main changes and continuities observed during recent years in some of the leading Latin American countries. Certainly we are now witnessing a transition, and probably only several years from now shall we be able to assess the scope and extent of current trends.

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Chapter 3

Mapping S&T Collaboration between Latin America and Europe: Bibliometric Analysis of Co-authorships (1984-2007)

Jane M. RUSSELL and Shirley AINSWORTH

Abstrat

The objective of the present analysis is to map the characteristics and trends in collaboration between Europe and the countries of Latin America and the Caribbean (LAC) through the co-publication of original scientific papers validated by a process of peer review and highly visible to the international scientific community. The analysis covers a 24 year period from 1984, the year of the first European Framework Programme STD1 "Science, Technology and Development" to 2007. We first take a global look at the international visibility and networking of research from LAC and go on to illustrate the role of collaboration with the European Union (EU) in this scenario compared to that of the North American countries of the US and Canada. Regional differences in international collaboration patterns within LAC are analysed as well as the main disciplines of co-authorship. The four most productive LAC countries of Brazil, Mexico, Argentina and Chile are selected for more detailed analyses. Results show a steady rise in the international presence of LAC research and in the production of collaborative papers with the EU in all main disciplinary areas associated with an expanding and more complex network of co-author links.

Introduction

Latin America and the Caribbean (LAC) have a long tradition of association with Europe. For over 500 years the region has sustained commercial and political links with the "Old World" (Martín, 2002). The historical and cultural ties that bind Spain, Portugal and to a lesser extent the UK and other European countries to the nations that make up this large and complex region of the Americas facilitate cooperation through a common language and a shared colonial heritage. According to Martín, support from Europe for activities of mutual interest in science and technology has increased considerably since 1980 (Martín, 2002) while Arenas Valverde refers to the necessity of greater development in the field of science and technology which led the European Community to join forces in the hope of achieving greater efficiency and competitiveness on a global scale (Arenas, 1991).

Several initiatives over the years particularly the different European framework programmes (Commission of the European Communities, 1992; European Commission, 201) and the EULARINET project (EULARINET, 2011) described in the introduction of this book have greatly facilitated the extent of collaboration between scientists from the LAC and their European colleagues. However, not all international scientific partnerships occur under the umbrella of cooperation programmes. More than ever in today's global networking environment intricate webs of relationships are weaved between and among scientific communities which has led to a well-documented increase in scientific co-authorships between countries. Today's scientists collaborate because they want to, not because they are told to (Wagner, 2008) with cooperation programmes providing the necessary infrastructure and resources to facilitate and render operational the desire to carry out joint research, but the decision to work together is essentially a personal one based on mutual interests and complementary skills. While the number of internationally co-authored publications has grown linearly the growth in the number of addresses of internationally collaborating authors has been exponential suggesting that with time more institutions and authors join the international communication network which functions as a global self-organising system through collective action at the level of researchers themselves (Leydesdorff and Wagner, 2008).

LAC international collaboration has been the subject of several studies over the last two decades. Narvaez-Berthelemot *et al.* and Lewison and co-authors were among the first to study the international co-production of knowledge of the region (Narvaez-Berthelemot, Frigoletto and Miquel., 1992; Lewison, Fawcett-Jones and Kessler, 1993) followed by Fernández and co-workers (Fernández, Gómez and Sebastián, 1998). In more recent years Lemarchand has looked at the co-author networking of Iberoamerican countries for the period 1973-2010. (Lemarchand, 2008, Lemarchand, 2012). The co-production of Spain with LAC has received special attention (Fernández *et al.*, 1992; De Filippo, Morillo and Fernández, 2008) as well as the intraregional collaboration of LAC institutions (Sancho *et al.*, 2006; Russell *et al.*, 2007a). Other studies have included international co-authorship patterns as part of a general analysis of scientific production within the LAC region (Santa y Herrero-Solana, 2010). However we have been unable to uncover any studies focussed specifically on the co-publication of LAC with Europe.

The present study therefore is a retrospective analysis of the development and trends in international collaboration between Europe and LAC from 1984-2007. We do this by analysing the co-authorship patterns between the two regions in mainstream journals in the *Web of Science*. In keeping with international trends we would expect to find increasing collaboration between Europe and LAC with the main regional players, Brazil, Mexico and Argentina assuming defining roles. We look especially at the relative strengths of LAC co-authorship with the US and Canada, and that with the EU.

Methodology

Data Source and Coverage

Three Thomson Reuters citation indexes accessed through the Web of Science platform with the following journal coverage:

Science Citation Index (SCI): 7,100 journals in 150 disciplines

Social Science Citation Index (SSCI): 2,100 in 50 disciplines cover to cover plus 3,500 scientific and technical journals selectively indexed.

Arts & Humanities Citation Index (A&HCI): 1,200 cover to cover plus 6,000 scientific and social sciences journals selectively indexed.

http://thomsonreuters.com/content/science/pdf/Web_of_Science_factsheet.pdf

Search Strategies

Search strategies were executed against the Web of Science (WoS) version of the Thomson Reuters citation databases during August-September 2008 to identify all records from the Latin American and Caribbean region with any kind of international collaboration published within the period 1984-2007. 187,764 unique records were imported into a MySQL 5 database named Lakam. Each record was tagged with its corresponding WoS section, SCI, SSCI or AHCI, a repeatable attribute as a high level of record duplication exists between the three sections (approximately 45% duplication of SSCI with SCI, as well as A&HCI with SSCI in our sample).

Geographical Considerations

The address fields, both main affiliation and reprint, were utilized in Lakam, and those records with only one author but 2 different countries of affiliation, a practice more common in SSCI and AHCI, were included. The country segment of the records was cleaned of errors, USA was assigned to the older records lacking this in the country segment, and a locally constructed catalogue of the equivalent continents and regions run against Lakam. Both geographic and political subdivisions were taken into account.

The CIA World factbook (https://www.cia.gov/library/publications/the-world-factbook/) was consulted for the assignment of continents, and the Europa EU webpage (http://europa.eu/abc/european_countries/index_en.htm) for the member countries, subdivided into the original EU-15 and the newer EU-12 to permit a finer-grained analysis of data. Country name changes were dealt with pragmatically, the German Democratic Republic and the Federal Republic of Germany treated as Germany for the purpose of this study, and Great Britain reunited. The complexities of Balkan politics necessitated the decision to include Slovenia and Slovakia, for example, in the EU-12 subdivision, while Yugoslavia remains classified only as Europe together with Serbia, and Bosnia & Herzegovina. Cyprus, although geographically part of the Middle East, was assigned to Europe and more specifically EU-12 as a newer member of the EU. No attempt was made to take into consideration the date of accession in this bibliometric study.

Latin America was divided into regions adapting the classification employed in the Ranking Web of World Universities (http://www.webometrics.info/index.html): Southern Cone (Argentina, Brazil, Chile, Paraguay, Uruguay): Andes (Bolivia, Colombia, Ecuador, Peru, Venezuela): Central America and Mexico (Belize, Costa Rica, El Salvador, Guatemala, Honduras, Mexico, Nicaragua, Panama): Caribbean (including Cuba and the Dominican Republic). The decision was taken to treat the Caribbean separately, and not as part of Central America as does the Ranking Web of World Universities, to facilitate the analysis of its behaviour.

Records from the Caribbean received special treatment given that they present multiple inconsistencies in the address fields. Geographical presence was deemed a priority, thus the records were edited so that islands which were previously European colonies or overseas or dependent territories, which may or may not have been represented correctly in the address fields, were assigned the name of the island as country and the Caribbean as continent.

Subject Considerations

All ISI subject categories were taken into account, and the Research Fields Courses and Disciplines (RFCD) classification scheme was utilized to assign the main disciplines (Butler, Henadeera and Biglia, 2006). This decision was taken in part due to the especially detailed Social Sciences equivalents. The translation of ISI subject categories from this paper was requested and kindly provided directly by Linda Butler.

Document counting

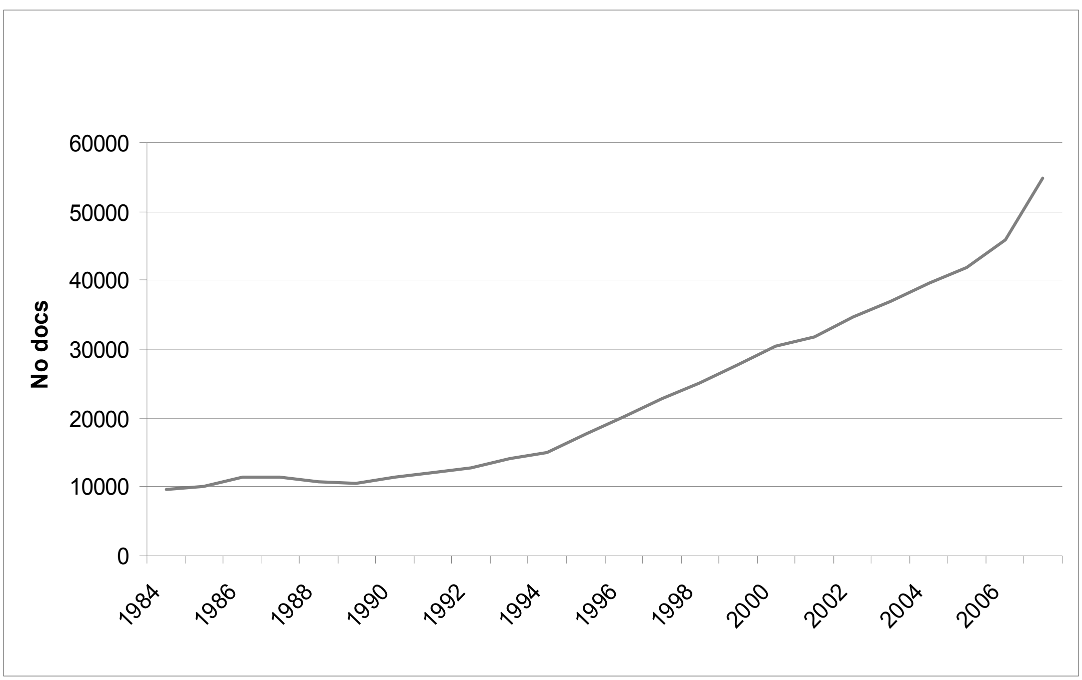
Unless otherwise stated results reflect the number of documents with occurrences of a given criteria.

Results

A Global View of Research from Latin America and the Caribbean (LAC)

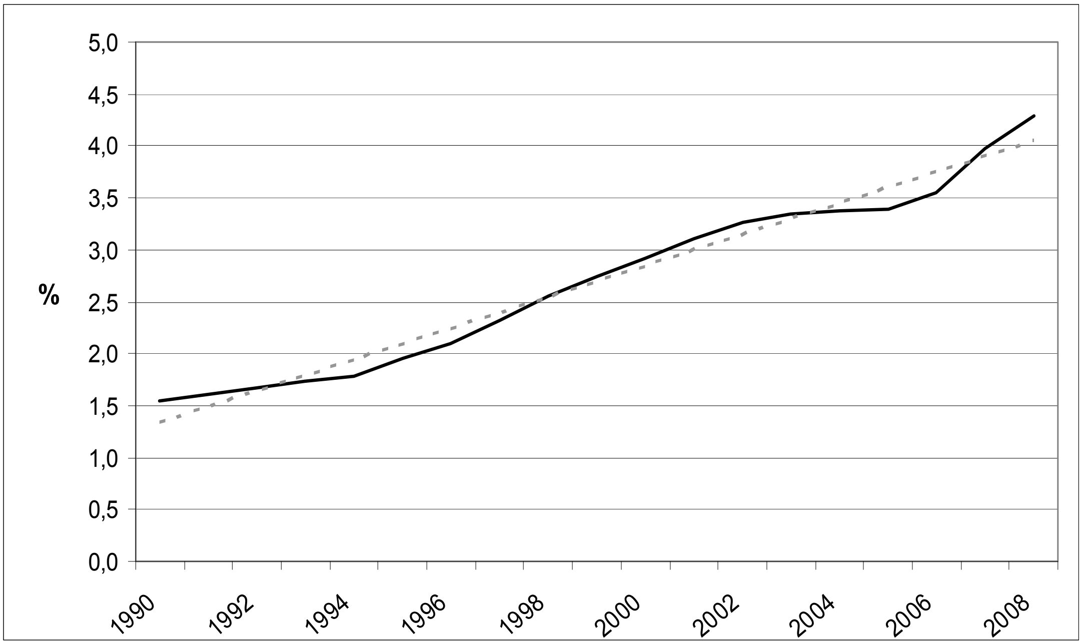
Latin America and the Caribbean (LAC) increased their mainstream scientific production in all knowledge areas from 9,641 papers in 1984 to 54,807 in 2007 indicating that 9.8% of the 559,151 unique documents registered in the three citation indexes in the 24 years analysed were published in the most recent year (Figure 1).

Figure 1. Total LAC production in all knowledge areas 1984-2007 (SCI, SSCI, A&HCI).



Not only did overall production increase but also the percentage of world share of publications (science areas only taken into consideration), at least in recent years, from 1.5% in 1990 to 4.29% in 2008 indicating a small but increasing presence on the world stage (Figure 2).

Figure 2. Latin American and Caribbean scientific production (SCI only) as a percentage of world SCI production 1990-2008.



Note: SCI total world production from RICYT:

http://www.ricyt.org/index.php?option=com_content&view=article&id=150&Itemid=20

In keeping with world trends the LAC region showed rapid expansion in co-authorship with other countries not only in terms of absolute numbers of papers but also as a percentage of total output. In 1984 only 1,868 mainstream papers were published as the result of international partnership, by 2007 this figure had risen tenfold to 18,770 (Figure 3). The equivalent percentages of total output were 19.4% for 1984 and 34.3% in 2007 (Figure 4).

Overall the Southern Cone countries were responsible for 69% of the total production of papers, a figure which varied little between the beginning and end of the 24 year period (69 and 72%, respectively). Central America and Mexico showed a slight increase (from 16-20% while the Andean countries and the Caribbean showed slight losses (9-8% and 6-3%, respectively) Nonetheless, all regions showed significant increases in the numbers of papers published during the period, Central America and Mexico, seven fold (1,550 to 10,745); Southern Cone, six fold (6,660 to 39,445) ; Andean region, five fold (891 to 4,134) and the Caribbean, three fold (577 to 1.795) (Figure 5).

Figure 3. Numbers of LAC publications in international collaboration in all knowledge areas 1984-2007.

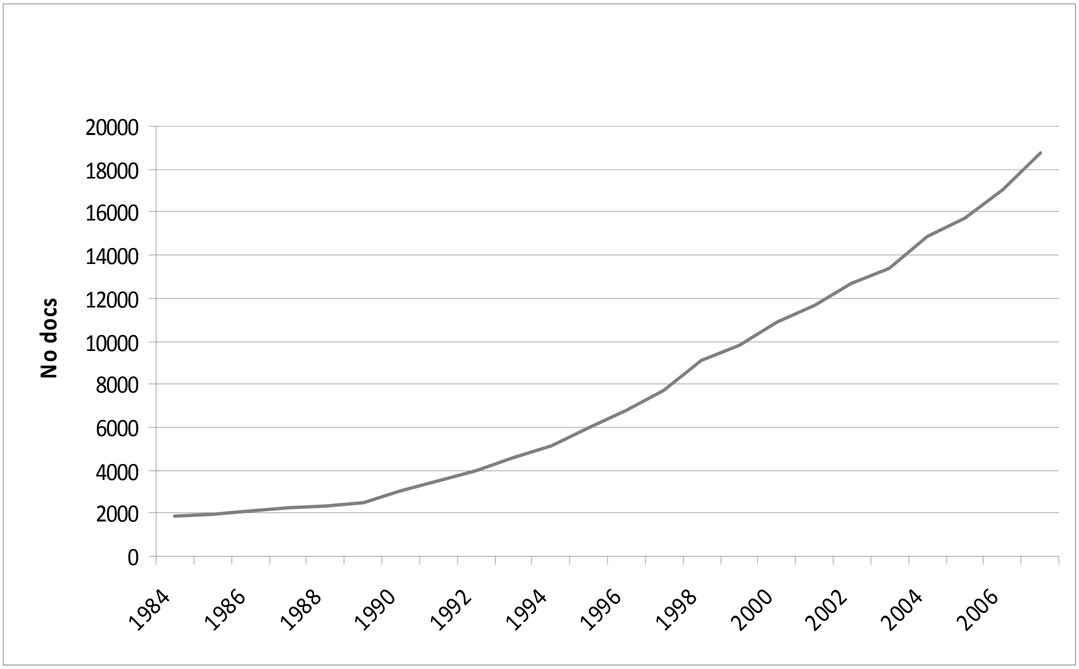


Figure 4. Percentage of total LAC publications in international collaboration in all knowledge areas 1984-2007.

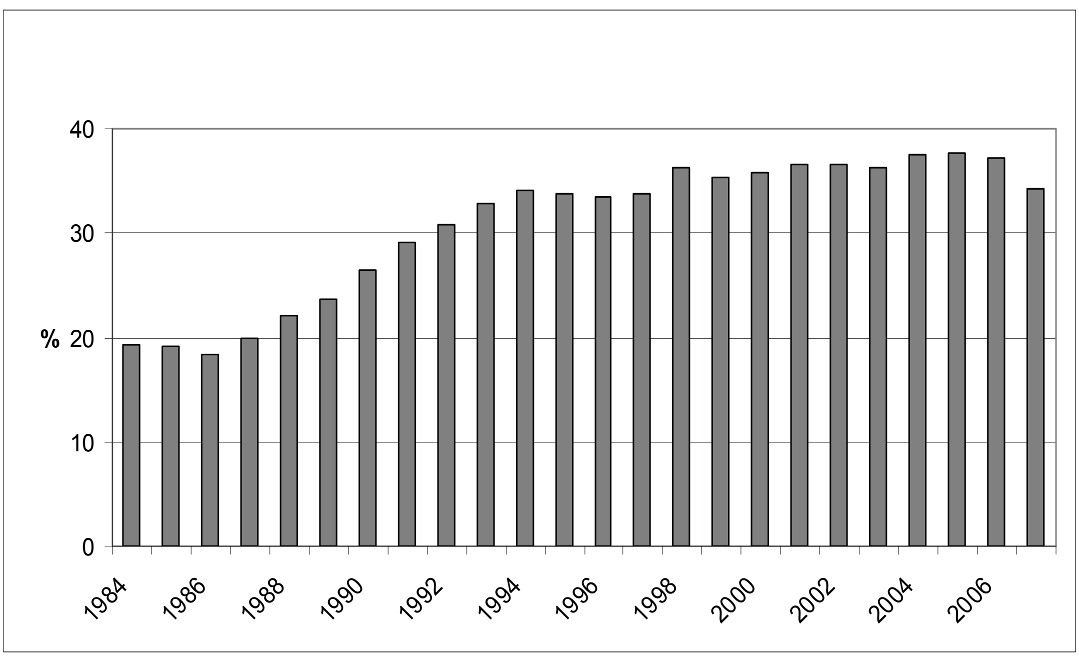
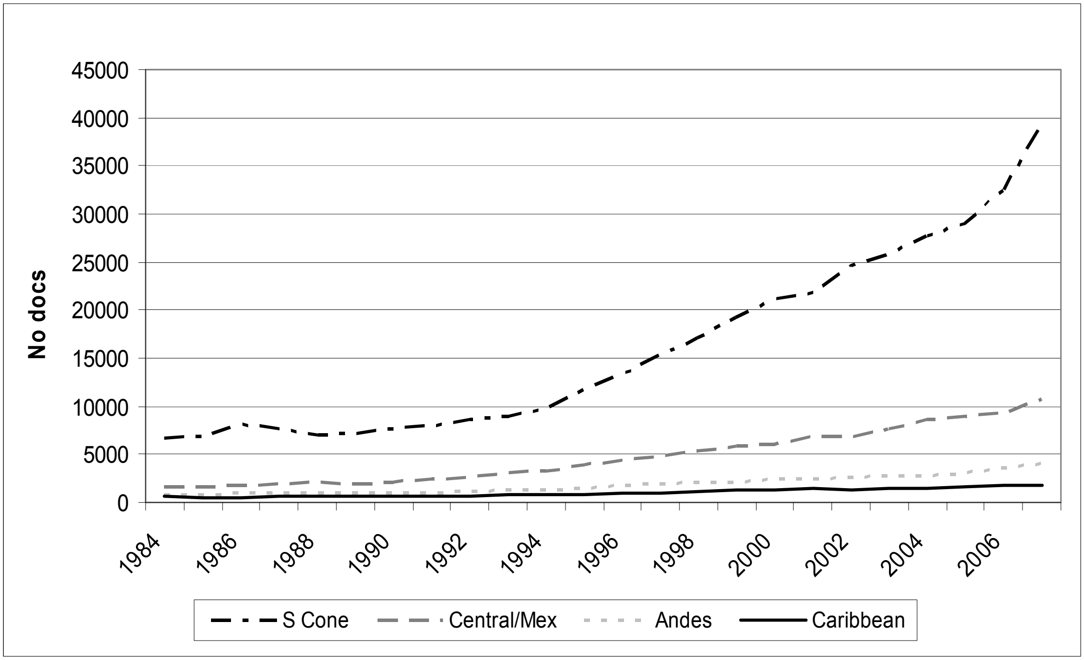


Figure 5. LAC production in all knowledge areas (SCI, SSCI, A&HCI) by region 1984-2007.



Brazil was the regional leader in papers published throughout the whole period of study increasing its dominance from 34% (3,312) of the total of LAC papers in 1984 to 52% (28,479) in 2007. Mexico took over second position from Argentina at the beginning of the 90s and increased its lead from the turn of the new century onwards (Figure 6). The consolidation of Mexican research as playing second fiddle to Brazil is also illustrated by an increase from a 14% (1,302) contribution to LAC science from the beginning of the period to an 18% (9,969) contribution at the end. Both Argentina and Chile decreased significantly their percentage contribution, from 21-13% (2,020-7,001) and from 13-8% (1,279-4,319), respectively.

With regard to international co-authorship patterns all regions showed a similar trend (Figure 7) as did the four top producers (Figure 8). As could be expected, the less productive regions and countries showed increasing reliability on international co-authorship to sustain or boost output. Brazil on the other hand, increased its percentage of internationally co-authored papers from 18% in 1984 to 34% by 1994, after which the role of foreign collaborators decreased, by 2007 only 26% of total production was in international co-authorship. The rise in the percentage for Mexico from 26% in 1984 levelled off after reaching 40% in 1998 while Argentina showed a steep rise from a mere 10% at the beginning of the study reaching percentages similar to Mexico by 2007.

Figure 6. LAC production in all knowledge areas (SCI, SSCI, A&HCI) by the four top producers 1984-2007.

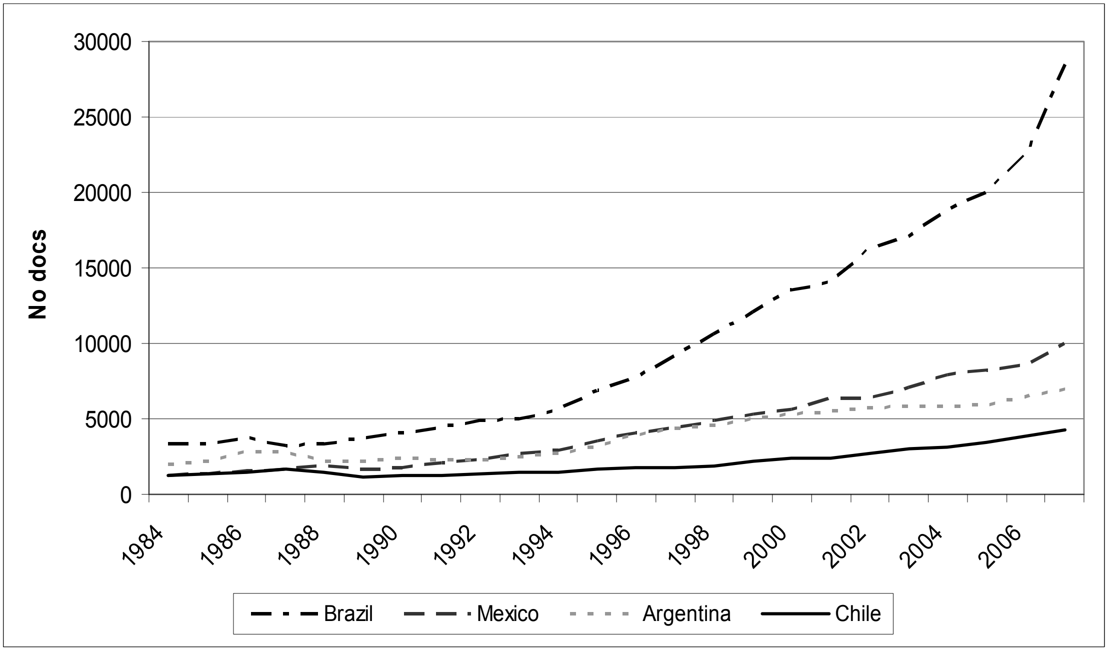


Figure 7. Percentage total production LAC with any international collaboration in all knowledge areas by region 1984-2007.

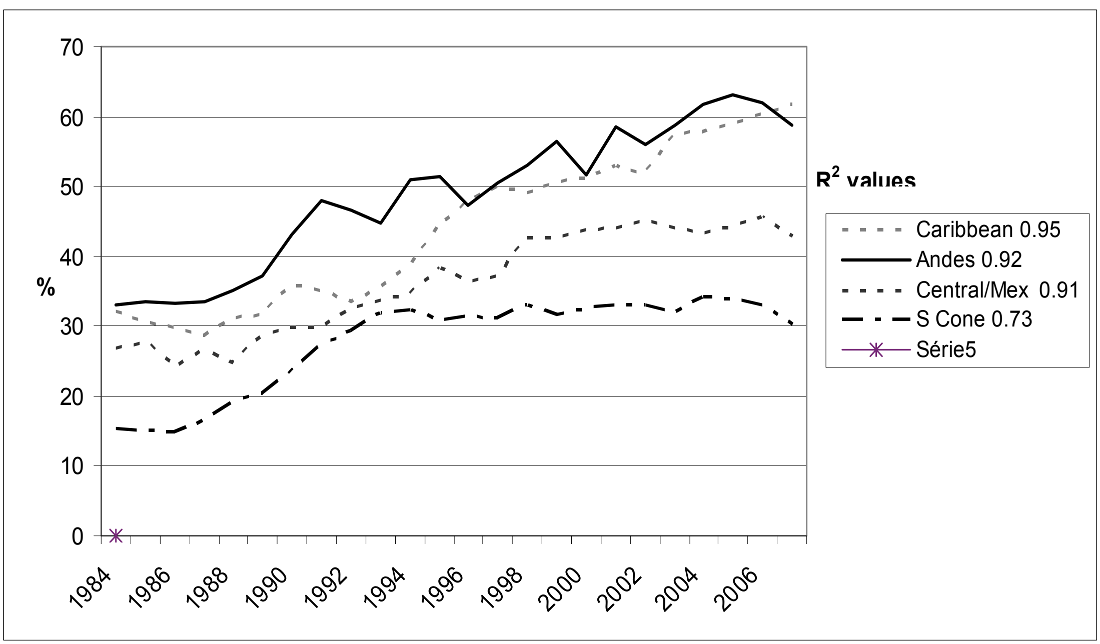
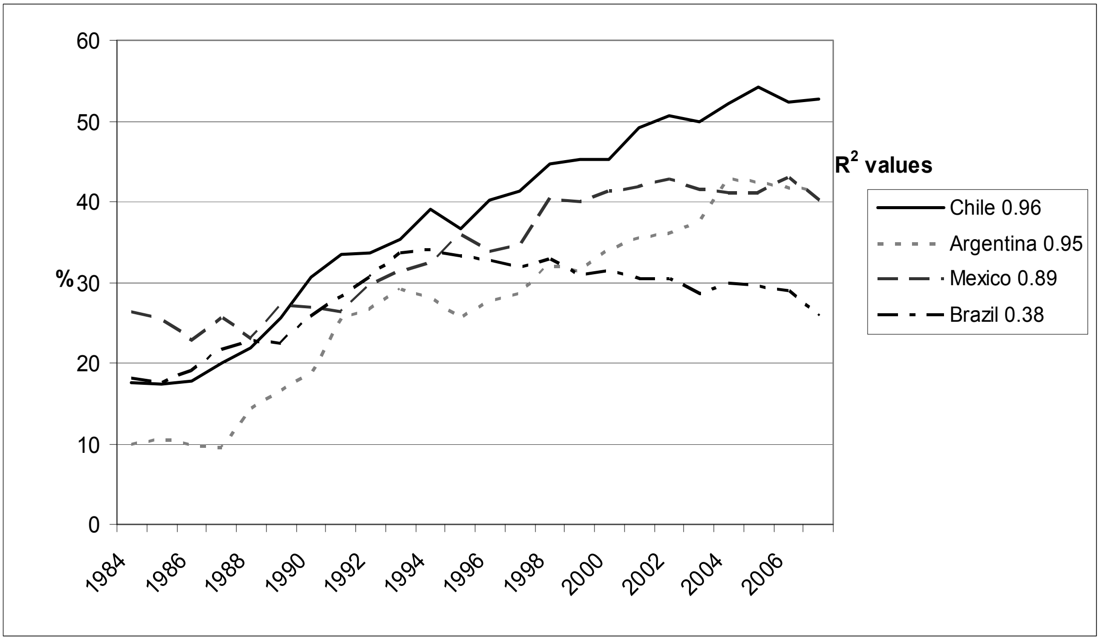
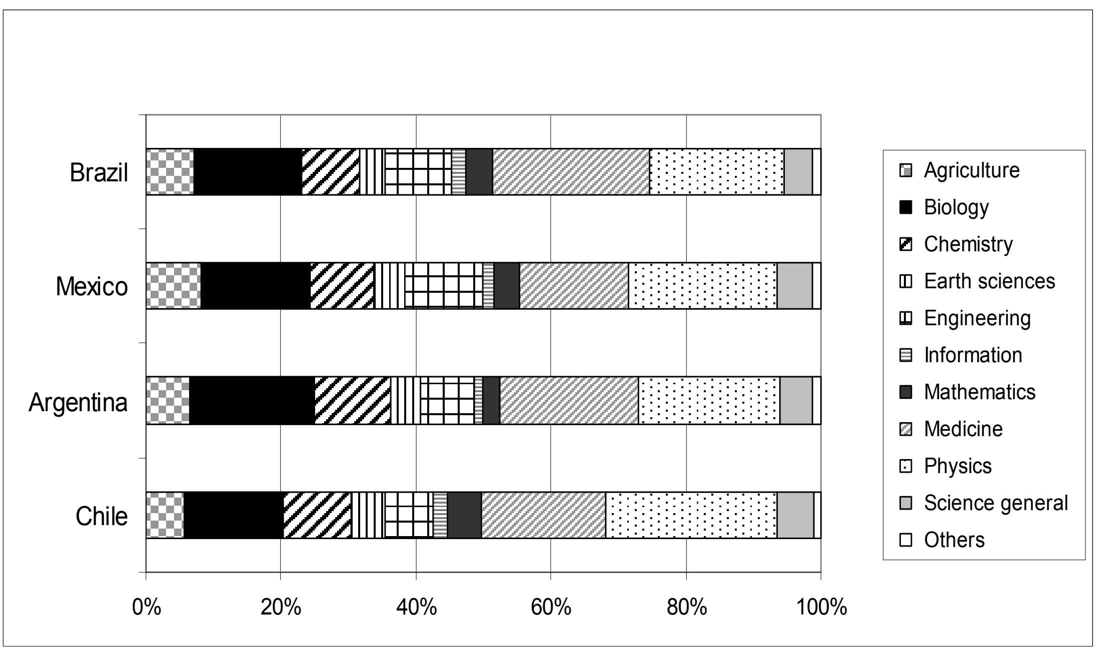


Figure 8. Percentage total production LAC with any international collaboration in all knowledge areas by the top producers 1984-2007.



Most Active Areas of Research Collaboration

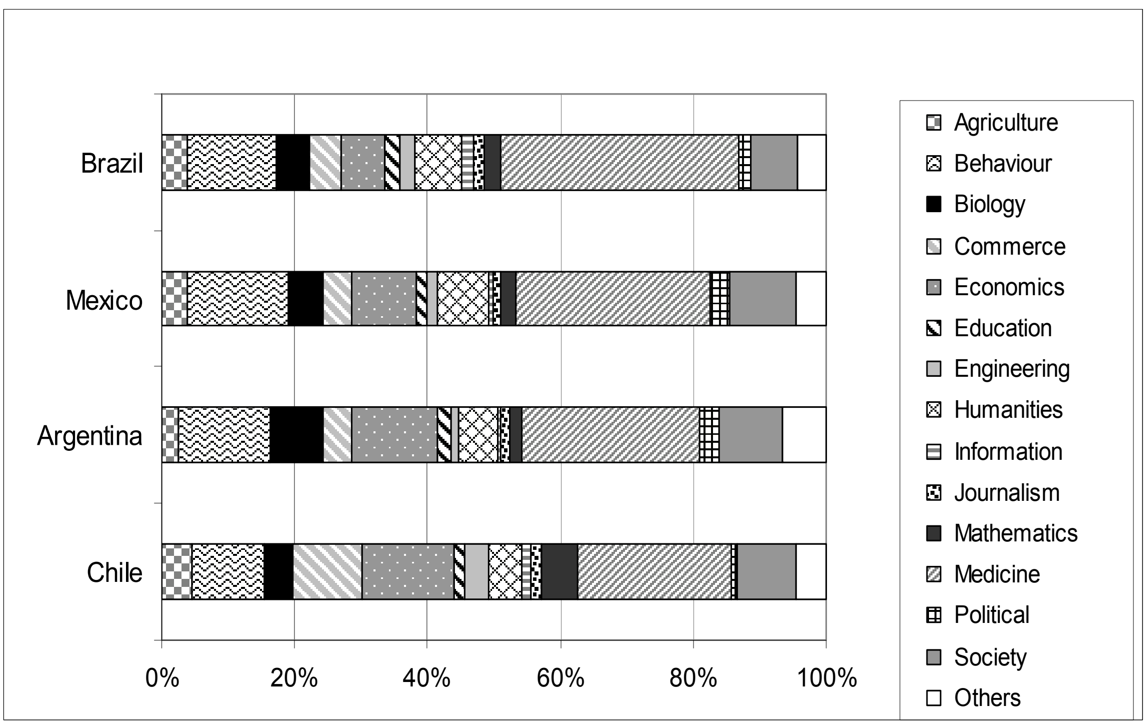
Figure 9 Main disciplines in Science of papers in international collaboration of the top producers 1984-2007.



The top four producers which contributed 80% of the total output of 182,941 papers in **Science** in international collaboration, show similar overall patterns with respect to their scientific disciplinary focus considering the period as a whole (Figure 9). Medicine, Physics and Biology are the main areas of collaboration with Medicine taking top priority in Brazil (23% of all papers) Physics in Chile (25%), in Mexico and in Argentina (both 22%). Biology is an important area of collaboration in all four countries (Argentina, 19%; Mexico and Brazil, 16%; Chile, 15%). Engineering is given more weight by Mexico (12%) than by the other countries (Brazil, 10%; Argentina, 8%; Chile; 7%).

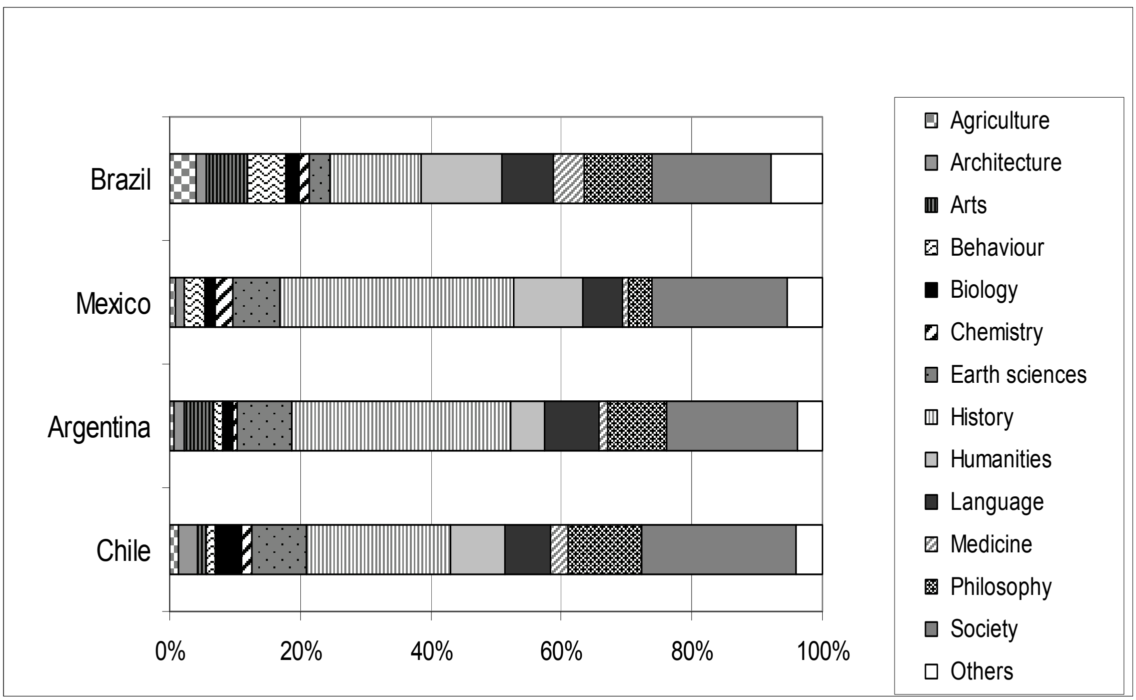
International collaboration in the **Social Sciences** show more varied disciplinary patterns, much due to the small volume of papers published in these areas in the mainstream literature, 8,812 in total (Figure 10). Social aspects of medicine take preference in all four countries, 36% of papers in Brazil, 29% in Mexico, 27% in Argentina and 23% in Chile. Behaviour papers take second place in Mexico, 15%, Argentina and Brazil, both 14% while in the case of Chile papers in Economics occupy second place with 14%, above Behaviour with an 11% share. Societal issues are a significant area of foreign collaboration also for Mexico with 10%, as well as for Chile and Argentina with 9% in each case. Economics, social aspects of the humanities, and Society account for 7% each in Brazilian international production.

Figure 10. Main disciplines in the Social Sciences of papers in international collaboration of the top producers 1984-2007.



With even smaller numbers, the 655 internationally co-authored papers in **Arts and Humanities** showed an even less consistent pattern between the four countries with the exception of History which had the largest share in Mexico, 36%, in Argentina, 34% and 14% in the case of Brazil (Figure 11). Societal issues followed in importance in Argentina and Mexico, both with 20% and with respect to Brazil, 18%. In the case of Chile, Society had a 24% share, slightly above that of History with a 22% share. Brazil showed a more even distribution of production over the different humanities disciplines. As distinct from **Science**, where Brazilian production was almost double that of Mexico, in **Arts and Humanities**, 189 were Brazilian papers with 167 from Mexico.

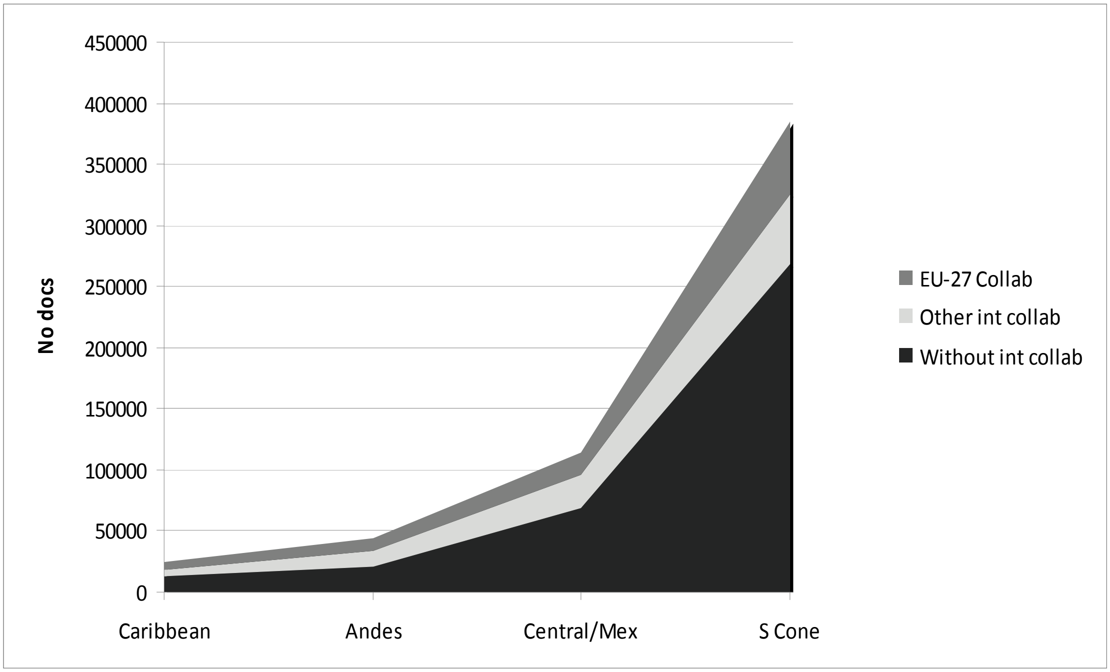
Figure 11. Main disciplines in the Arts and Humanities of papers in international collaboration of the top producers 1984-2007.



Relative Importance of International Collaboration for LAC

The majority of 1984-2007 papers involved only national institutions in all four regions (47% in the Andean region reaching 70% in the Southern Cone) (Figure 12). Although the EU-27 countries are essential partners for the whole of the LAC region once again we see important variations in the different regions and countries with respect to the relative weight of EU-27 co-authorship with respect to other international co-authorship.

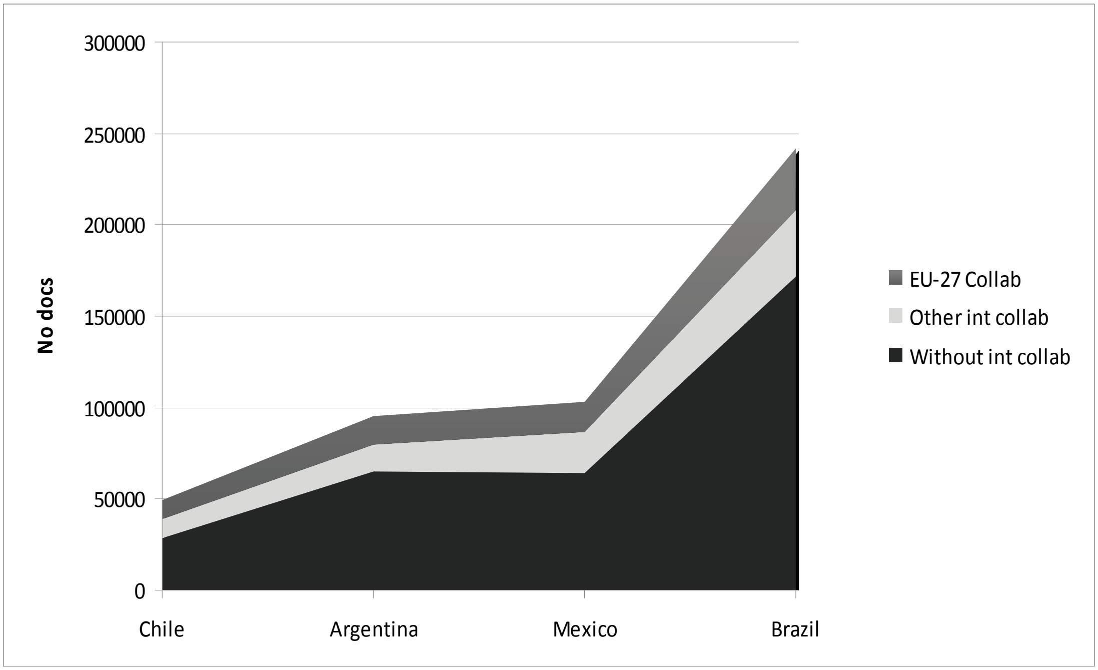
Figure 12. Relative weight of collaboration in total numbers of LAC publications with the EU-27 countries in all knowledge areas, by region 1984-2007.



Note: Other int collab refers to publications with no EU-27 involvement.

The Southern Cone, Argentina and Brazil showed an almost equal balance between EU-27 and other international partners considering the period as a whole while the Andean Region, Central America and Mexico showed a preference for partners other than those from the EU-27. The Caribbean, Chile and Argentina showed a slight preference for the EU-27 over other partners. However, when we look at annual trends we see a rising incidence of collaboration with the EU-27 even in countries such as Mexico traditionally more inclined towards partnership with the United States and Canada. In 1984, papers with the EU-27 countries were present in 7% of Mexico´s total mainstream production and in 27% of all internationally co-authored papers; by 2007 the respective figures were 17% and 43% (Figure 13).

Figure 13. Relative weight of collaboration in total numbers of LAC publications of the top producers with the EU-27 countries in all knowledge areas 1984-2007.



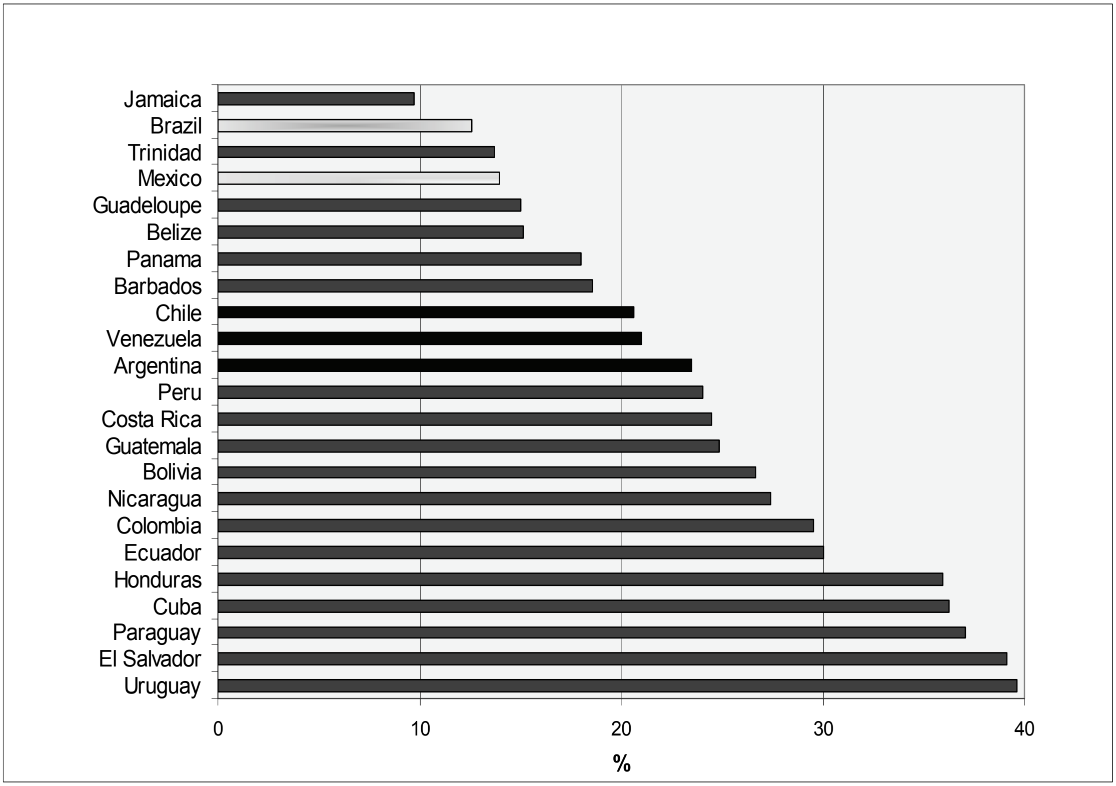
Note: Other int collab refers to publications with no EU-27 involvement.

Intraregional Collaboration

Intraregional collaboration plays a varied role in the region, and generally speaking, the more productive countries co-authored less regionally than the small producers, though there is an overall upward trend in all 23 countries analysed (Figure 14). Exceptions are the English and French speaking Caribbean countries which clearly prefer international collaboration with the mother country and North America.

In the case of large producers in the three year period from 2005-2007, a scarce 15% of Brazil's and 16% of Mexico's international collaboration papers involved at least one other country from the region while the equivalent figure for Uruguay was 45% and Costa Rica, 31%.

Figure 14. Intraregional collaboration as a percentage of all international collaboration 1984-2007.



Taking the period as a whole we see more LAC papers co-authored with European partners than with the US and Canada, 98,155 and 87,540, respectively (Figure 15). However, regional differences exist, while the Southern Cone favours European counterparts, 54% of its internationally co-authored papers as opposed to 44% with the US and Canada, Mexico and Central America look more to North American partnership, 53% of papers compared to 45% with Europe (Figure 16) suggesting that geographical proximity could be a determining factor in this case. For the Caribbean we see a different trend, 55% collaboration with Europe and just 31% with North America pointing towards the possibility of colonial ties influencing the choice of international partners.

In 1984, the US and Canada were more frequent co-authors of LAC than Europe when North America had a 56% share of internationally co-authored papers and Europe, 40% By 1993, the number of papers with Europe had overtaken that with the US and Canada and in 2007, Europe had a 53% share and North America 46%.

Figure 15. Relative percentage weight of LAC collaboration by continent 1984-2007.

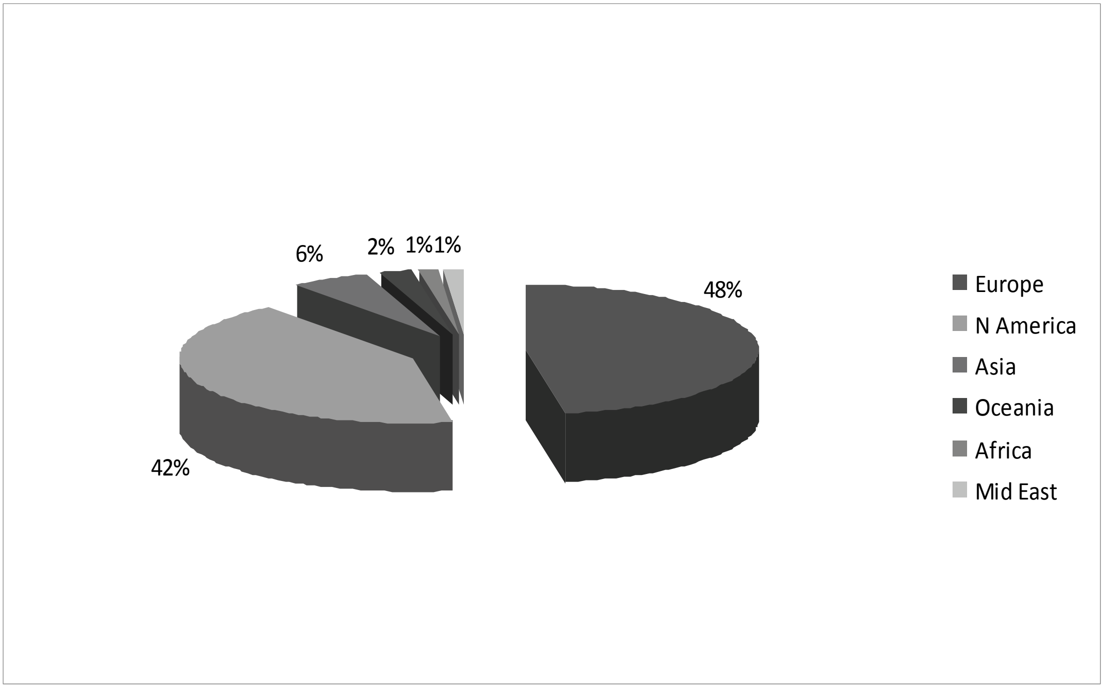
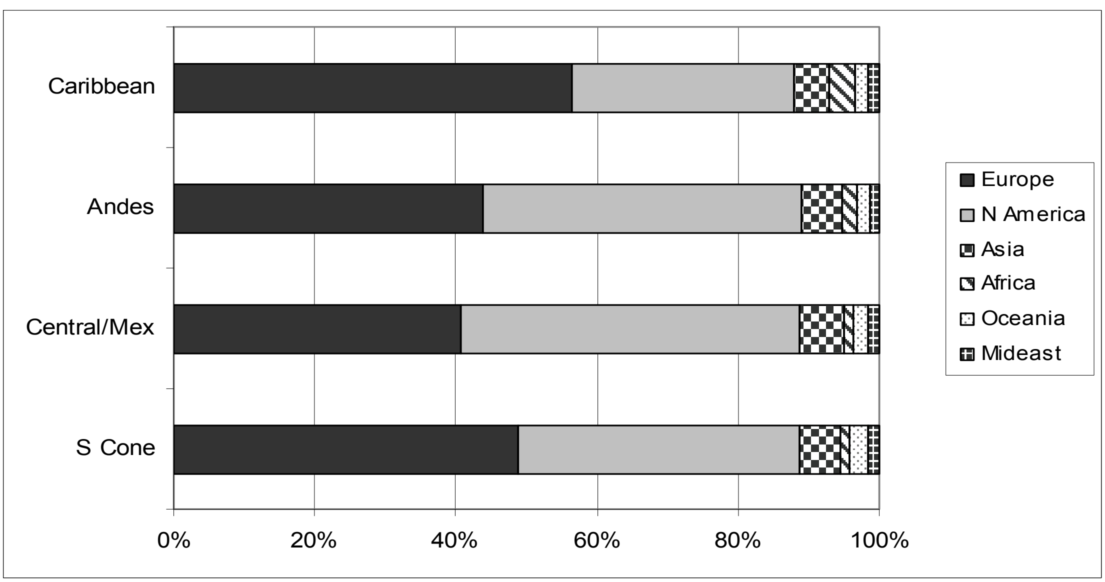
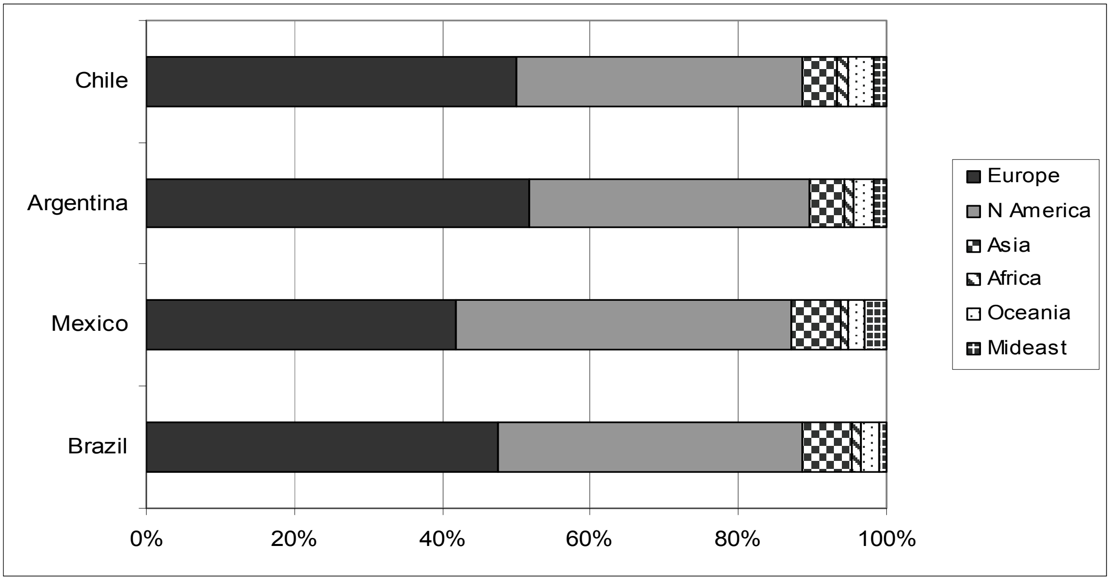


Figure 16. Relative percentage weight of LAC collaboration by continent, by region 1984-2007.



All three Southern Cone countries, Argentina, Chile and Brazil, showed more collaboration with Europe than with the US and Canada during the724 year period, while the opposite was true for Mexico (Figure 17).

Figure 17. Relative percentage weight of LAC collaboration by continent, top producers 1984-2007.

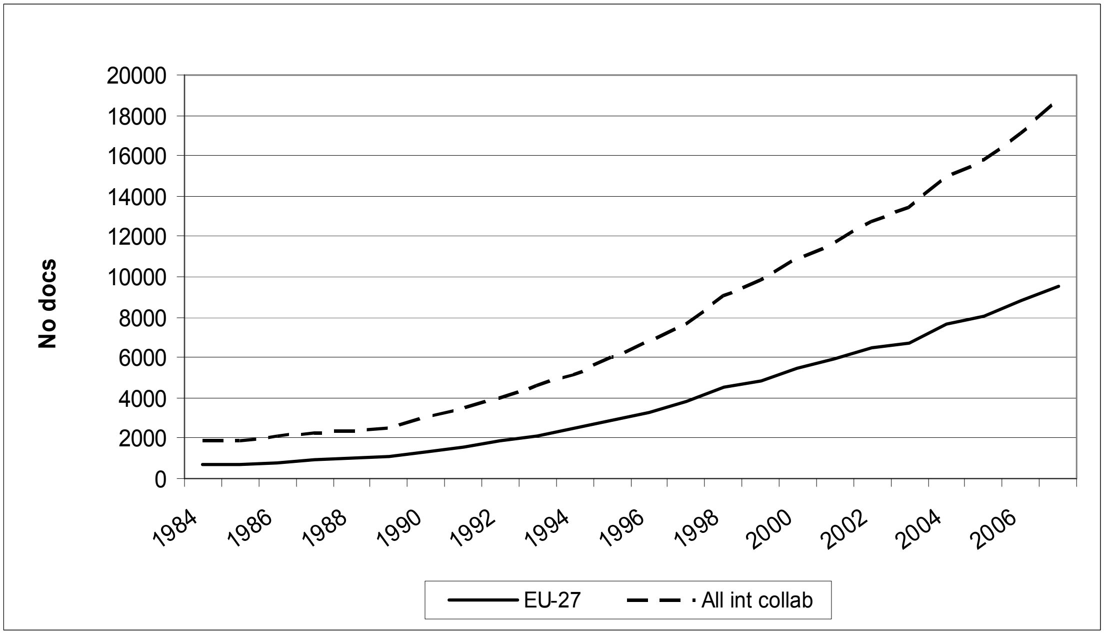


An increasing presence of the EU-27 was apparent since the start of the period accounting for 38% (705) of all LAC internationally co-authored papers in 1984 rising to 51% (9,501) in 2007 (Figure 18).

While the LAC publishes with virtually all European countries the preference for the original EU-15 is notable throughout the period with the EU-12 countries taking priority over all non EU European countries as a group (Figure 19).

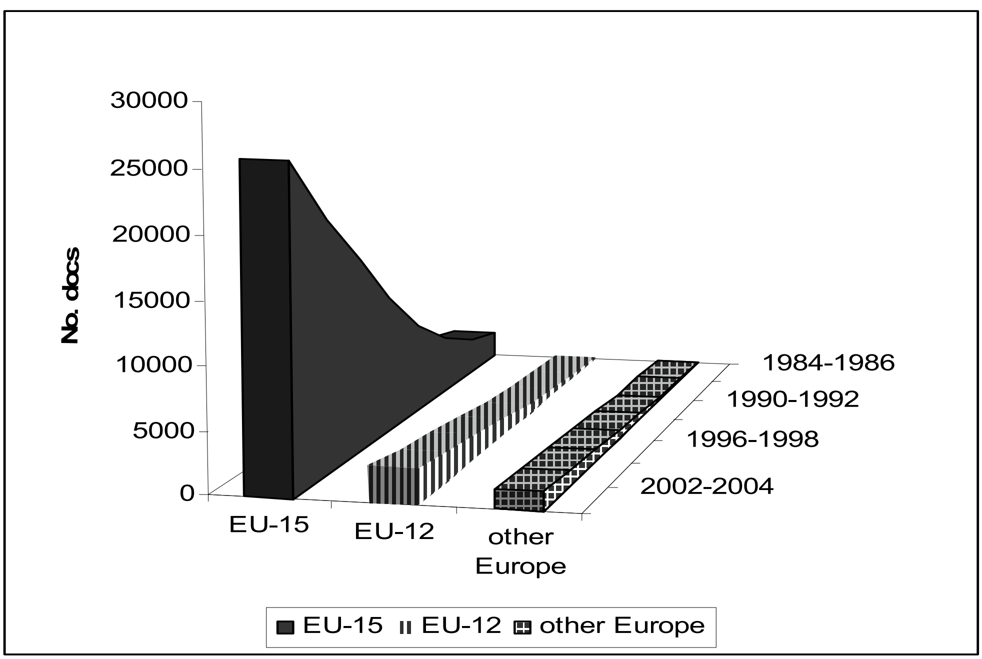
The partnership with the EU-15 is dominant with respect to the four regions and the four most productive countries (Figures 20-21). In all instances EU-15 countries account for more than 80% of internationally co-authored papers except in the specific cases of Mexico where non EU European countries assume a greater importance, a situation also reflected in the Central America and Mexico region. Brazil not surprisingly had the largest volume of papers published with the EU-15 countries, 33,389, followed by Mexico with 15,520, Argentina with 14,951 and Chile with 10,632 (Figure 22). All other countries accounted for 4,000 or less papers.

Figure 18. Relative weight of collaboration in total numbers of LAC publications with the EU-27 countries in all knowledge areas as compared to all international collaboration 1984-2007.



LAC Collaboration with Europe

Figure 19. Numbers of documents in collaboration with the three divisions of Europe 1984-2007



Note: Documents with authors from more than one of the divisions were counted more than once.

Figure 20. Percentage weight of collaboration of LAC publications with the three divisions of Europe, by region 1984-2007.

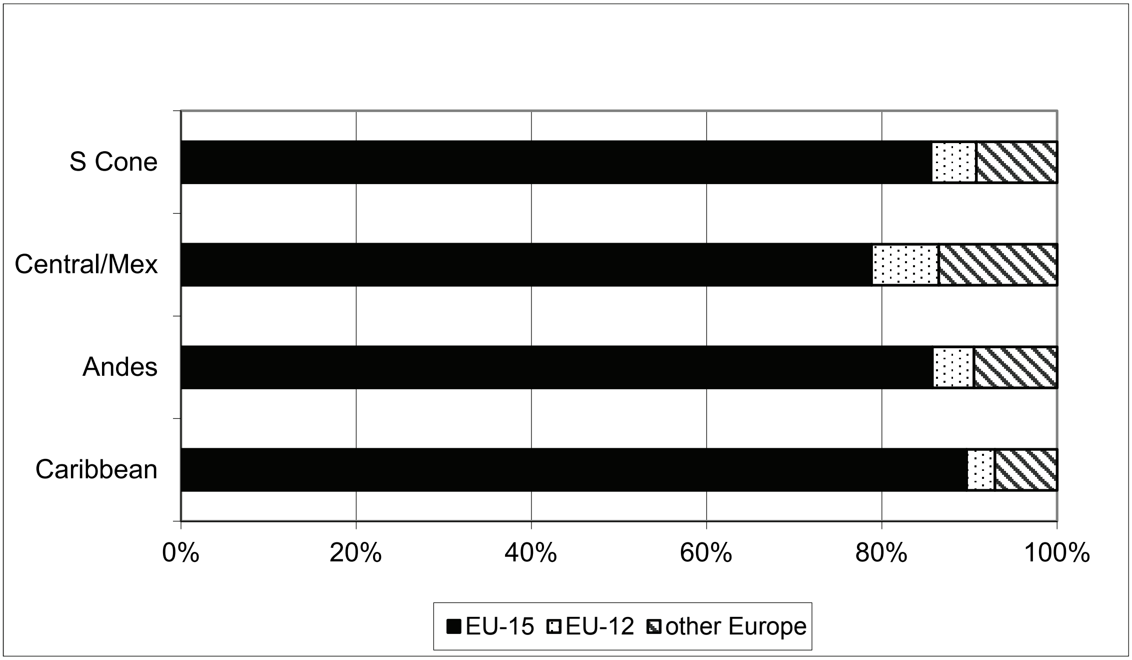


Figure 21. Percentage weight of collaboration of LAC publications with the three divisions of Europe, high producers 1984-2007.

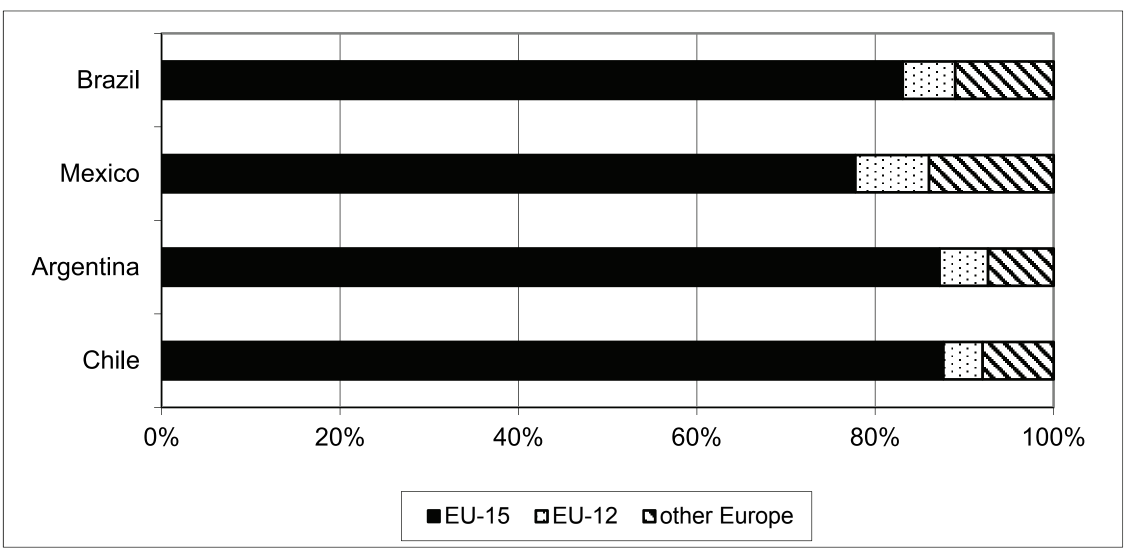


Figure 22. Countries of LAC with most collaboration with EU-15 by country and region1984-2007.

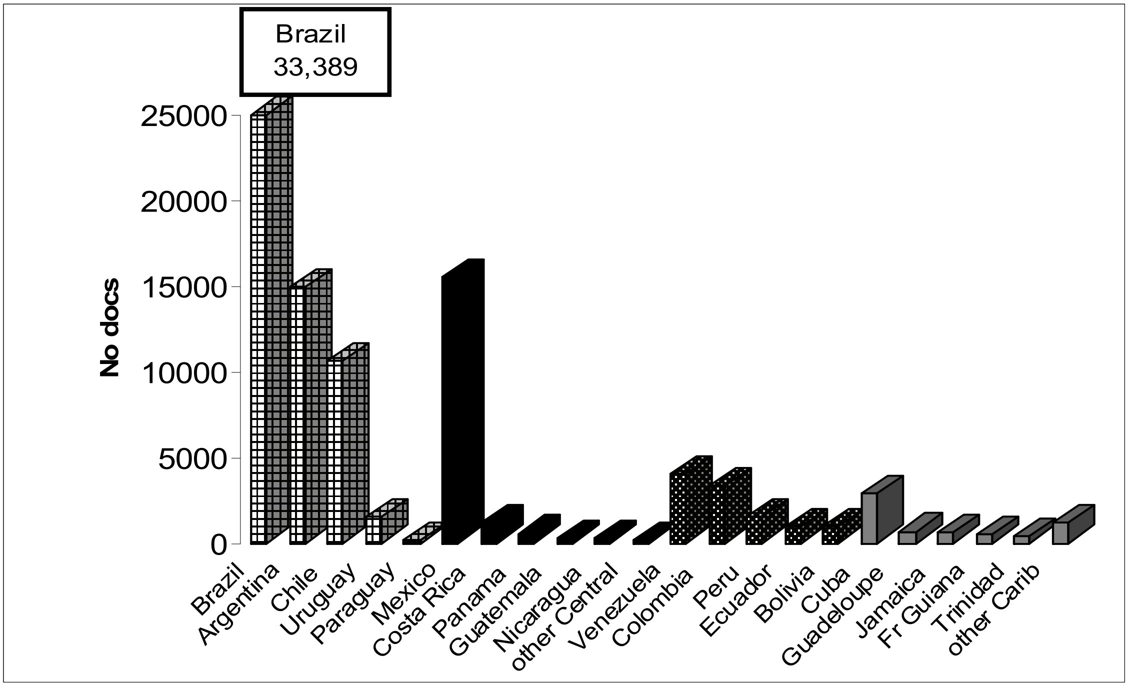
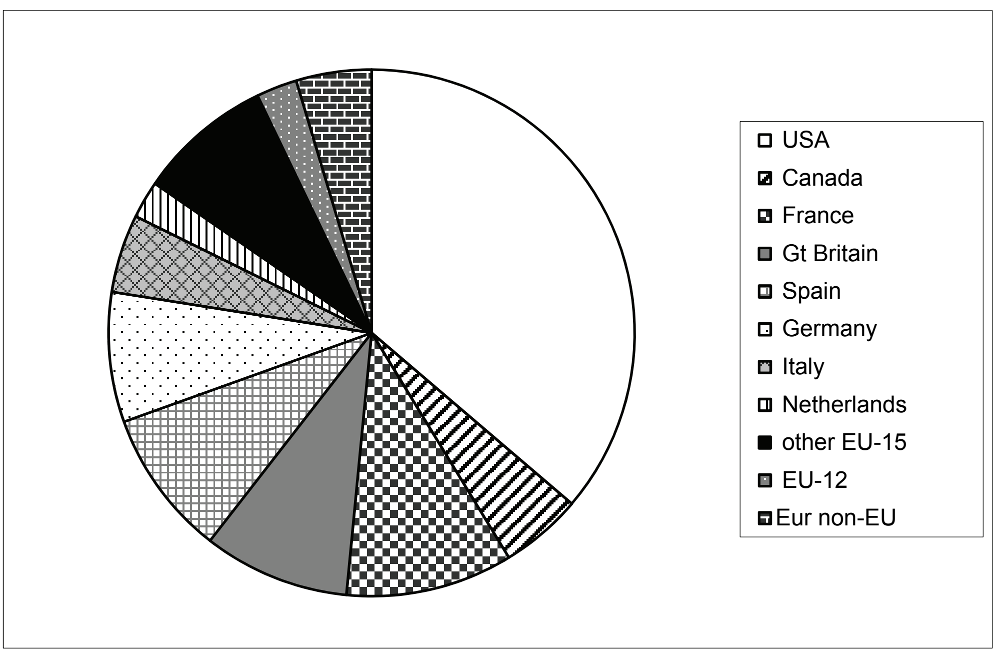
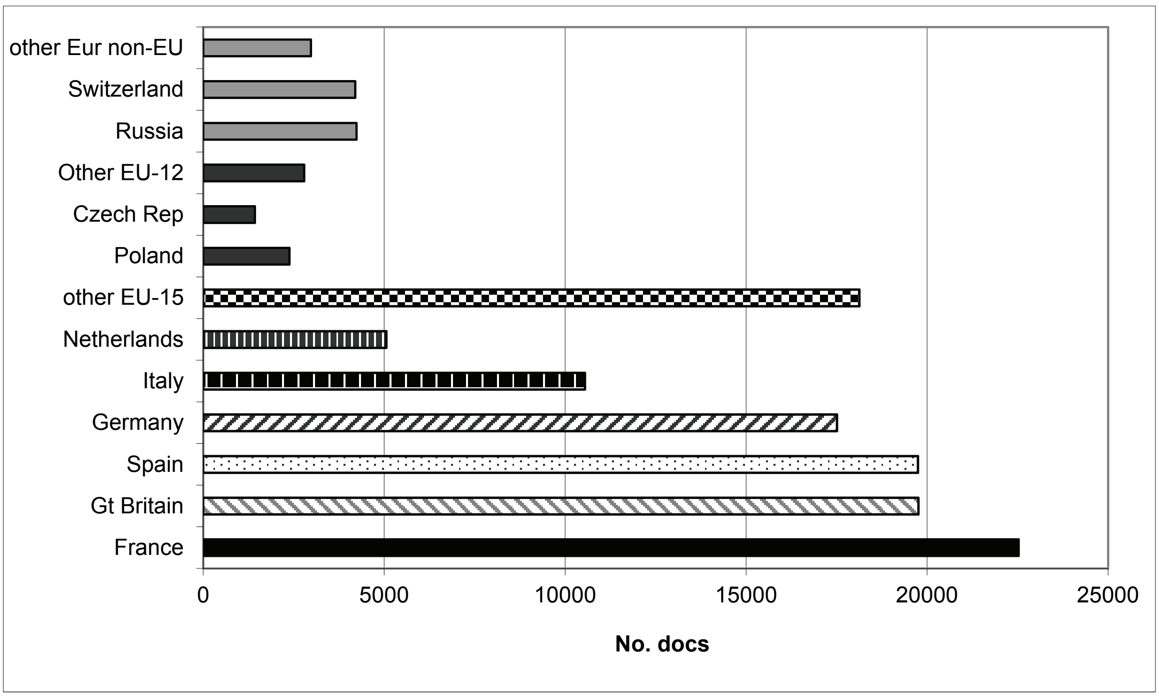


Figure 23. Countries of Europe and North America with most LAC collaboration by country and region 1984-2007.



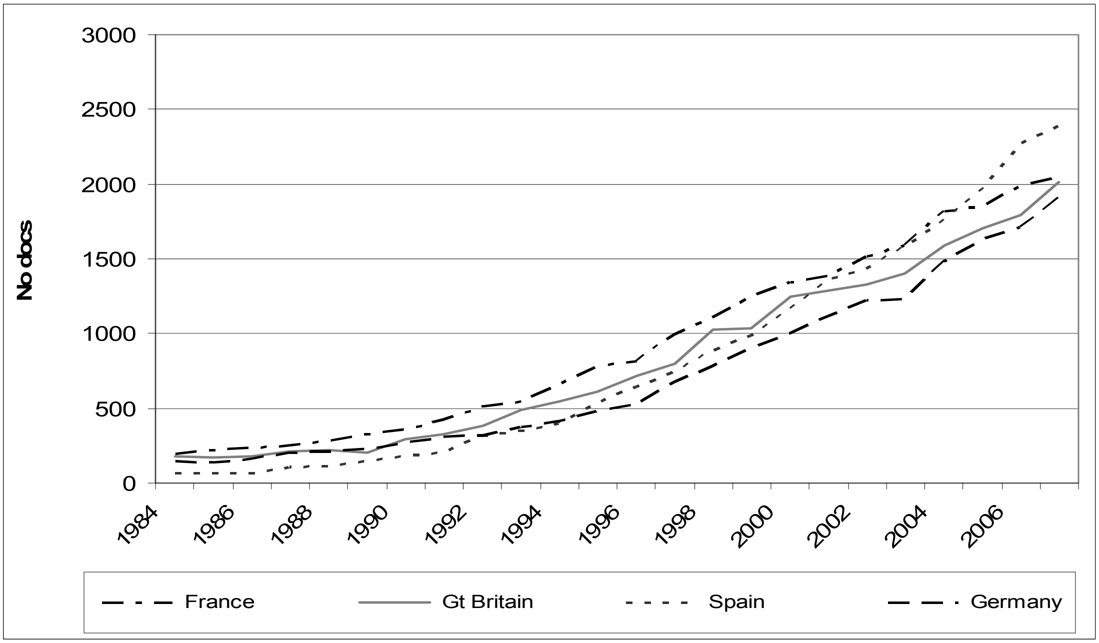
The percentages of relative participation of the US, Canada and the various European countries are illustrated in Figure 23. The US leads the group with a participation of 36.2%, far outweighing that of any individual EU27 country. Leading the EU-27 participation is France with 10.3%, followed by Great Britain and Spain, both with 9%. Of the newer members of EU, Poland and the Czech Republic are the most frequent partners of LAC with 2,386 and 1,428 papers, respectively, small in comparison with the US total of 79,568 papers, France with 22,529, Great Britain with 19,756 and Spain 19,744 (Figure 24). Germany has 17,506, Canada and Italy trail with 11,037 and 10,544, respectively. All other countries have less than 5,000 collaborations with LAC, including the non-EU countries of Russia and Switzerland with 4,238 and 4,200 papers, respectively.

Figure 24. Countries and divisions of Europe with most LAC collaboration 1984-2007



The relative weight of the four main European partners changed over time. While in 1984 Spain occupied the fourth position with only 62 publications with LAC (compared to 197 for France, 177 for Great Britain and for 149 for Germany) in 2007 Spain had the most publications, 2,387 compared to 2,045 for France, 2,014 for GB and 1905 for Germany (Figure 25).

Figure 25. Main EU partners in LAC international collaboration 1984-2007.



Evolution of Mexico-EU-27 Collaboration

Figure 26. Collaboration of Mexico with European countries 1984-1989.

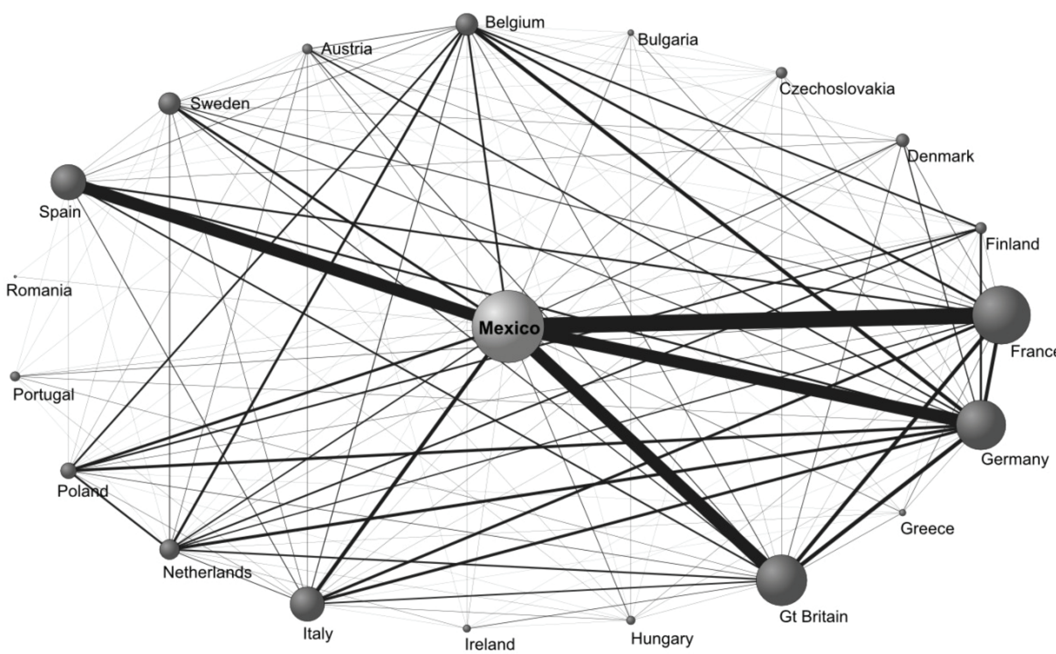
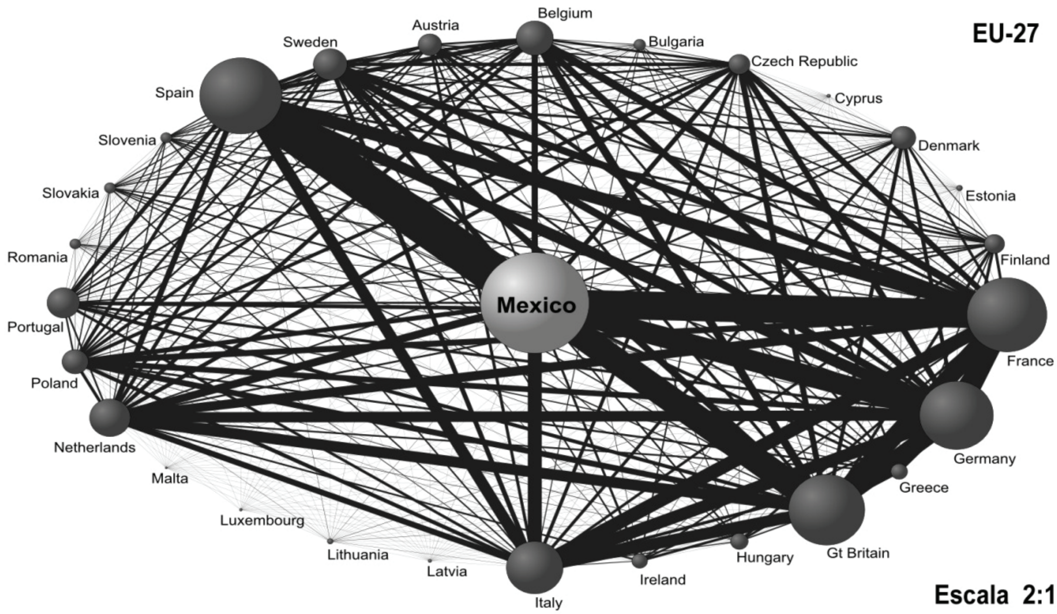


Figure 27. Collaboration of Mexico with EU27 countries 2002-2007.



Taking the first six year period of our study, 1984-1989, and comparing the density of the collaborative patterns using social networks analysis with that of the most recent six year period, 2002-2007, we find a progressively complex network of relations as illustrated by the case of Mexico with the EU-27 countries (Figures 26-27). While the main partners remain the same (France, Great Britain, Spain and Germany) the co-publication ties with other EU-27 countries have diversified, from 19 countries in the first period to 27 countries in the latter. Examples of new and significant partners are as could be predicted from the reorganization of Europe over the last two decades, the newly independent states of Slovakia and Slovenia, as well as countries such as Cyprus. Also worth a mention is the fact that Spain in the last period co-authored more papers with Mexico than any other EU-27 country, no doubt due to a series of factors which must take into consideration the re-establishment of diplomatic relations between Mexico and Spain in 1977 following the death of Franco but more importantly, the progress made by Spanish science since its incorporation into the EU in 1986.

Collaboration LAC with EU-27 and North America

Again looking at the overall regional picture for the 24 years, Brazil is the most frequent co-author of both North America (US and Canada) and the EU-27, than Mexico, Argentina or Chile (Figures 28-29), with little apparent intraregional collaboration, suggesting that a wide range of international partners goes hand in hand with strong scientific performance. Venezuela and Colombia also show a significant number of co-authorships with both the US and Canada, and EU-27.

Figure 28. LAC collaboration with North America 1984-2007.

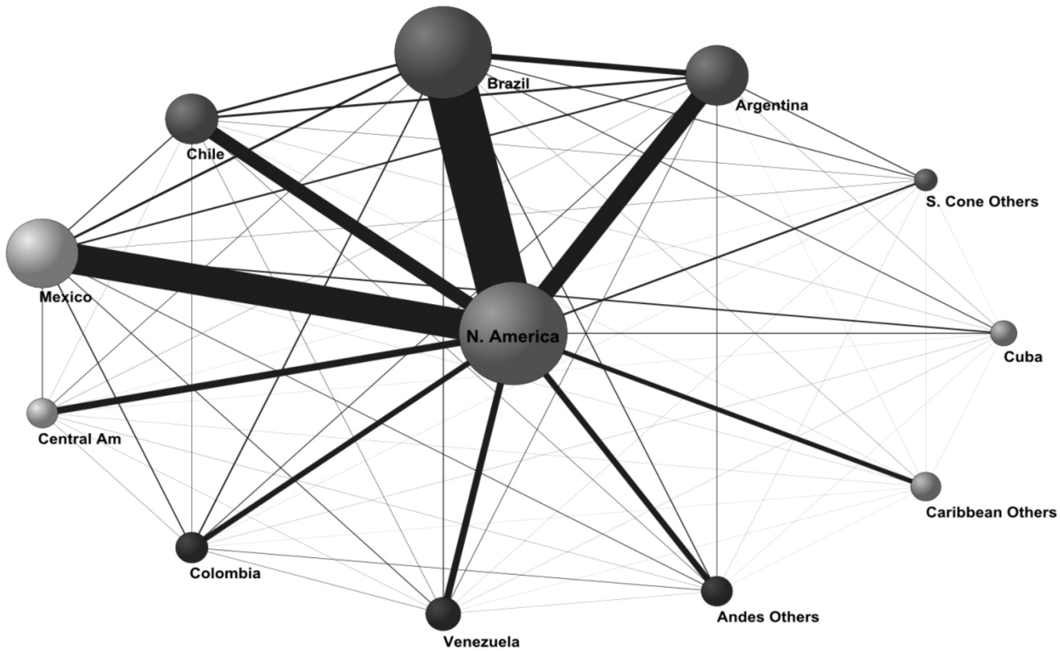
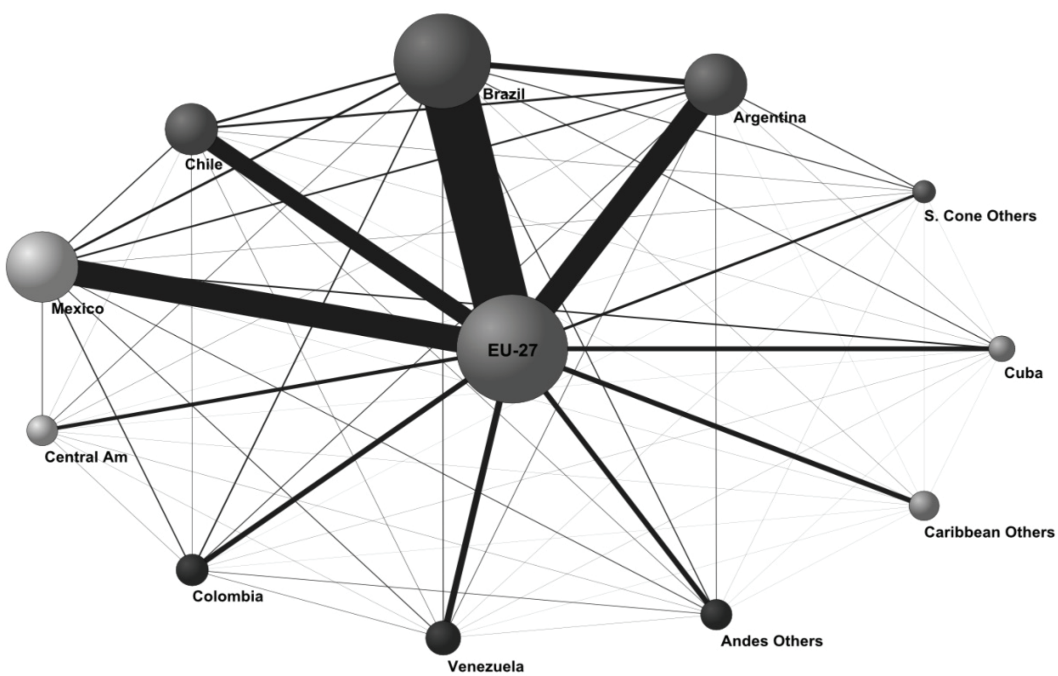
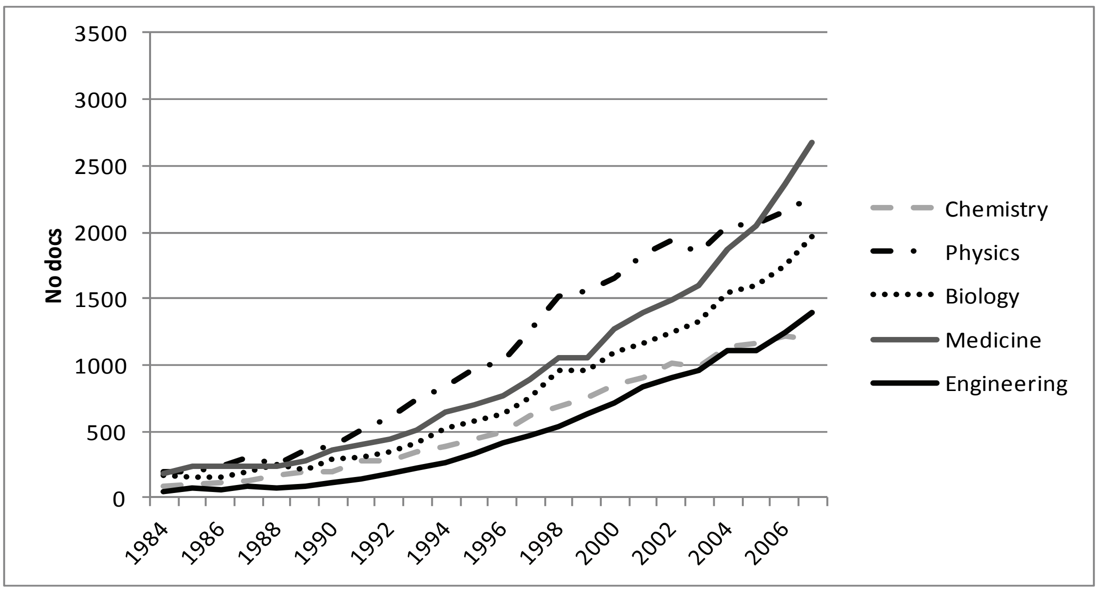


Figure 29. LAC collaboration with EU 27 1984-2007.



From 1984-1986 Medicine was marginally the area of most collaboration of the LAC countries with EU-27, from 1988 it was overtaken by Physics which remained the case until 2006 when Medicine underwent a resurge (Figure 30). All the main disciplines showed steady increases during the 24 years. By 2007 Medicine (2,672) was the area where most papers were published with EU-27, followed by Physics (2,264), Biology (1,964) and Engineering (1,389). The most prominent social sciences, arts and humanities themes in 2007 were Behaviour (119), Society (53), Commerce (48) and Economics (46). Information in the RFCD classification scheme is found together with Computing and Communication Sciences and not as Library and Information Science. Library Science is included under Journalism, Librarianship and Curatorial Studies.

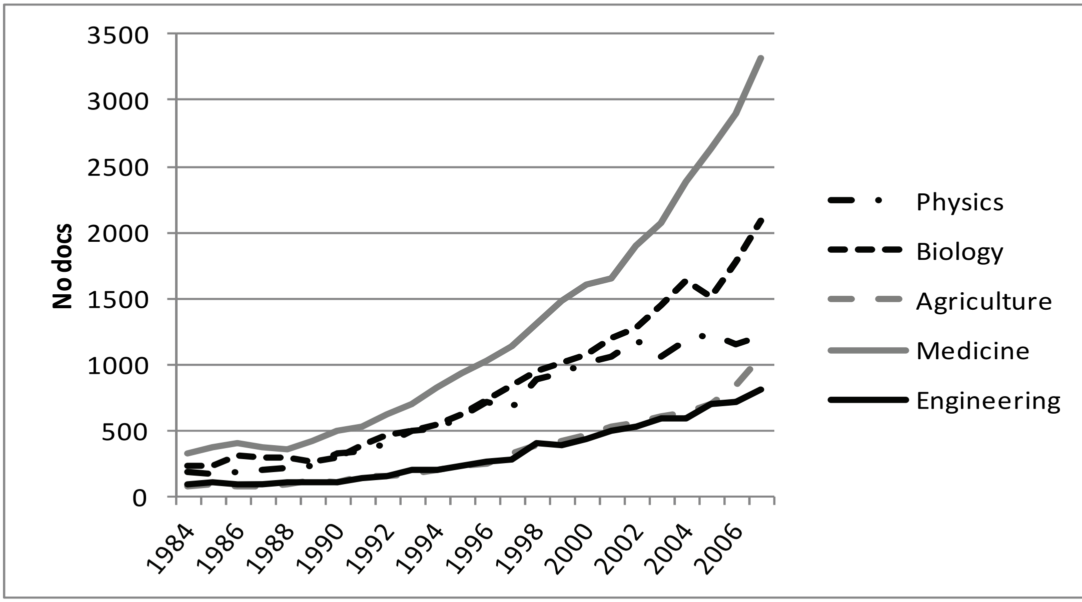
Figure 30. LAC-EU collaboration by main disciplines 1984-2007.



Medicine, Biology and Physics in that order were consistently the main areas of collaboration with the US and Canada throughout the 24 year period (Figure 31). The increase from 1984 to 2007 in the case of Medicine was ten-fold from 331 to 3,321 while Biology at nine-fold, (240 to 2,081) and Physics seven fold (183 to 1,212) showed lesser gains. In 2007, in the social sciences, arts and humanities Behaviour (137) was the subject of the greatest volume of papers, then Society (84), Commerce (68), Humanities (61) and Economics (53).

We can conclude that in general terms the disciplinary patterns of LAC international collaboration do not differ greatly between that with the EU-27 and that with the US and Canada. Developing regions of the world with small scientific communities have certain disciplinary strengths and weaknesses which will be reflected not only in total outputs but also in the collaborative patterns with different regions. This in turn will mainly reflect the strengths and weaknesses of the top producers, in this case, Brazil, Mexico, Argentina and Chile.

Figure 31. LAC-North America collaboration by main disciplines 1984-2007.



Discussion

A steady increase in overall production of mainstream papers and as a percentage of world output of the LAC region seen in the present study has also been noted by other authors. A study likewise conducted on *WoS* data from 1991-2003 showed marked differences between Latin American countries with respect to their percentage contribution to world scientific output, even within the region's most productive countries. On the one hand Brazil and Mexico showed the strongest increase, from 0.65% to 1.61% and from 0.26% to 0.70%, respectively while on the other the share of Argentinean, Chilean and Venezuelan publications grew but at a lower rate, 0.34% to 0.56%, 0.19% to 0.30% and 0.08% to 0.13%, respectively (Glänzel, Leta and Thijs, 2006). These same authors also reported similar trends to those found in our study with respect to the percentage share of papers in international co-authorship for the main scientific producers. While the share of scientific co-publications increased significantly in Mexico, Argentina, Venezuela and Chile, Brazil showed a downtrend. The notable increase in the share of internationally co-authored publications in Brazilian science during the 1980's as well as its decline in the 1990's seen in the present study has been previously reported by Leta and Chamovich, 2002. Our study confirms that this downward trend has continued well into the new century. Also noteworthy from Leta and Chamovich's data is that in the case of Brazil co-publication with Europe had surpassed that with Central and North America by the mid-80s.

The number of co-authorship links between the LAC and other countries as well as the number of countries involved in co-authorships has become increasingly complex even in the case of Brazil which appears to be coming much less dependent on international collaboration to boost mainstream production. In the present study we illustrate the fact by showing increased density of co-authorship networks for Mexican output with Europe between the period from 1984-1989 and that of 2002-2007 while Glänzel et al. showed the number of links as well as the number of strong links among Brazil and other joint countries increased remarkably in the decade from 1991-2003 (Glänzel, Leta and Thijs, 2006)

In this context of increasing international output of LAC science and rising levels of international collaborative links, co-publication with the EU is seen to take on special importance. Notable players in this scenario are Brazil, Mexico, Argentina and Chile on the one hand and France, Great Britain, Spain and Germany on the other. While no individual EU country approaches the levels of co-authorship of the US with LAC, the region as a whole surpassed North America (US plus Canada) as the number one scientific partner of LAC. It is well documented that the world in general collaborates with the USA, 17% of all papers in international collaboration between 1996 and 2008 involved the USA (The Royal Society, 2011)[1] corroborating its central position in the global scientific network.

The decrease in percentage collaboration with the US of Mexico, a country known for its ties with its northern neighbour, found in the present study was also noted by Lemarchand (Lemarchand, 2008). In their study of Latin American international co-publication patterns from 1986 to 1991 Lewison and co-authors already referred to a strengthening of the European position in relation to that of the US. Furthermore they attributed an increase in the number of mainstream papers in collaboration with the EU to the programme of International Scientific Co-operation which had been active in many countries of the region since the mid-80s (Lewison, Fawcett-Jones and Kessler, 1993).

A steady increase in the production of collaborative papers between LAC and the EU was seen in all the main disciplinary areas with Medicine, Physics and Biology the subject of more papers in the natural sciences. Behaviour, Economics and social aspects of Medicine figured predominantly in the smaller dataset of papers in the Social Sciences. The scant representation of papers in the Arts and Humanities was mainly in History. Important disciplinary differences are seen among individual LAC countries with respect to their co-publication with the EU. Overall the disciplinary pattern of LAC collaboration with the EU differs little from that with the US and Canada.

Also evident from our study is that the smaller LAC countries rely more heavily on international and regional collaboration to boost scientific production than do their more productive neighbours. The percentage of national output corresponding to papers in international collaboration varies from one group of countries to another, smaller nations being known to have high levels of co-authorships with other countries. The recent report by The Royal Society suggests that the rapidly growing scientific nations such as China, India and Brazil are collaborating less than their developed counterparts whose research output is increasingly collaborative (The Royal Society, 2011). Our results demonstrate that papers in international collaboration as a percentage of total output have indeed become less significant for Brazil, dropping from a third in 1994 to a quarter in 2007.

An earlier study on the international cooperation of the European Union between 1985 and 1995 considered four LAC countries, Argentina, Brazil, Chile and Venezuela, in their sample of 10 developing nations. In 1995 as compared to 1985 the percentage contribution of the

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[1] The Royal Society report bases its findings on publication data from Scopus published by Elsevier which together with the Web of Science from Thomson Reuters have the most comprehensive coverage of mainstream peer-reviewed scientific journals.

EU to the total output of papers in international co-authorship rose in all four where it represented around 20% (Glänzel, Schubert and Czerwon, 1999).

Towards the end of the period Spain overtook the other EU countries as the main co-author of LAC. Latin American collaboration with Spain in the sciences has increased enormously from when 12 papers were reported in international journals for 1980 and 192 ten years later in 1990 (Galbán and Gómez, 1992). The notable increase even in these initial years is credited in part to the launch of the CYTED programme in 1983. Our count of 62 papers for 1984, the starting year of our analysis, suggests that collaboration was already on the rise even before scientists had access to CYTED funding. The middle of the first decade of the 21st century saw the annual production of papers between LAC and Spain surpass the 2000 mark and by 2007 Spain was the most frequent EU partner for the region.

This finding is perhaps not surprising given the close relationship that Spain shares with Latin America based on long historical associations, a common culture, language, religion and strong investment and trade ties and taking into consideration the remarkable progress that Spanish science has made, particularly since its incorporation into the EU in 1986 making it an important player on the European research stage and on its way to a significant global role (Levine, 2010). Outside the central role played by the industrialised north, historical and linguistic ties between nations are known to determine where collaborations take place (The Royal Society, 2011). The resurgence of a special relationship between Spain and LA and the creation of an Iberoamerican community has brought considerable benefits for both players. In the case of Spain this has been in terms of the internationalisation of her economy and the strengthening of her global political position within the EU and in her relationship with the US. The European Union is the single most important instrument of Spanish foreign policy in Latin America and it is also the resource in which Latin Americans are most interested (Martin, 2002).

As far as intraregional co-authorship is concerned in a study covering the period 1999-2002, Sancho *et al*. drew attention to the lack of regional policies to promote inter-regional scientific networks, leading to a low level of regional collaboration compared to national and international collaboration (Sancho, 2006) with little variation in the period studied. Russell *et al.* (2007a) in a 30 year study of the region, found an increase of 2,000% in intraregional collaboration between the periods 1975-1979 and 2000-2004, and concluded that regional policies have had a positive effect on intraregional collaboration, and that those countries with a historical collaboration tended to formalize these links though regional agreements.

Our analysis covers only mainstream publications which many authors have suggested implies only partial coverage of total production in the case of developing regions of the world such as LAC where output is mainly via national journals poorly covered by sources such as the WoS (Narvaez-Berthelemot, Frigoletto and Miquel., 1992; Fernández, Gómez and Sebastián, 1998; Gaillard et al., 2001; Russell et al., 2007b). However, in the particular case of international co-authorship a recent study on Mexican production for the period 2000-2005 revealed a larger percentage of internationally co-authored documents (43.8%) in the total production of Mexico in non-Latin American journals in the WoS than in a regional database (5.1%). (Russell et al., 2008). This was the case not only in the sciences but also in the social sciences and humanities suggesting that papers co-published with foreign partners in all fields are much more likely to be published in mainstream journals than in national titles.

The picture that emerges from our study is that of a small but rising presence of LAC science on the world stage related to increasing and denser international collaborative networks and particularly to a greater involvement in papers co-authored with the EU. It has been alleged that the funding and sponsorship of the European Commission is a major factor in the fostering of international scientific collaboration and that collaboration of EU countries with non-member countries reflects the increasing role of the EU as a partner of advanced countries, as well as economies in transition and developing countries (Glänzel, Schubert and Czerwon, 1999). Our study reiterates the importance of European partners for LAC science in all major fields of study, particularly in recent years and mainly with respect to collaboration with Spanish, French, British and German institutions.

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Chapter 4

Scientific Cooperation between the European Union and Latin American Countries: Framework Programmes 6 and 7

Pablo KREIMER[1] and Luciano LEVIN

Abstract

In this chapter we analyse the main trends in scientific cooperation between the European Union (EU), and the leading Latin American countries (LAC) by studying the structure of the cooperative projects funded by the EU through the most recent Framework Programmes (FPs) that include Latin American groups and institutions, e.g. all of the projects funded by FP6 and FP7 up to April 2010. The analyses focus on total number of projects, funding, relative contribution made to the project funds by the different countries, geographical distribution and other general features. The analyses also focus on the thematic structure of this type of scientific collaboration, the concentration of projects in specific urban areas, such as capital cities, the existence of dominant elites or institutions in each field that may explain the greater involvement of a country or a city in a higher number of projects and other specific features. We have chosen this approach taking into account the availability of information sources. The advantage of our selection of sources of information is the existence of their time series and the scope of their programmes, which cover many disciplinary fields not covered by the most active institutions working with Latin America (NIH, NASA, US and private foundations) whose initiatives are restricted to research in fields such as health, space, biomedical research or other specific subjects.

Introduction

On broad lines, the perception of international cooperation has changed over the last few decades, moving from a basically positive and often naive view highlighting values related to the cosmopolitanism and internationalism of science to more critical analyses that take into account the different types of potential consequences (not just the "positive" ones) of the scientific activities[2]. This said, the observations are highly dependent on the methodologies of the different approaches, since, in general, the quantitative approaches, and particularly the bibliometric methods, are useful in the study of some dynamics and trends but are less suitable for studying social and institutional structures, the role played by the various local

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[2] For the first point of view, see (Katz Martin, 1997) and for a more critical outlook (Gaillard, 1994; Kreimer, 2010b; Velho, 2002)

elites, including the scientific communities, and the changing paradigms of Science and Technology (S&T) policies.

Literature makes two significant distinctions in the analysis of scientific collaboration. The first one refers to the difference between formal collaboration, institutionalised through projects, programmes and cooperation agreements, and informal collaboration, through interpersonal and – increasingly – intergroup relationships (Kreimer 2010a; Velho 2002). The second distinction is between collaborations, whether formal or informal, that are either assumed as "horizontal" in the relationships established between the partners or classified within the category of "help", which is usually aimed at creating or strengthening capabilities in the less developed countries (Gaillard 1996; Wagner, Brahmakulam, Jackson, Wong and Yoda, 2001), and assumes an asymmetrical relationship from the outset.

There are a number of precedents in the analysis of international cooperation in Latin America. Several of them use bibliometric methods for the observation of both formal and informal collaborations (Cardoza and Fornés 2011; Fernández Gómez and Sebastián 1998; De Filippo, Morillo and Fernández 2008; Gómez, Fernández and Sebastián 1999; Miguel and Moya-Anegón 2009), but are naturally restricted to recording key indicators such as co-authoring, which is actually an indirect indicator of existing cooperation, since cooperation is a multidimensional phenomenon: to appear as a co-author of an article may reflect many different circumstances, from well-structured collaboration to a sporadic or incidental relationship.

Other texts have focused on formal networks, (Bonfiglioli and Mari 2000; Cuadros, Martínez and Torres 2008; Sebastian 2007). These studies, like those of the preceding type, take Latin America as their object, but are explicitly restricted – as we already mentioned – by leaving aside informal collaborations. Even more important is the fact that they, like the previous ones, are mainly based on an uncritical perspective of the practices of international cooperation, and assume that the greater the flow of cooperation, the more positive the consequences will be, particularly for the less developed countries. This is even clearer in the analysis of actions framed within "aid" from rich countries to peripheral ones, since it is assumed that the "degree of internationalization" of the research is, by definition, a dynamic factor for scientific development and hence should be valued as such.

Therefore, there are comparatively few contributions that consider international scientific cooperation as a constituent of scientific research that may or may not benefit the scientific groups of non-hegemonic countries. For example, Velho (2002) pointed out that “there are a number of examples of projects undertaken under the merit-based category which create exactly the same problems of asymmetry of all kinds of Research-for-Aid and which contribute only to the excellence of the Northern partner”. Vessuri and Kreimer (Kreimer and Zabala 2007; Vessuri 1996) reached similar conclusions in the analysis of the Venezuelan and Argentinian cases, respectively, while Gaillard (1998) and Waardenburg (1997) proposed other typologies that cover a greater variety of situations that do not involve immediate benefits for the Southern countries (Gaillard 1998, Waardenburg 1997). Gaillard focused on the difficulties of cooperation between unequal partners, noting, for example, that “Another problem is that mathematics and the basic natural sciences, which must be developed to a sufficient level in any country in order to support health, are often not included among the cooperative projects. A main reason is that the researchers in these fields in the North generally find the reward for cooperation with other researchers in the

North much more rewarding". As discussed below, this latter aspect seems to have changed in recent years.

Beyond the assessment that might be made about its consequences – an issue to be addressed empirically later on in this chapter – international scientific cooperation, whatever the methods used to measure it, has been increasing significantly during the last decades, both in formal and informal terms, although the informal increases are more difficult to identify.

The increase in international scientific cooperation in recent decades can be seen, for example, by looking at the total number of research articles published in a set of international peer-reviewed journals: the figure rose from about 460,000 in 1988 to an estimated 760,000 in 2008[3]. Further, in 1988 only 8% of the world's Science and Engineering (S&E) articles had international co-authors; by 2007, this share had grown to 22% (N.S.F. 2010). EU policies to increase intra-European research integration appear to be having their desired effect, as intra-EU collaboration index values increased substantially over the period. According to Sebastian (2009), international co-authored publications have multiplied fivefold in the European countries in the last twenty years and have now reached almost 50% of their national output, while in countries like the U.S.A. or Japan, this percentage reached 25% (Sebastian 2009). This increase is due, among other factors, to the promotion and encouragement that this type of collaboration has received from government initiatives, such as bilateral and multilateral cooperation agreements and treaties signed among countries and regions as well as intergovernmental research programmes established with the explicit aim of promoting global and regional cooperation by supporting projects (Velho 2002).

Other authors have also shown that international collaboration improves the scientific impact of publications in certain disciplinary fields (Glanzel *et al*. 1999; Katz and Martin 1997). Therefore, the determination of which potential partners will allow a country to reach a higher research potential (more and better results in terms of visibility) is not a trivial issue in designing the countries' cooperation policies.

According to Leydesdorff and Wagner (2008), as co-authorship increased linearly, the number of institutions involved increased exponentially (Leydesdorff and Wagner 2008). Persson *et al.* (2004) pointed out that this situation created an "inflation", due largely to the purported high correlation between the *co-authorship* and the *citation impact* (though this hypothesis is controversial at the moment) (Persson, Glänzel, and Danell 2004). This trend has become even more pronounced through the exponential increase in the participation of Chinese authors, a trend that is expected to grow in the future (Royle, Coles and Williams 2005). However, most of the perspectives discussed above analyse the increases in international scientific cooperation without exploring the qualitative aspects that vary, depending on the context and, in particular, between the centres and the peripheries, in order to analyse the 'real' practices of scientific cooperation among different partners.

Since these increases will be included in the issues that we discuss later, it is worth considering and briefly discussing the factors underlying the increase in international

[3] Bibliometric issues are discussed and presented in greater détails in chapter 4.

collaborations. In their report Wagner *et al.* (2001) suggest the main reasons for enhanced international cooperation:

Geographic proximity: Neighbouring countries often have similar research projects or complementary interests and common publication profiles;

History: Common elements that represent human, linguistic or other sorts of ties, formed as a result of historical interactions (including colonial relationships) support present day collaborations;

Common language: A shared language facilitates collaboration;

Specific problems and issues: Common problems, such as disease control or natural disaster mitigation;

Economic factors: Factors include investments in a particular field because of research priorities set by scientists and policymakers, individual scientists collaborating with particular universities, and the need to share facilities and equipment;

Expertise: Collaborations can be driven by the need for the best, or most appropriate, expertise to pursue the objectives of the scientific query. Many developing countries have institutions and individuals with world-class expertise;

Research equipment, databases, and laboratories: The presence of particular research equipment, databases, and laboratories in a country can give rise to international collaborations.

Some of these possible reasons may seem original and explanatory although not empirical. For example, geographical proximity is not a frequent "strong" reason for collaborations; in Latin America, as well as in other regions, research groups are more frequently associated with groups from “the North" than with groups that are akin or geographically close to them. The "common language" does not seem to be decisive either, though combined with other factors could enhance collaborations; the Spanish-speaking countries of Latin America, for instance, have more collaboration with Spanish research groups because of the language (see data in EULARINET 2010). But the intensity of these links is clearly less than that of collaborations established with the United States or with other leading European countries, though the scenario is different for each field. In Medicine, for instance, the main partner is UK, in Biomedical Research the main partners are UK and France, while in Physics the preferred partners are France and Germany (EULARINET 2009, 2010).

Many studies indicate that "specific problems and issues" can be quite challenging since the work agendas are often strongly influenced by the more advanced countries (Bradley 2007; Gaillard 1994; Kreimer and Meyer 2008; Vessuri 1996).

Other causes seem more plausible, such as "*Economic factors"* or "*Research equipment, databases, and laboratories*," and can better explain the motivation of the groups located in non-hegemonic contexts, on the condition that their access to resources is, indeed, seriously limited. However, as we shall see below, this does not seem to be the case in Latin America, where funding has increased steadily in recent years in the countries that cooperate most actively (Brazil, Argentina, Mexico and Chile), although still far below the funding level available in the more advanced countries. Perhaps, – and this issue is less frequently addressed – the resources available in these countries are sufficient for scientific research, but not for the industrialisation processes stemming from knowledge generated by such research (Kreimer and Zabala 2007).

We agree with Katz and Martin (1997) who pointed out that "… the list of possible contributing factors is almost endless. Even though some of these factors may occur more frequently than others, collaboration is an intrinsically social process and, as with any form of human interaction, there may be at least as many contributing factors as there are individuals involved." However, it is worth briefly considering one of the aspects pointed out by Wagner *et al*., since it will help us to articulate our hypotheses. We are referring to the role that the local researchers' *expertise* plays in collaboration projects. "Many developing countries have institutions and individuals with world-class expertise". This, of course, has several aspects that the authors do not consider in detail. On the one hand, the so-called "world-class expertise" is defined by the dominant groups, at an international level, for each field of science or problems and on the other, this expertise is often related to two aspects qualitatively different: in a sense, this expertise relates to the ability to carry out research with the same capabilities and quality standards that are applied by their peers in the more advanced centres. This might be called *location of global expertise*. But considered from another vantage point, this expertise can take the form of knowledge – and its accumulation over decades – of local problems or issues that may be of general or universal interest, as is the case for research on particular sites on native species, or specific conditions that can only be observed in a certain *locus*[4].

In sum, it seems evident that in order to reach a deeper understanding of the forms of international cooperation today, and the changes that have occurred more recently, it is necessary to complete the analysis based on aggregate data with a socio-historical perspective that could provide a framework for interpretations and micro-level studies that might explain the case-specific peculiarities. But, above all, it is necessary to break the preconception, often taken for granted by several authors and, even worse, in many policies of non-hegemonic countries, that "all scientific cooperation has positive effects"[5].

1-Background, object and methodological aspects of the study

In this section we analyse the main trends in scientific cooperation between the European Union (EU), and the leading Latin American countries (LAC). We included all the projects funded by the FP6 and FP7 up to April 2010. The analyses focus on total number of projects, scope of funding, relative contribution made to the project funds by the different countries, geographical distribution and other general features. But we are also interested in specific features such as the thematic structure of this type of scientific collaboration, the concentration of projects in specific geographical areas, such as capital cities and the existence of dominant elites or institutions in each field that may explain the greater involvement of a country or a city in a higher number of projects.

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4 For an excellent analysis of this, several elements of local/global research referred to the research in Tierra del Fuego (Argentina), see Albarracín, 2011.

5 For a further discussion about the internationalization of Latin American science and its consequences, see Kreimer (2010b)

As was observed by some authors who have been studying the patterns of cooperation in science from a bibliometric perspective (where the co-authorship rate and the percentage of works in collaboration are the more widely used indicators), Latin America seems to follow some patterns that can be perceived internationally (Sancho 1990). Although there are disparities across disciplines, the U.K., Italy, France, Spain and Germany are the European countries with the largest participation in the collaboration. They are second after the United States, which is the main partner of most of the countries of the world[6].

To support a conceptual approach focused on the magnitude and characteristics of international scientific cooperation in Latin American countries, we propose to reduce the scope of these relationships to the links established between Latin American groups and European scientists, as institutionalised through the EU 6 and 7 Framework Programme. This reduction leaves out an important part of international scientific relations, since Latin America researchers have developed, as noted above, strong links with their American colleagues. Therefore, a future study that is complementary to this one, will compare EU/LAC and LAC/US patterns of cooperation to determine the extent of differences. This practical exercise will be supported by the existence of databases that facilitate this kind of analysis, and by the increasingly institutionalised EU science, technology and innovation ‘Liaison Offices’, which collect and analyse data at the various national i.e. federal, provincial, state, levels in Latin America, thereby allowing for some kind of inter-country comparisons.[7] Moreover, scientific cooperation between Europe and Latin America only became really strong after the establishment of FP6 in 2001.

In sum, the object of our study can be defined as the links of scientific cooperation between Latin American countries and their European counterparts implemented through FP6 and FP7.

The corpus of data was obtained from CORDIS, the public database of the European Union and from CORDA, an internal database of the European Commission, which provided updated and complete data (http://cordis.europa.eu/home_es.html). The FP7 data correspond to the programme’s first three years, ending on April 9, 2010. These data were supplemented with data provided by the various Liaison Offices.

To quantify EU-LAC collaboration, we took account of the number and cost of projects involving Latin American countries and studied the structure of LAC and EU participation. Groups belonging to European countries are ‘natural’ participants in the FPs. The participation of third countries is partly funded by the EU, usually with counterpart funding, depending on the country. Further, the funds that each third country invests in the EU projects can come from a variety of sources. For this reason, there are many categories that need to be explained.

The ‘total cost of the project’ refers to the total amount disbursed for project implementation.

The ‘contribution of the EU’ refers to the total contribution provided by the EU member countries together with the EU central body to third countries.

[6] See the chapter 3 by Jane M. Russel and Shirley Ainsworth in this volume .

[7] For instance: ABEST (Argentina), CHIEP (Chile), EUMEXCYT2 (Mexico), B. Bice (Brazil)

The ‘Latin American total cost’ is a compound of the European contribution to Latin American countries plus the contribution made by each (Latin American) country.

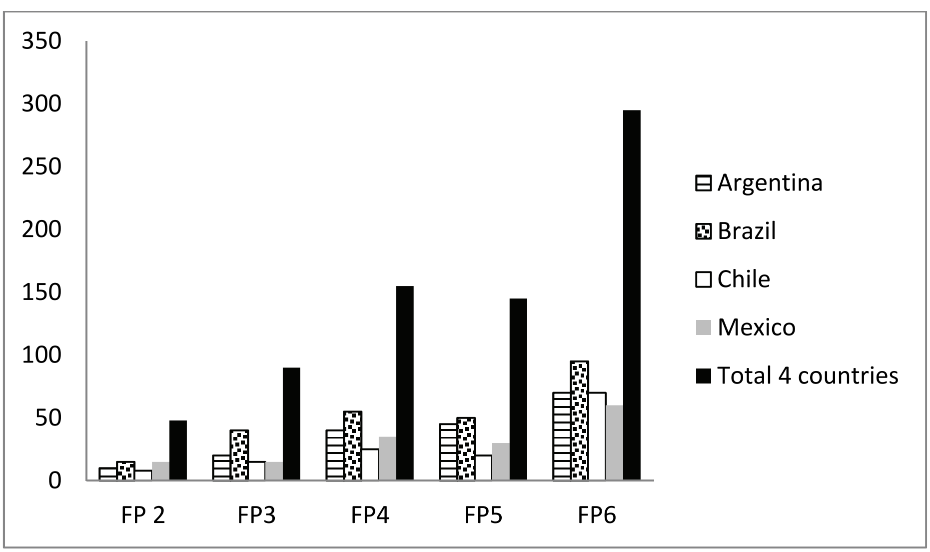
The ‘European contribution to Latin America’ refers to the European contribution.

Another key point in the analysis of international scientific cooperation is the thematic classification of projects. Each FP is structured around different subjects and areas of knowledge. Moreover, the institutions and groups in the participating countries feel that access to their disciplinary fields and areas of knowledge is facilitated through participation in the FP. To overcome these differences, we have used the information available about each project: title, subject of research, the framework programme it belongs to, institutions involved, and categories (primary and secondary): Agriculture, Biology, Chemistry, Earth Sciences, Engineering, Medicine, Social and Human Sciences and Physics.

The FP is an essential tool designed by the EU to support the competitiveness of the European economy through strategic partnerships with third countries. The FPs seek to promote the production of knowledge by establishing links between European universities and research centres, on the one hand and partners in third countries, on the other. At the programmatic level, the declared aim is to try to find answers to specific or global problems on the basis of mutual interest and mutual benefit (CORDIS 2009). The FPs are structured as sets of projects carried out by research teams from Europe, Latin America and other regions. The EU determines which nations are eligible for each programme and activity.

Prior to FP4, no specific programme was devoted to scientific cooperation with third countries, but starting with the 1994-1998 period, a specific FP was set up for "Cooperation with Third Countries and International Organizations" (INCO), with clearer guidelines and more specific measures. Thereafter, Latin American countries started participating more actively.

Figure 1: Evolution of number of projects involving four leading LA countries (FP2 to FP6)



Source: CORDIS

2-Results

2.1 General funding structure

In Table 1 we can see the number of projects that have been funded by both FP 6 and FP 7 up to the time of this study. Since FP7 is still underway, the total number of projects to be funded up to the time of completion, obviously, will greatly exceeds the total number of projects funded by the previous programme. However, the trend indicates that, for the same number of projects, the average total cost per project has fallen to slightly over 50%.

(2) Average cost (€) of projects involving at least one Latin American country.
(3) Total cost (€) of Latin American participation.
(4) Europe's contribution (€) to participation of Latin American countries.
(5) Contribution of Latin American countries (€).

The decrease in the average cost per project (in projects involving at least one Latin American country) can be explained partly by a greater relative participation of SHS (Social and Human Sciences) projects (as will be discussed in Section 2.2.3), whose costs are significantly lower than projects in other knowledge areas that involve, for example, the purchase of sophisticated equipment. However, this is only a partial explanation: except in the field of Physics, the average cost per project is significantly lower in FP6 than in FP7 in almost all disciplinary fields, with some major drops, e.g. Earth Sciences and Chemistry where the average costs are about half[8].

Table 1: Total costs and regional contributions for the FP6 and FP7 EU-LAC projects (€)

	Number of Projects	Total Cost of LA Projects (1)	Average Project Cost (2)	LA Total Cost (3)	EU contribution to LA (4)	LA contribution (5)
FP6	221	1,078,753,038	4,881,235	56,755,734	48,117,373	8,638,361
FP7	226	606,283,223	2,682,669	73,007,101	50,156,106	22,850,995

(1) Total cost (€) of projects involving at least one Latin American country.

The explanation above may suggest that the resources received by each FP7 participant (except in the Physics groups) are lower than those received under FP6. But this is not so, because there are additional data to be considered such as the lower average number of participants per project in FP7 (under 11) than in FP6 (close to 18): In fact, over 22% of the FP6 projects had more than 30 participating groups (and some projects with as many as 70 participants). In FP7, only 4% of the projects have 30 or more participants involved, and the largest project only has 38. Thus, if the distribution of resources per project were homogeneous among every participant group (regardless of the disciplinary field, country, project type, etc.) each of them would receive more money under FP7 than under FP6:

[8] An additional explanation may be found in the EU decision to limit the funding of 'huge' projects, since they are more difficult to manage (Hubert, Chateauraynaud and Fourniau 2012)

respectively about 327,000 euros and 280,000 euros. These figures hide a lot of heterogeneity and dispersion within the programmes, which we will briefly discuss.

From the above data, it is evident that, although the total European contribution to projects involving at least one Latin American country is similar in both FPs – about 70% – the total cost of Latin American participation (consisting of the European participation plus the Latin American participation) shows a significant increase. While in FP6 the Latin American share was 5.26% of the total project costs, in FP7 the figure is more than double, 12.04%. An important part of this relative increase comes from the funds supplied by the Latin American countries themselves. While in FP6, the EU funded almost 85% of Latin America's total costs, in FP7 (until now), this percentage has dropped to 68%. The difference can be explained by the fact that the countries of this region are investing, in relative terms, more money to participate in the same number of projects.

The increase in the Latin American contribution can be traced to the following factors: a) a higher concentration of Latin American groups in the more expensive projects; b) an increase in the number of Latin American countries in each project; c) Latin American policies that encourage the participation of their research groups in European programmes, as a part of their internationalisation strategies, based on the assumption that Latin American countries may benefit from them.

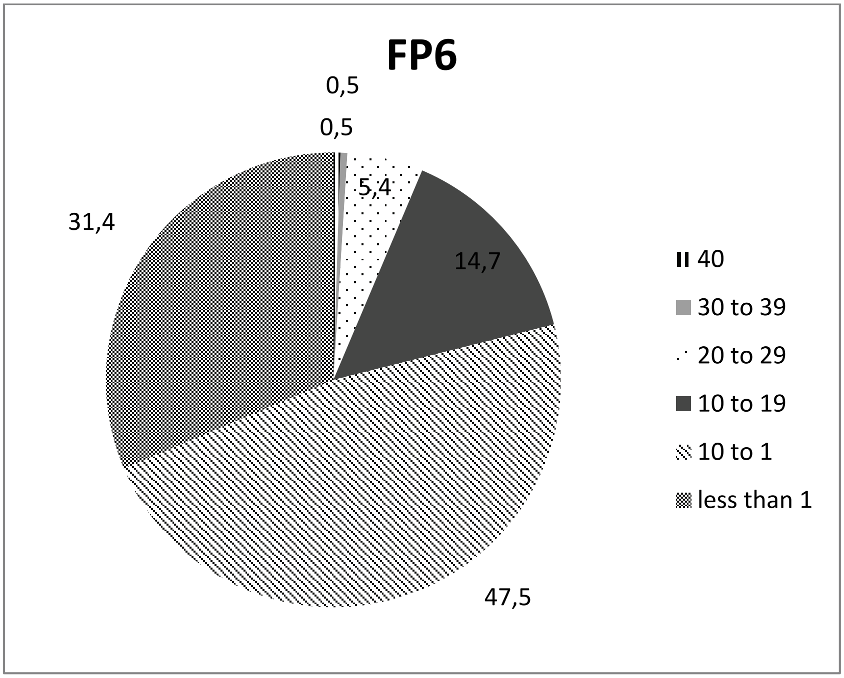
It is interesting to observe the cost distribution of projects in which LA groups participate. Figure 2 shows that the majority of projects in the two FPs cost about the same. Approximately 30% of the projects cost less than one million euros, while 47%s of FP6 and 64% of FP7 cost between 1 and 10 million euros. This indicates that the high average cost observed in FP6 is due, mostly, to the existence of a very small number of projects costing over 40 million euros, and a certain number costing between 20 and 30 million euros, while in FP7 there is no project with LA participants that costs over 15 million euros[9].

Since these projects also involve other countries it is interesting to observe the consequences of the increase observed in the LAC contribution. To evaluate this, we analysed the relative share of 'other countries' on given projects (see Table 3). We define "other countries" (OC) as all those countries that have participated in the FP and that are neither EU nor LAC.

Our analysis of OC participation in given projects that involved at least one Latin American country, assumed that a bias may have been introduced in favour of projects that addressed 'regional issues', thematically or geographically. But the trend was not exactly what we expected. During FP6, the OC contributed almost 10.61% of the total investment, while in FP7 (until April 2010), that percentage rose to just over 11.19%. Meanwhile the LACs contributed, as noted before, more than double the amount they contributed to FP6, thus exceeding the OC contribution.

[9] On the whole, LAC financial participation per project in FP7 was lower than in FP6. During our study period, some FP6 projects cost up to 40 million euros, while in FP7 there were no projects with a total cost exceeding 15 million euros. Despite a small number of expensive projects, we found that the majority of projects funded by the two FPs cost between 1 and 10 million euros.

Figure 2: Distribution of projects involving LA, by total cost (in million €) in FP 6 and FP7



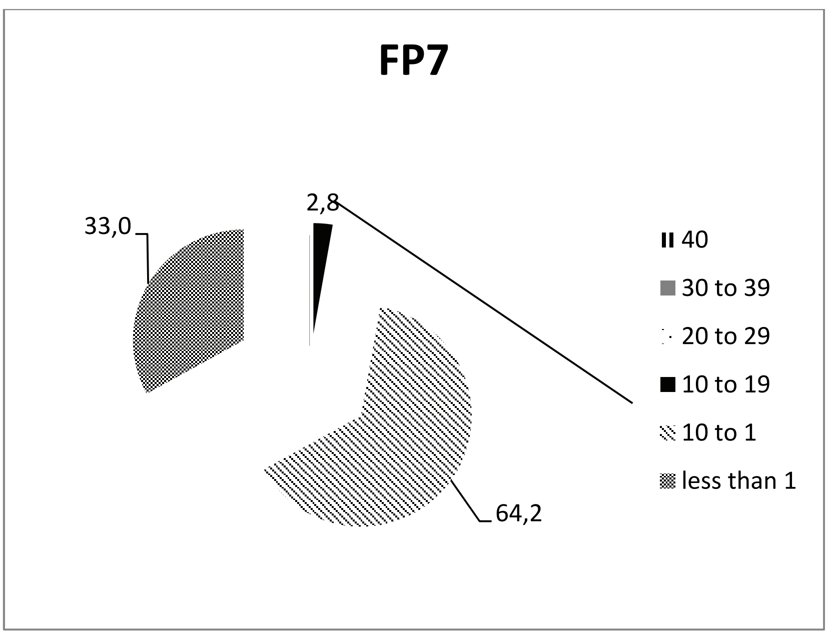


Table 2: Distribution of participation cost by region (LAC and OC) in the FPs

	Number of Projects	Total cost of projects	LAC total cost	% LAC	OC Total cost	% OC
FP6	221	1,078,753,038	56,755,734	5.26	14,511,313	10.61
FP7	226	606,283,223	73,007,101	12.04	67,901,413	11.19

The LACs participate in more projects, provide more funds in absolute terms and, as we mentioned, now consider the distribution of their contribution as a major component. The OC, on the other hand, are contributing less, a situation that is offset by a concomitant increase in European funding.

Table 3: Distribution of the amount of EU contributions to the FP projects by region

	LAC	%	OC	%
FP6	48,117,373	85	66,691,306	58
FP7	50,156,106	68	49,242,126	72

If, indeed, the projects had some sort of regional bias, one would expect two things. First, a greater show of interest by the countries belonging to the project's region, which should mean increased participation in the number of projects and in each project and more funding for each project. This trend is apparent, but, if these projects were actually "region-dependent", we would also see some indication of greater Latin American participation, with a subsequent increase in the European contribution (or, at least, no decrease in the relative contribution). What is happening is exactly the opposite: the European contribution in the region is going down, while the Latin American participation fallaciously seems to be going up, a theory not supported by the data because a larger number of the projects focus on regional issues. In conclusion, and in spite of other influences, the more plausible explanation corresponds to factor c) under 2.1 above, that purports that Latin American policies are indeed encouraging the participation of their research groups in European Programmes.

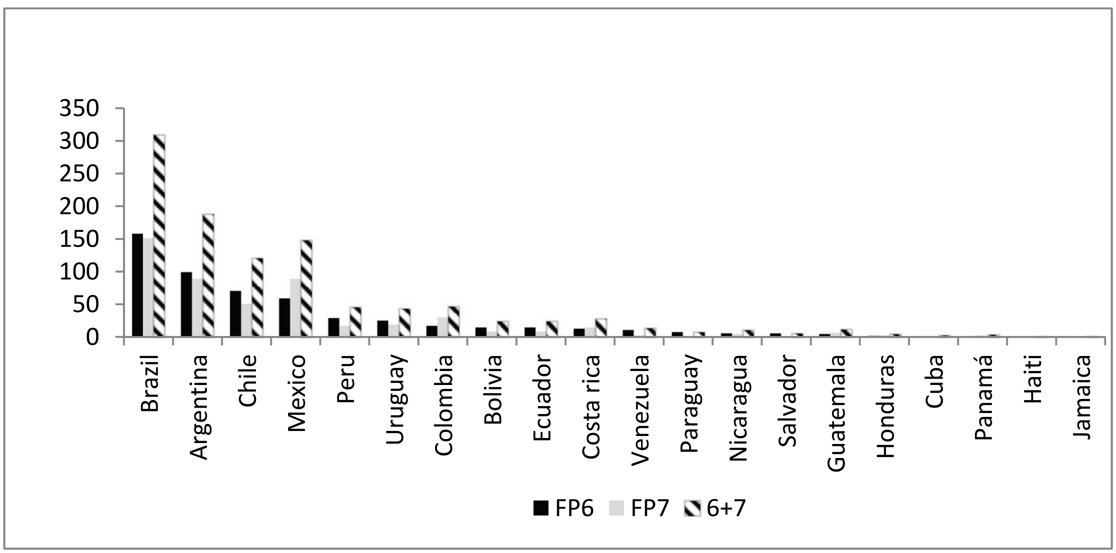
2.2 LAC Trends

The above data indicate that, on the whole, LAC participation in scientific collaboration with EU has increased significantly, both in terms of number of projects and project funding. We were interested to know how these funds were allocated in the various Latin American countries.

2.2.1 Breakdown by country

As a general rule, the countries with the more established scientific institutions and the more powerful scientific elite had a higher level of international cooperation, as measured by the number of FP projects. In Latin America, this referred to Brazil, Mexico, Argentina and Chile. We could qualify this group of countries as "very active", followed by a second group, with moderate but important participation, composed of Colombia, Uruguay, Peru, Bolivia, Ecuador and Costa Rica and a third group with little or no participation in FPs, composed of Venezuela, Paraguay, Nicaragua, Salvador, Guatemala, Honduras, Cuba, Panama, Haiti and Jamaica.[10]

Figure 3: LA participation in number of FP projects



As we can see Colombia increased its participation (measured in number of projects), by 70% (17 projects in FP6 and 30 in FP7), Mexico by 50% (59 and 89), while Costa Rica increased it by 15%, but with a lower number of projects (13 and 15 respectively).

[10] We established the following classification: “Very active” meant participation in more than 50 projects, “moderate” meant participation, in 10 to 49 projects incl., and “little or none” meant participation in less than 10 projects. This included the average number of projects in both programmes.

Table 4: Costs per country for FP6 projects (€)

FP6						
Participating Country	**Number of projects**	**Total Project Cost**	**EC Contribution to project**	**Total Cost EU + LAC Participants**	**ParticipingEC Contribution**	**ParticipingLAC country contribution**
Brazil	158	886,241,078	590,286,827	17,784,246	13,836,655	3,947,591
Argentina	99	465,918,348	320,798,797	9,325,017	8,081,881	1,243,136
Chile	70	274,491,789	199,289,722	8,424,923	6,693,055	1,731,868
Mexico	59	203,378,242	153,756,253	6,266,814	5,819,527	447,287
Peru	29	86,534,429	68,560,776	3,239,820	2,866,609	373,211
Uruguay	25	88,556,629	67,867,337	2,249,265	2,139,103	110,162
Colombia	17	73,309,572	55,489,646	2,140,880	1,711,853	429,027
Bolivia	15	44,302,003	31,036,167	1,339,936	959,809	380,127
Ecuador	15	62,893,902	55,681,002	1,921,148	1,981,368	-60,220
Costa Rica	13	39,007,314	29,477,534	1,139,892	1,139,892	0
Venezuela	11	16,607,792	14,503,913	1,518,867	1,518,861	6
Paraguay	8	7,064,415	6,526,212	430,405	430,405	0
Nicaragua	6	17,719,036	14,950,409	489,335	454,835	34,500
Salvador	6	7,715,743	7,604,239	210,540	210,540	0
Guatemala	5	22,058,072	17,066,696	184,780	184,780	0
Honduras	2	530,000	530,000	46,200	46,200	0
Cuba	1	1,886,475	1,700,000	43,666	42,000	1,666
Panama	1	0	201,714	0	0	0
Haiti	0	0	0	0	0	0
Jamaica	0	0	0	0	0	0
Overall Total	540	**	**	56,755,734	48,117,373	8,638,361

** These columns cannot be added to obtain the total because there are repetitions, since several participating LAC may be involved in the same project.

Measured in total project costs, Brazil, Argentina, Bolivia and Ecuador increased their participation most.

As noted above, the Latin American share is higher in FP7 than in FP6. This growth, however, depicts specific features for the different countries. In terms of number of projects, Mexico and Colombia stand out since their FP7 participation has already exceeded their FP6 participation by, respectively, 50% and 70% although FP7 is only midway. If we consider total project costs, except for Mexico all the LA countries are participating in projects whose cost is below the average.

Table 5: Costs per country for FP7 projects (€)

Participating Country	Number of projects	Total Project Cost	EC Contribution to project	Total Cost EU + LAC participants	Participing EC Contribution	Participing LAC contribution
Brazil	151	355,094,914	264,091,206	22,458,471	15,946,748.74	6,511,722
Argentina	89	194,843,888	146,823,353	10,015,559	7,666,589.21	2,348,970
Mexico	89	249,978,962	150,138,042	13,930,231	5,406,059.23	8,524,172
Chile	51	140,346,775	104,576,933	4,536,355	3,433,215.78	1,103,139
Colombia	30	68,158,466	49,747,572	4,913,691	3,862,842.20	1,050,849
Uruguay	19	46,103,621	32,170,325	2,120,256	1,629,175.20	491,080
Peru	17	59,024,061	43,042,222	3,181,789	2,435,643.30	746,146
Costa Rica	15	44,557,936	34,306,329	3,126,475	2,420,316.00	706,159
Bolivia	9	24,296,257	18,778,846	1,796,916	1,354,542.10	442,374
Ecuador	9	27,841,928	19,787,087	2,146,341	1,624,524.60	521,817
Guatemala	7	18,735,445	14,509,843	869,954	611,171.00	258,783
Nicaragua	5	13,215,756	11,137,348	1,131,702	776,888.00	354,814
Honduras	3	11,282,948	8,793,852	474,793	369,304.00	105,489
Panama	3	6,171,330	4,503,633	331840	269,820.00	62,020
Venezuela	3	12,262,445	7,869,507	596,373	383,927.00	212,446
Cuba	2	5,756,244	2,677,000	38,180	28,580.00	9,600
Haiti	1	2,669,987	1,490,171	96000	72,000.00	24,000
Jamaica	1	17,162,412	12,949,264	1242174	1,864,760.00	-622,586
Paraguay	0	0	0	0	0.00	0
Salvador	0	0	0	0	0	0
Total	504	**	**	73,007,101	50,156,106	22,850,995

** These columns cannot be added to obtain the total because there are repetitions, since several LACs may be involved in the same project

In terms of fund allocations, Figures 5 and 6 show that the following countries increased their share of total funding most: Mexico, Brazil, Colombia, Uruguay and Argentina. The first two made particularly remarkable increases (This comparison does not include countries that were inactive during FP6).

As was to be expected from the general trends presented above, the average cost of projects with Latin American participation has diminished in most cases although a notable increase has been observed in the case of Mexico and, to a lesser extent, Costa Rica (see Figure 7).

Figure 4: Total cost of LA participation (millions €)

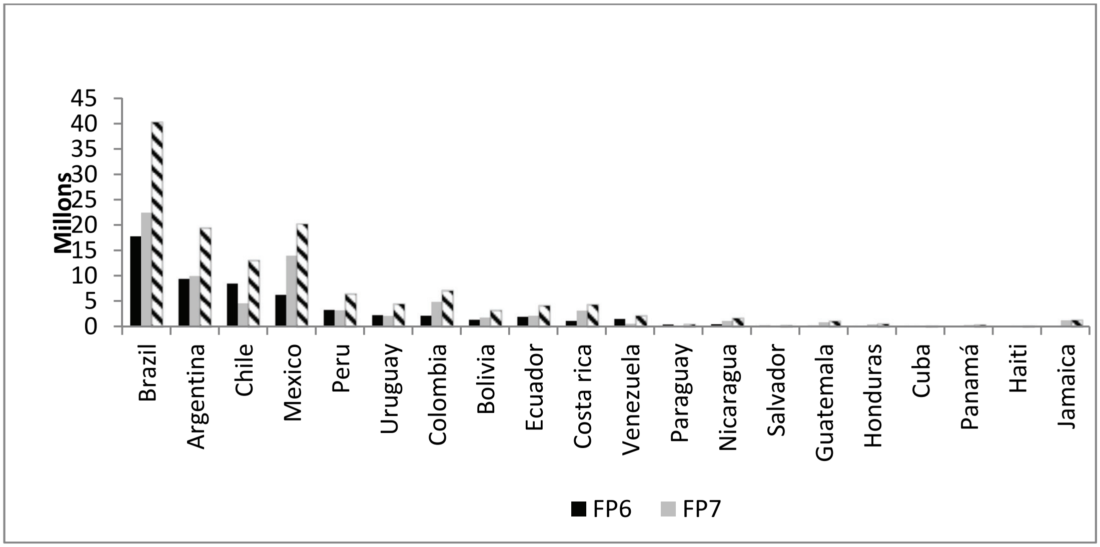
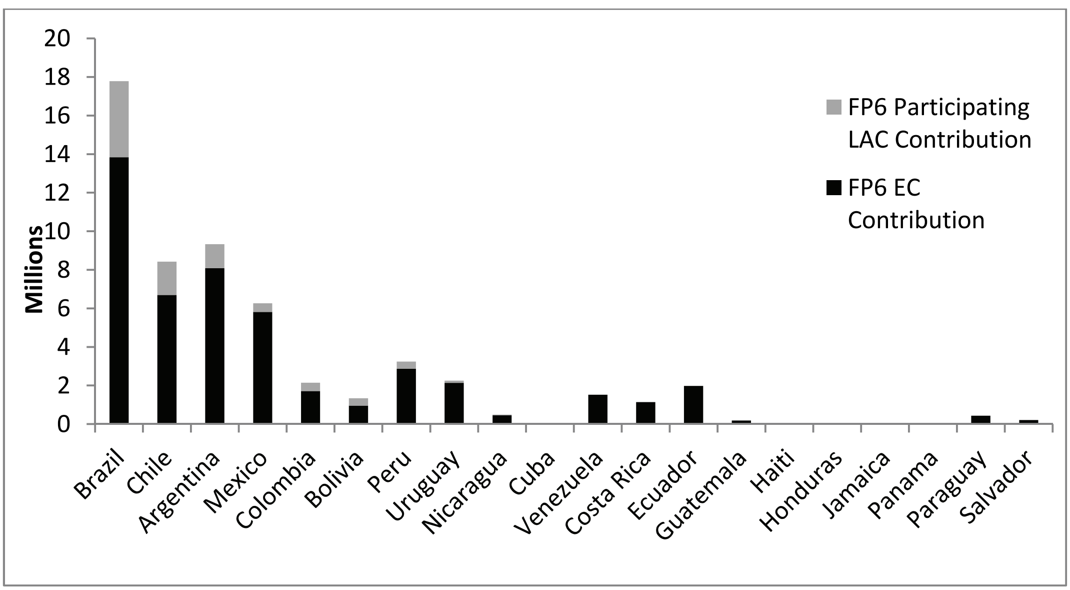


Figure 5: Distribution of cost for each of the LAC in FP6 (millions €)

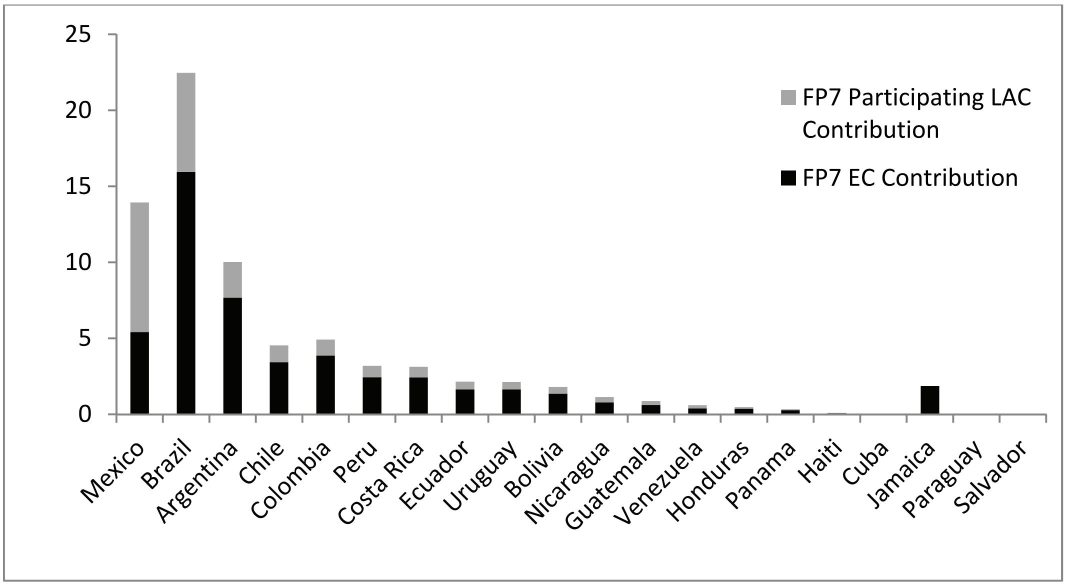


Note: Data are presented in decreasing order of European contribution to each participating Latin American countries

Although the three very distinct groups of countries we established above still remain, the gap between the most active seems to be shrinking, thus consolidating two groups: those who regularly participate and those who do so only sporadically.

2.2.2 Distribution of projects by LAC cities and institutions

Figure 6: Distribution of cost for each of the LAC in FP7 (millions €)



Note: Data are presented in decreasing order of the European contribution to the contribution of each participating Latin American country.

The increased LAC project funding is not accompanied, however, by a linear increase in the number of participating institutions (Table 6).

Table 6: Number of institutions participating in FP6 and FP7

	LAC Institutions		EU Institutions		Institutions in Other Countries (OC)	
FP6	366	13.53%	1757	64.93%	583	21.54%
FP7	298	18.53%	938	58.33%	372	23.13%

In FP7, the number of Latin American Institutions rose but is smaller than in FP6, which would indicate a somewhat higher concentration of projects in a smaller number of institutions. But, the concentration process, however, is less strong in LAC that in the OC (the representation of other Latin American institutions from one PF to the other), since the LAC receive less money for FP7 and yet, in terms of number of institutions, are better represented. LAC institutions that were participating on average in 0.6 projects per institution in FP6, are involved on average in 0.76 projects in FP7, while the figure for the OC rose from 0.38 to 0.61. Since this concentration process is also found in EU institutions, whose participation on average has risen from 0.13 projects per institution in FP6 to 0.24 in FP7, the situation perhaps is not inauspicious for LAC. The response of Latin America as a region to the widespread phenomenon of concentration of research in fewer institutions is somewhat more "moderate" than that of other regions.

Table 7: Concentration of cooperation in FP by cities

	LAC cities	Number of projects	Average projects per city	Cities with one project	Cities with 10 or more projects	Cities with 90% of the projects
FP6	147	540	3.67	87	11	94 (64%)
FP7	118	504	4.27	58	11	68 (58%)

This phenomenon of research concentration in LACs is not only connected to scientific institutions. The number of Latin American cities involved in FP projects has also declined. During FP6, 90% of the projects were implemented in 64% of the participating cities, but only 58% under FP7. Since the number of cities is the same for many projects, we concluded that the cities that had "disappeared" in FP7 were the ones that had participated in a small number of projects. This supports the theory that the scientific elite, who settled in the leading institutions in major cities, kept increasing their hegemony over the research being conducted in collaboration with international groups.

Table 8: Distribution of projects in LAC cities

FP6 Projects		FP7 Projects	
Buenos Aires	53	Buenos Aires	62
Santiago	44	Mexico D.F.	42
Rio De Janeiro	28	Santiago	34
Sao Paulo	25	Rio De Janeiro	30
Mexico D.F.	23	Sao Paulo	28
Montevideo	23	Bogota	23
Brasilia	22	Montevideo	19
Lima	20	Brasilia	16
Bogota	11	Campinas	13
Concepcion	10	Lima	13
La Paz	8	Porto Alegre	10

FP6 Projects		FP7 Projects	
Quito	8	Guatemala	7
Asuncion	7	Belo Horizonte	6
Cordoba	7	Sao Jose Dos Campos	6
Manaus	7	Cochabamba	5
Campinas	6	Cordoba	5
La Plata	6	Managua	5
Belo Horizonte	5	Nuevo Leon	5
Florianapolis-Sc	5	Quito	5
Guatemala	5	Sao Carlos	5
Managua	5	Valparaiso	5
Merida	5	Guanajuato	4
Sao Carlos	5	La Plata	4
Belem	4	Saltillo	4
Cali	4	San Jose	4
Caracas	4	San Luis Potosi	4
Cochabamba	4	Turrialba	4
Curitiba	4	Antofagasta	3
Mar Del Plata	4	Cali	3
Nuevo Leon	4	Manaus	3
San Salvador	4	Mar Del Plata	3
Turrialba	4	Pedro	3
Valparaiso	4	Piracicaba	3
Others (Less than 3 proj per city)	158	Recife	3
		Rosario Santa Fe	3
		San Nicolas De Los Garza	3
		San Pedro De Montes De Oca	3
		Valdivia	3
		Others (Less than 3 proj per city)	103
Total	**53611**	**Total**	**504**

From FP6 to FP7 we observed a growing concentration in several cities; the number of cities declined by 20% in some of the projects. If we combine the projects (see table below) with the percentage of cities in the total, that had only one project the figure was 60%, while in FP7 the figure dropped to 50%.

[11]There are four projects that did not indicate the name of the city where they were located.

Table 9: Number of projects in capital cities

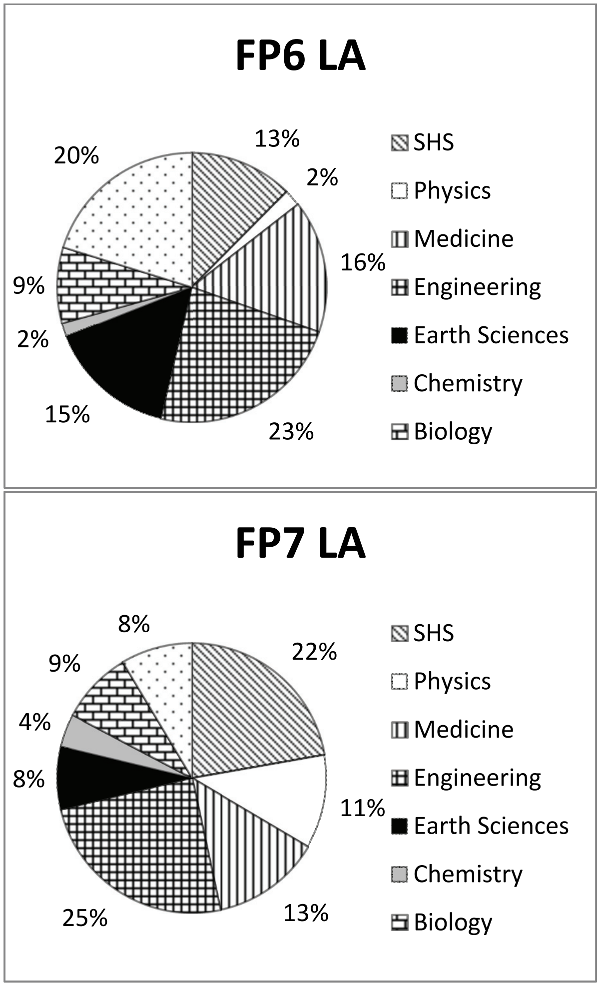
	FP6 Projects			FP7 Projects		
Country	In capital cities	In the rest of the country	In capital cities (% in the country)	In capital cities	In the rest of the country	In capital cities (% in the country)
Brazil (S.P)	25	133	15.82	28	123	18.54
Brazil (Rio + SP)	53	105	33.54	58	93	38.41
Argentina	53	46	53.54	62	27	69.66
Chile	44	26	62.86	34	17	66.67
Mexico	23	36	38.98	42	47	47.19
Peru	20	9	68.97	16	1	94.12
Uruguay	23	2	92.00	19	0	100.00
Colombia	11	6	64.71	23	7	76.67
Bolivia	6	9	40.00	1	8	11.11
Ecuador	8	7	53.33	5	4	55.56
Costa Rica	2	11	15.38	4	11	26.67
Venezuela	4	7	36.36	1	2	33.33
Paraguay	7	1	87.50	0	0	0.00
Nicaragua	5	1	83.33	5	0	100.00
Salvador	4	2	66.67	0	0	0.00
Guatemala	5	0	100.00	7	0	100.00
Honduras	2	0	100.00	2	1	66.67
Cuba	1	0	100.00	2	0	100.00
Panama	1	0	100.00	2	1	66.67
Haiti	0	0	0.00	1	0	100.00
Jamaica	0	0	0.00	1	0	100.00

We see a general tendency to concentrate projects in the capital or big cities. Brazil is a special case because, in spite of the particular weight of Sao Paulo and Rio de Janeiro, projects are dispersed throughout more than 10 cities. Bolivia is another special case, because of the weight of two cities, Cochabamba and La Paz. Montevideo is another interesting case; although Uruguay is not among the countries with the highest participation (due to its size), almost all the projects are concentrated in the capital.

2.2.3 Disciplinary structure of the EU-LAC partnership

While the data shown above regarding the participation of LAC in the FPs are very informative, they need further analysis based on disciplinary field, to see how this kind of collaboration applies in other knowledge areas. The thematic structure of collaboration is shown in the Table 10 and Figure 7 below.

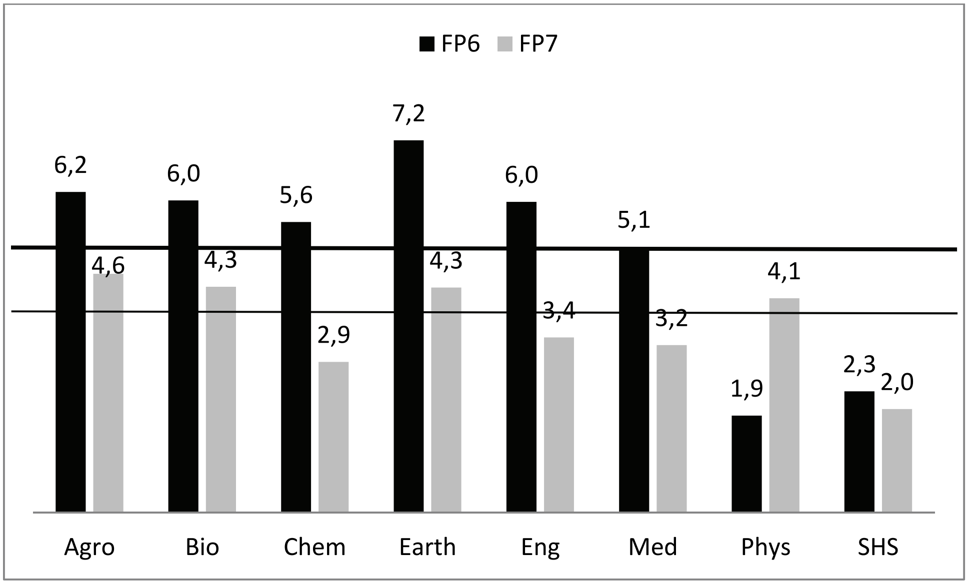
Figure 7: Distribution of projects with LAC participation, in % by disciplinary field



As mentioned above, the LAC increased their participation in the FPs, a fact that will become more apparent at the time of completion of FP7. This increase was not evenly spread across the different disciplines. Engineering remains the most important area, and increased slightly, now reaching 25% of all projects. The SHS projects show a significant 50% increase over their share in FP6, and account for more than 20% of all projects. The number of projects in the field of Physics, show a very strong percentage increase (over five times), but started from a very small base in FP6 (2% of the total).

One hypothesis about the relative prevalence of Engineering can be traced to the calls for projects, which require more applied research and even tend to set guidelines to orient methodologies. The EU documents specify that the overall objective is “to increase competitiveness and foster innovation" (EU 2006; Rouquayrol Guillemete and Herrero Villa 2007). Since projects are applied more and more to production processes, Engineering can be expected to play a major role[12].

Figure 8: Average cost per project with LAC participation, by discipline (millions €)



There are several explanations for the increase in the number of Social and Human Sciences (SHS) projects. Perhaps the most important one is the existence of specific subject areas within the calls for projects: in FP6 the SHS theme called "Citizens and Governance in a Knowledge-based Society" had a 247 million euro budget, and "Science in Society" (SIS), 88 million euros, which meant that these two areas together consumed 335 million euros, for projects distinctly belonging to SHS. In FP7, the "Socio-economic Sciences and the Humanities" programme has a total budget of 623 million euros, while SIS has 330 million euros, totalling 953 million euros, almost three times the amount allocated in the previous programme. The budget for SIS was nearly quadrupled. But this percentage of increase does not apply in all the fields. For example, Nanotechnology, which is one of the most active fields, had a budget increase, but a somewhat smaller one: in FP6 it had 1429 million euros and in FP7, 3475 million[13] (EU 2006).

[12] An exception to this trend is the lesser importance given to agricultural sciences, as we explain below.

[13] The comparison of thematic budgets between FPs is a complex matter because the subject areas are not the same in all of them. For example, in FP7, Health was a single broad subject, with a total budget of 6100 million euros, while in FP6, the field was divided into three major areas: Life Sciences, Genomics and Biotechnology for Health, with a budget of 2.514 billion; Advanced Genomics and its Applications for Health, 1.209 billion, and Combating Major Diseases, 1.305 billion, which led to a total of 5.028 billion, so that the increase from one programme to another is not so important. Budget increases in other areas were similar to that of SHS, e.g. ITCs whose budget was almost triplet (from 3984 million in FP6, to 9050 million in FP7).

Analysing SHS projects by disciplinary field does not produce a homogeneous representation. On the contrary, a substantial part of the budget is allocated to projects in Economics, especially projects on market analysis and changes, and management projects.

As was to be expected, the average cost per project in SHS is much lower than in all other fields: in both FP6 and FP7 the average cost per project in SHS, is about 50% below the overall average (see Table 11).

Table 11: Average cost in € per project involving LAC, by disciplinary field for FP6 and FP7

	FP6	FP7
Agric	6,175,994	4,598,944
Bio	6,012,607	4,349,024
Chem	5,596,167	2,902,262
Earth	7,171,649	4,334,728
Eng	5,985,521	3,374,485
Med	5,119,250	3,224,737
Phys	1,868,161	4,128,496
SHS	2,334,990	1,992,843
Average	5,033,042	3,613,190

In Physics, growth in the number of projects with LAC participation can be characterised, in order of importance, by: (a) the major increase of development projects in Nanoscience and Nanotechnology, (b) the Astronomy projects related to the installation of major international astronomical observatories in the region, (c) the rise in the average cost of the projects in this field.

As noted above, the total budget for Nanotechnology has doubled, which would explain an important part of the related project growth. But, at the same time, most of the LA scientific and technological systems created specific thematic areas to promote Nanotechnology projects, thus producing a double effect. On the one hand, the “classical” projects in the area actually increased. On the other hand, we can support the hypothesis of "functional adaptation" by research groups or consortia. Projects that in former times were presented in areas such as Biotechnology, Chemistry or even Biomedical Sciences, have been reformulated in terms of Nanoscience, so as to capture new funds (Meyer 2007; Schummer 2004). This is the case, for example, for the biosensors projects and could also explain a part of the slight decrease in Biology projects.

The Astronomy projects are related to the creation, maintenance and utilisation of international observatories installed throughout Latin America, like the Pierre Auger Observatory in Mendoza, Argentina, which benefited from the FP6 project "Integrating Auger Observatory and European Research Institutions Into a Worldwide Grid" and the FP7 project "Cherenkov Telescope Array for Gamma-ray Astronomy", just to mention two of them.

The FP7 projects in Physics are more than twice as expensive as those in FP6 and now have per unit costs essentially equal to those in Biology, Agriculture and Earth Sciences, as can be seen in Table 11.[14]

During this same period, the number of projects in Agriculture and Earth Sciences, decreased to less than half their FP6 level: 20% to 8% and 15% to 7% respectively.

The decrease in these two fields can be explained by the hypothesis that within the Latin American participation in European projects the "advantages of local issues" tends to be less important than it was in the past. Thus, the major importance of these two fields in the past, even in FP6, can be traced to the possibility of profiting from local conditions such as crops, soils, climate, native species, and so on. Today, they have given way to projects less dependent on "local conditions", projects whose applications can be globalised and become independent of their original contexts.

On the other hand, there is a sort of European restriction on project funding in Plant Biotechnology. In countries such as Argentina and, more recently, Brazil, where agricultural production of GMOs is very strong, there are research projects with enough weight and importance to attract a considerable percentage of the LA agricultural researchers, thus leaving less room for scientific cooperation in this field.

2.2.3 Breakdown by country

This section discusses the main features of the distribution of projects for each disciplinary field among the countries of the LA region (cf. figures 9 and 10).

The first relevant fact is the increased participation of Mexico and Colombia. In the case of Mexico, the increase is particularly important in Chemistry and SHS, which exceed the national average. Colombia increased its participation in the fields of Medicine and Engineering, and also in SHS.

Brazil is the country in the LA region that has increased its participation in Agriculture most. Chile and Mexico improved in Biology while Argentina increased its collaboration in the Earth Sciences. Interestingly, Brazil has increased its production of transgenic plants in recent years (the production of transgenic crops was only approved in 2005), while countries like Argentina or Mexico, which started producing transgenic plants earlier, did not. The FP7 expressly states that it will fund research in health-related biotechnology, but not in agriculture for food production (EC 2002, 2006), whereas in FP6 this condition was not so strongly expressed. On the other hand, Engineering received significantly more funding in all the countries but Brazil.

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[14] The extremely low average cost per project recorded in FP6 in Physics compared with other fields and with FP7 values, suggests an effect generated by the low number of projects (a total of 11) with LAC participation in this field.

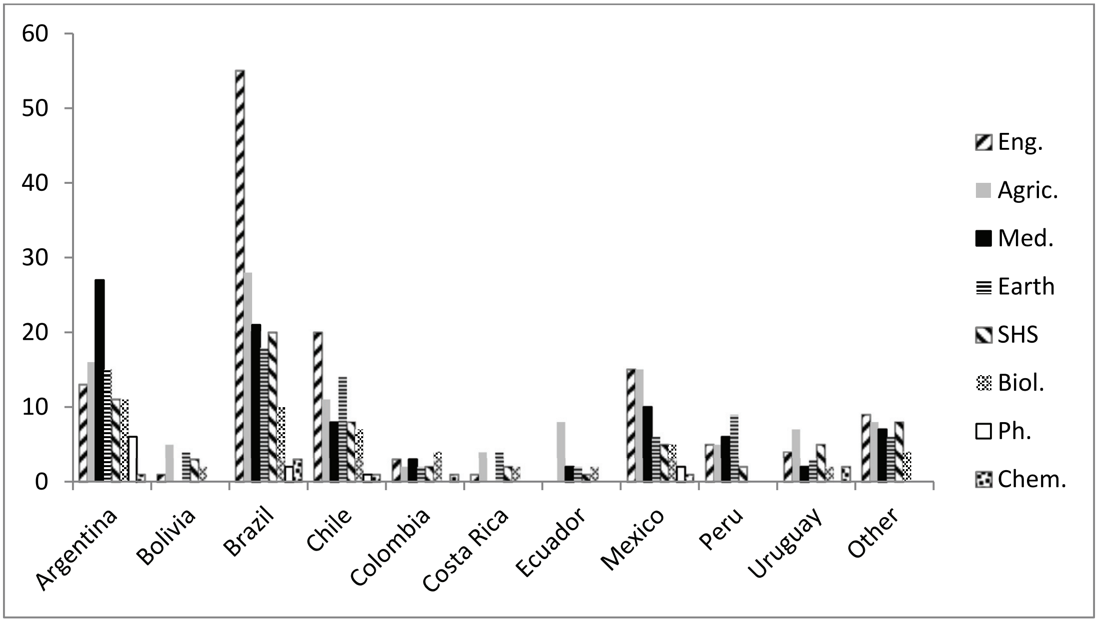
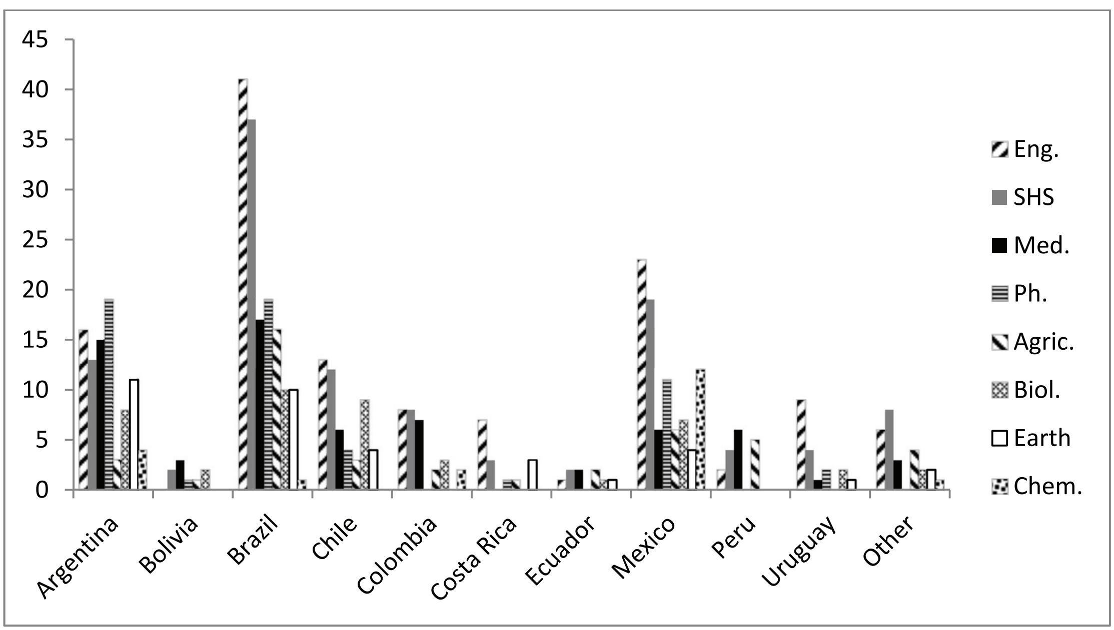


Figure 10: Number of projects by country and disciplinary field in FP7



3. Conclusions

A look at the participation, in terms of numbers of projects, of the leading Latin American countries shows that their role is especially important, far from being an ancillary phenomenon: Argentina, Brazil and Mexico together are involved in as many projects as Germany and France, the leaders (along with UK) in European research. Even more illustrative is the fact that Brazil, if measured by number of projects, would rank 6th among the 'European' countries and Argentina or México, 7th. Thus, the participation of Latin American research groups has become, from the European point of view, a very important component in efforts to strengthen the European Research Area (ERA).

We have shown that this participation is far from homogeneous throughout time, country or scientific discipline. On the one hand, the more scientifically developed countries of Latin America are the most active in collaborating with European projects: both in FP6 and in FP7 the four largest countries (Argentina, Brazil, Chile and Mexico) accounted for 75% of Latin America's participation, which correlates with these four countries' share in the total scientific production in the region, where they account for a similar percentage of the whole (see chapter 3 by Russel and Ainsworth in this book).

The disciplinary pattern shows an important increase (almost double) in SHS as a disciplinary field and, together with Engineering, accounts for almost half of Latin American participation in European projects. The basic disciplines (Chemistry, Biology, Physics) are also moving up and, together, represent almost a quarter (with a steeper increase in Physics), while the sharpest decrease is observed in Agricultural Research and Earth Sciences. This seems to contradict the "local advantage", centred on the capitalisation of the especially advantageous conditions in developing countries in terms of plant or animal species, soils, privileged observation points, etc. Furthermore, except for the social sciences, research seems to be directed more towards "universal themes" in which Latin American groups can make a contribution to the general cognitive objectives of the projects[15].

The situation described above needs more explanation and a further word on the increase in Engineering projects. Most of the related project themes are strongly oriented towards European priorities, which are increasingly geared to very specific and applied purposes that the European scientific communities and governments are defining with active input from, last but not least, the firms that might industrialise the knowledge produced from these projects. In sum, the Latin American groups would be producing knowledge for industrial application that could hardly benefit their societies.

This situation is paradoxical when considered along with the fact that Latin American institutions promote, through various mechanisms, the involvement of research groups in European projects, but do not analyse the consequences that such collaborations will have on their own societies. Thus, as we have shown, the contribution of Latin American countries to the European projects grew from 5% in FP6 to 12% in FP7 while the European contributions have remained more or less constant.

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[15] We do not have enough room to develop this hypothesis, since we would need to "enter the black box" of each project to be confirmed. Knowledge we obtained earlier, however, shows that this hypothesis is plausible (Kreimer 2010, Kreimer and Meyer 2008).

It is important to note the decrease, as we pointed out above, in both the per project unit costs and the average number of groups participating in each project (from 18 in FP6 to 11 in FP7). This means that each group in the Agriculture, Biology and Earth Sciences projects, whose average costs are the highest, (around 4.5 million euro), receives an average of around 400,000 euros. And in the Social and Human Sciences (SHS) projects, which have the lowest cost per project, each group receives around 180,000 euros. The figures are significant for a local group, but not enough to explain the strong attraction of Latin American groups to participate in these programmes *per se*.

Rather, in addition to the potential economic benefits, the continued participation of Latin American groups can be explained as part of their social and cognitive integration strategies, guided by a quest for greater visibility, better interchange opportunities and access to information and data, and, indeed, the best chance to publish in international journals. All of these highly valued achievements play a leading role in each local situation.

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Chapter 5

Determining Factors of International Collaboration in Science & Technology Results of a questionnaire survey

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Abstract

This chapter is based on the results of a questionnaire survey conducted in the frame of the EULAKS project. It primarily seeks to better understand the main determining factors for initiating, promoting and enhancing international collaboration in S&T among the individual researchers in Latin American and Caribbean (LAC) countries and the European Union countries (EU) and the extent to which the internationalisation of their activities have contributed to increasing the transfer and production of knowledge. One of the main findings stresses the growing homogenisation of the determining factors such as international scientific mobility in the two continents. This survey also reveals the win-win character of such collaborative schemes. Overall LAC and EU researchers acknowledge the numerous outcomes and benefits derived from international collaboration.

1. Method and sample

1.1 The questionnaire

A *web questionnaire survey* was sent to a large sample of scientists (14,406) composed of:

3,997 researchers who answered a preliminary questionnaire sent to scientists in EU countries and LAC countries and had published at least one publication indexed in the Web of Science in co-authorship with a scientist from the other country grouping (EU countries and LAC countries) during 2003-2007;

4,687 researchers whose e-addresses had been provided by scientists who had answered the preliminary survey;

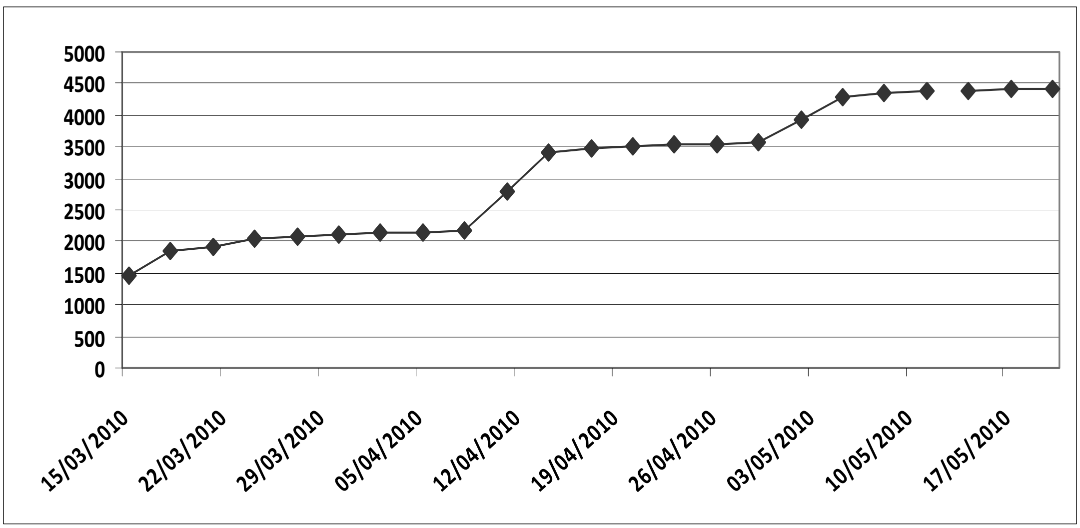
5,722 researchers from LAC and EU who applied jointly to EU calls for proposals within the Framework Programme (FP) 6 and 7.

The questionnaire was circulated between 15 March and 17 May 2010. Two reminders were sent (12 April and 3 May). Altogether more than 30% of the targeted scientists (4425) completed the questionnaire satisfactorily (see chart 1).

The open source application “Lime Survey” http://www.limesurvey.org/ was used to circulate the questionnaire. Altogether 55 countries participated: 29 in Europe (see footnote 1) and 26 in Latin America.[1]

Despite the very high response rate, the results of this survey, based on an uncontrolled sample, cannot be deemed representative of the targeted population. However, the characteristics of the group show a fair distribution among the countries and reflect their level of scientific development; not surprisingly more respondents come from the most scientifically developed countries. Likewise, the repartition of respondents in terms of e.g. research areas and gender, are more or less in line with the characteristics of the targeted populations and can be interpreted through different histories and states of scientific development in the respective countries.

Figure 1. Pace of responses



1.2. The sample

The response rate, was good, but was not evenly distributed (chart 2). The average response rate was better in the LAC countries (35.9%) than in the EU countries (22.2%)[2]. The most likely reason for these unbalanced rates is related to the fact that LAC scientists felt a greater interest in the survey since, for their own scientific careers, this specific LAC-EU

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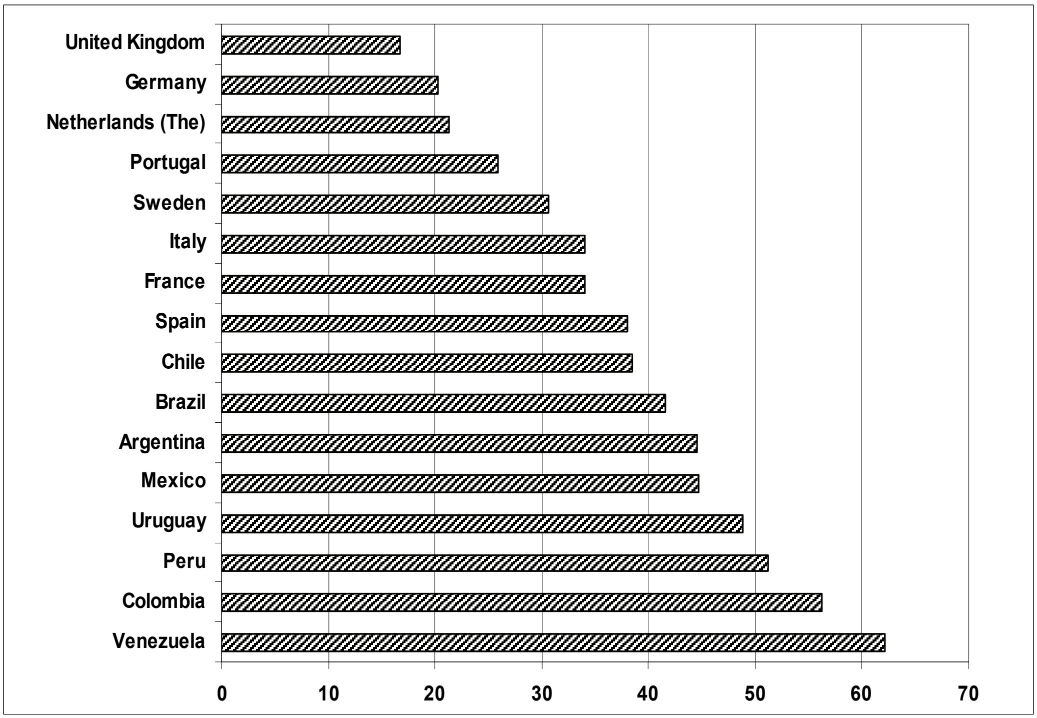
[1] The 26 Latin American countries are: Antigua & Barbuda, Argentina, Barbados, Bolivia, Brazil, Chile, Colombia, Costa Rica, Cuba, Dominican Republic, Ecuador, San Salvador, Guatemala, Guyana, Haiti, Honduras, Jamaica, Mexico, Nicaragua, Panama, Paraguay, Peru, Saint Vincent & the Grenadines, Surinam, Uruguay, Venezuela.

[2] The e-mail addresses of the invited scientists did not provide country identification in 19.72% of the cases. To calculate the answering rates, we applied the *pro rata* geographic breakdown observed for the known addresses to these generic addresses.

collaboration is needed much more by LAC scientists than by their EU colleagues. This assumption was confirmed by the results of the present survey: scientists working in LAC demonstrate higher levels of motivation and satisfaction regarding international collaboration (charts 40, 41 and 50).

Figure 2. Response rates by country (at least 50 responses per country)



2. The surveyed population

2.1. Countries where the responding scientists work

As mentioned above, the questionnaire was completed by 4425 scientists working in 55 countries (29 countries in EU and 26 LAC countries). Nearly 4/5th of the respondents (78.35%) work in the first ten main countries and include the top scientific producers and the top LAC-EU S&T collaborators of the two country groupings namely (by decreasing order of number of responses) Brazil, Mexico, Argentina, Chile and Colombia for the LAC and Spain, France, Italy, Germany and the United Kingdom for the EU (Figure 3).

Figure 3.The main countries of work of the responding scientists

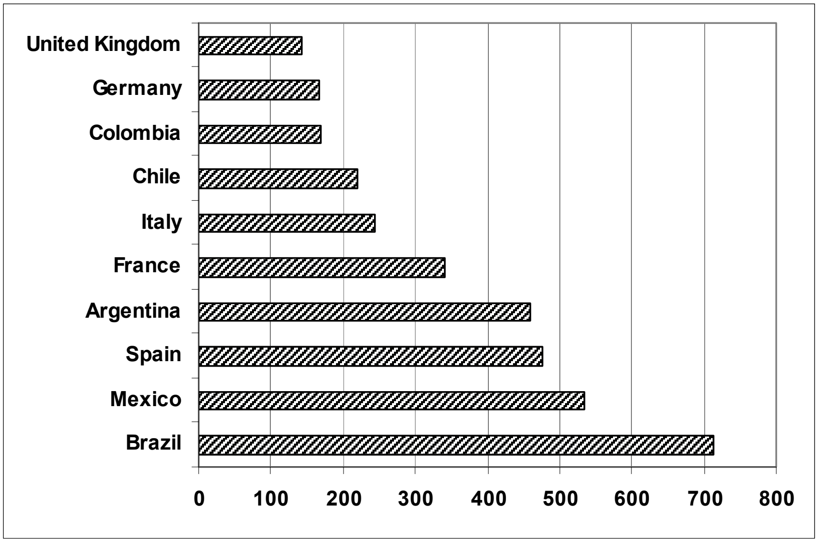


Table 1. Other countries of the responding scientists (between 10 and 100 answers)

Country	Nb	Country	Nb	Country	Nb
Venezuela	95	Ecuador	43	Switzerland	20
Uruguay	85	Austria	37	Norway	17
Netherlands (The)	68	Poland	35	Romania	17
Peru	64	Costa Rica	33	Hungary	13
Portugal	61	Greece	31	Nicaragua	13
Sweden	52	Denmark	29	Czech Republic	11
Cuba	44	Bolivia	26	Paraguay	10
Belgium	43	Finland	26	**Total**	**873**

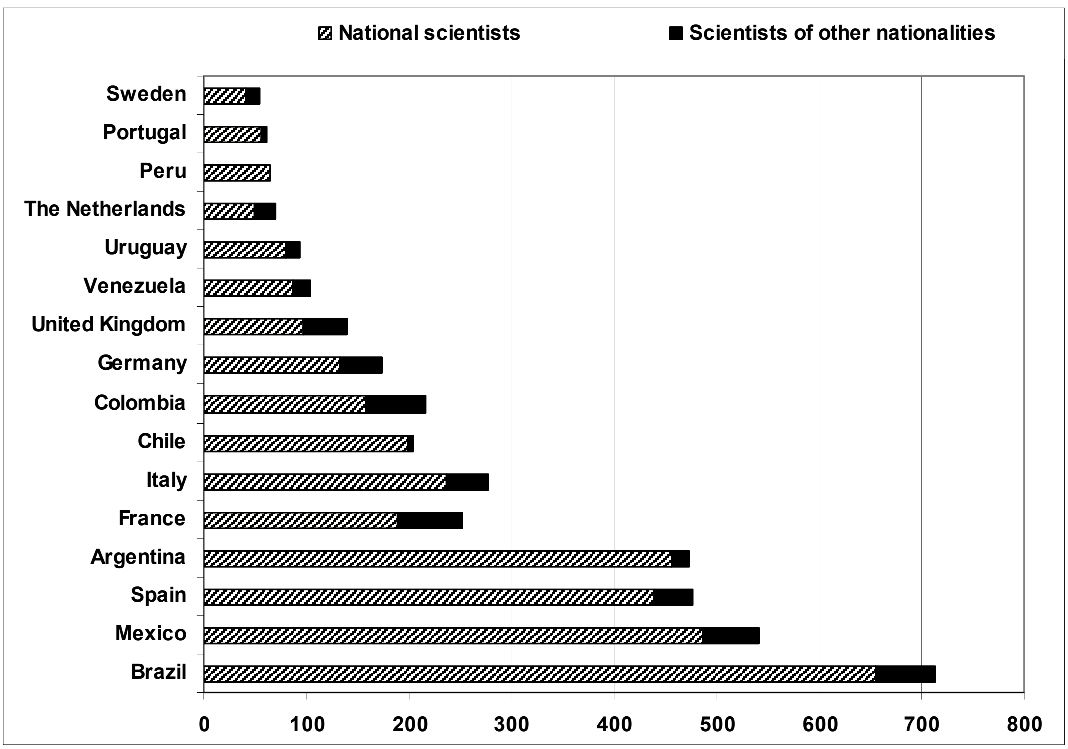
2.2. The country of nationality and the scientists' mobility

The repartition in the aforementioned countries does not completely fit in with the nationalities of the respondents: for the LAC countries 2499 out of 2550 respondents are LAC nationals, while for the EU countries the rate is 1864 out of 1875. The remaining 62 scientists who filled in the survey are nationals of countries outside LAC and EU. They work on one of the two continents and are engaged in a collaborative effort with the other continent.[3]

[3] In this chapter we use the two groups (workers and nationals) alternatively as a global reference to compute the percentages. For the countries where people are working we use the definition "Countries of institutions" and for the countries of nationality we use "Countries of nationality". When talking about individuals, we use the definitions "LAC scientist" or "EU scientist" when referring to the region where people are working and "LAC national" or "EU national" when referring to the nationality (mostly to compute mobility).

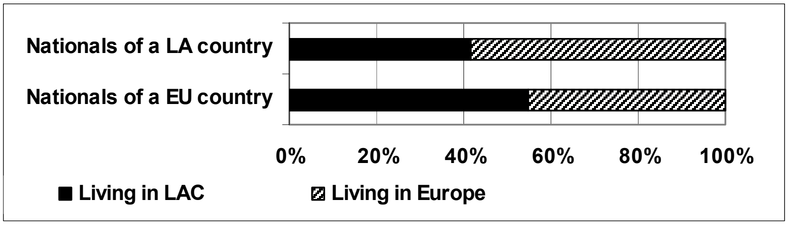
Nevertheless, and not surprisingly, most respondents are nationals of the country of the institution where they work. Although, almost 1 out of 10 (9.3%) declare being a national of another country (Figure 4). This percentage varies significantly from country to country. Whereas all scientists working in Peru are Peruvian nationals, close to one-third (30%) of the scientists working in UK state that they are nationals of another country. Overall, the percentage of scientists working in a country other than their country of nationality is smaller in LAC countries, apart from Colombia where 34% of the responding scientists working in national institutions are of foreign origin. The rate is 16% in Uruguay and Venezuela, 10% in Mexico, 8% in Brazil, close to 4% in Argentina, and just under 3% in Chile. In institutions located in EU countries the percentage of non-nationals is higher, except in Spain (8%) and Portugal (10%). In other EU countries: Italy has 16% non-national scientists, France 18%, Germany 23%, The Netherlands and Sweden 27% and, as already mentioned, United Kingdom 30%.

Figure 4. Number of respondents according to nationality and country of work



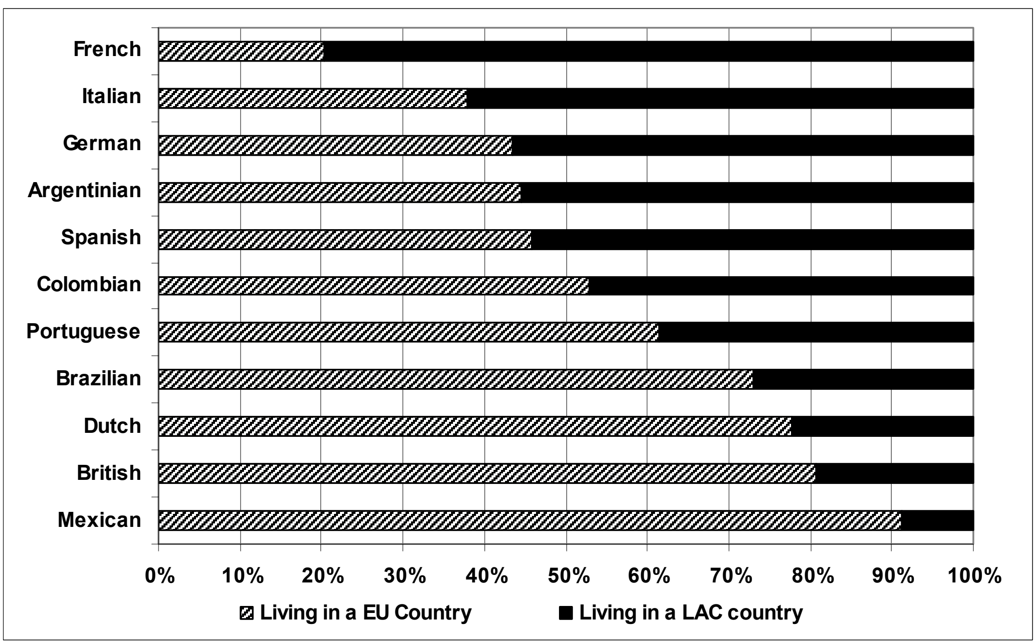
But this does not imply cross migration: all non-nationals in EU are not of LAC origin and *vice versa*. When analysing the total sample (4425 responses), scientists of EU nationality appear to be more mobile than LAC scientists and dominate the group of expatriates (EU 64%, LAC 36%). Among the EU scientists 55% place their country of residence in LAC and 45% in another EU country while the LAC scientists are proportionately more settled in EU (58%) than in another LAC country (42%) (Figure 5).

Figure 5. Repartition of the diasporas in the two continents (in %)



This general observation hides a more heterogeneous situation. More French, Italian, German and Spanish as well as Argentinean, Peruvian and Chilean scientists from the diasporas tend to live in a LAC country, while British, Dutch, Portuguese and Swedish as well as Mexican, Brazilian, Uruguayan scientists from the diasporas tend to live in Europe (Figure 6).

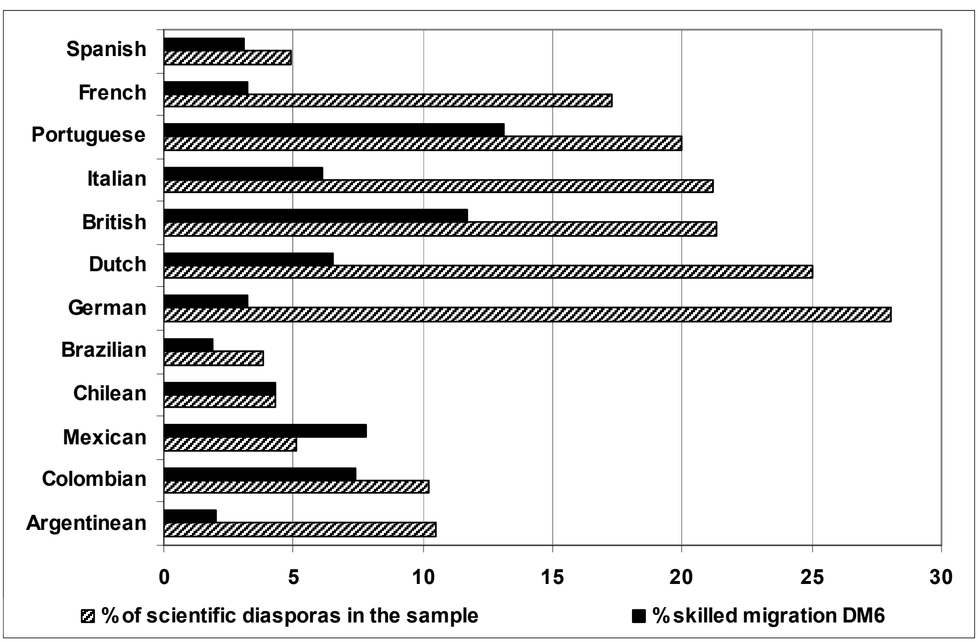
Figure 6. Regions of residence of the diasporas (in %)



The cross-border movement of researchers constitutes another factor contributing to the growing internationalisation of science and technology. Whilst the migratory flow of researchers (and indeed of highly-skilled workers more generally) is as old as science itself, there is convincing evidence that the mobility of highly qualified people increased during the last decades (Dumont, Spielvogel, Widmaier 2010). It is also likely that scientists' mobility followed the same accelerating pace, although it is difficult to measure statistically the proportion of researchers as a subgroup of the highly-skilled workers. Among non-OECD countries the impact of the international mobility of the highly skilled is diverse. The largest developing countries seem not to be significantly affected and indeed may benefit from indirect effects associated with this mobility (Docquier & Rapoport 2007) such as return migration, technology watch and transfers, easier access to collaboration, etc. At the other end of the spectrum, some of the smallest countries, especially in the Caribbean and in Africa, face significant 'emigration rates' of their elites (Docquier & Marfouk 2006). Indeed the smaller the national highly-skilled resource base, the higher the percentage of highly-skilled expatriates. As might be expected, countries that suffer long civil wars, such as Haiti, and / or military regimes, such as Argentina, Chile and Uruguay, have also suffered from the emigration of their scientists.

The comparison of the migration rate of our sample with the only available reference today on highly-skilled migration for all countries (including non-OECD countries), the DM06[4], shows that the mobility of the population in our survey is far greater than that of the population reported in statistics on highly-skilled migration (Figure 7). However, the data selected for the comparison in the DM06 do not focus on the precise same category of population. The only possible choice in DM06 is the category of migrants having completed a tertiary education curriculum (regardless of level)[5].

Figure 7. Relative importance of the scientific diasporas (in the sample) compared to the highly-skilled migration from the same countries (as evaluated in the DM06 base in 2000)



[4] DM06 is a database compiled by Docquier and Marfouk (2005) from the OECD and World Bank joint database on migration: DIOC-E http://go.worldbank.org/RFRQAN6BO1). This database takes account of non-OECD countries for the year 2000 in an attempt to measure South-South migration also.

[5] A second selection was made on the subgroup of people who left their country after having completed their education and after the age of 22.

Some assumptions can be made to explain the great mobility of the survey population:

1) The selected group observed in the DM06 is based on ISCED classification levels 5 and 6[6]. Given that level 6 represents a very small share of the whole category, calculating the percentage on the sum of the two levels automatically lowers the rate of the smallest level (level 6).

2) The very high mobility of the survey population may be inherent in the selection itself: scientists who co-published with foreign colleagues may be more mobile than their colleagues.

3) The lack of data to measure international mobility of scientists does not obviate the postulate) (Mahroum, 2000) that the population of PhD holders working in science and technology is more migratory than the average of the general tertiary educated people. Several reasons support this view:

Historically, science has no nation (Loemker 1976)[7] and scientists have been circulating between universities since the middle ages (Kibre 1948, Dedijer 1968)[8]. The elite migration is part of “normal” scientific mobility so vital to knowledge flows (Crawford *et al.* 1993).

The migration of scientists today is usually funded by several schemes and programmes (Ackers & Gill 2008).

The presence of foreign students and scientists in universities nowadays is an indicator of the degree of the institutions’ attractiveness and excellence (Baumgratz-Gangl 1995).

3. Gender and age

Overall, slightly more than one-quarter (26.4%) of the respondents are women (Table 2). Women are better represented in LAC countries (29.2%) than in EU countries (23.0%)

Table 2. Repartition of gender of respondents in EU and LAC countries

Gender	EU	LAC	Total
Males	904 (77%)	943 (70.8%)	1847 (73.7%)
Females	270 (23%)	388 (29.2%)	658 (26.3%)
Total	1174 (100%)	1331 (100%)	2505 (100%)

Ref: Countries of institutions

[6] UNESCO’s International Standard Classification of Education (ISCED) is an instrument which presents standard concepts, definitions and classifications for six education levels. Usually, only people with levels 5 (people who completed at least one tertiary education curriculum) and 6 (PhD holders and researchers) rank in the category of Highly-Skilled Personal. Scientists with a PhD and researchers belong to level 6 and are rarely separated from level 5 in international statistics. http://www.unesco.org/education/information/nfsunesco/doc/isced_1997.htm

[7] Reference is made to the famous letter from Leibniz on the subject of “making sciences flourishing”: “In this I make no distinction of nation or party ... The country which does this best will be the country dearest to me, since the whole human race will always profit from it” (Foucher de Careil, 1712, Oeuvres de Leibniz, VII, 503) cited by Loemker, 1976.

[8] Scientists in this survey give reasons for migration that do not depart from the oldest tradition: scientists move to the places where science is best.

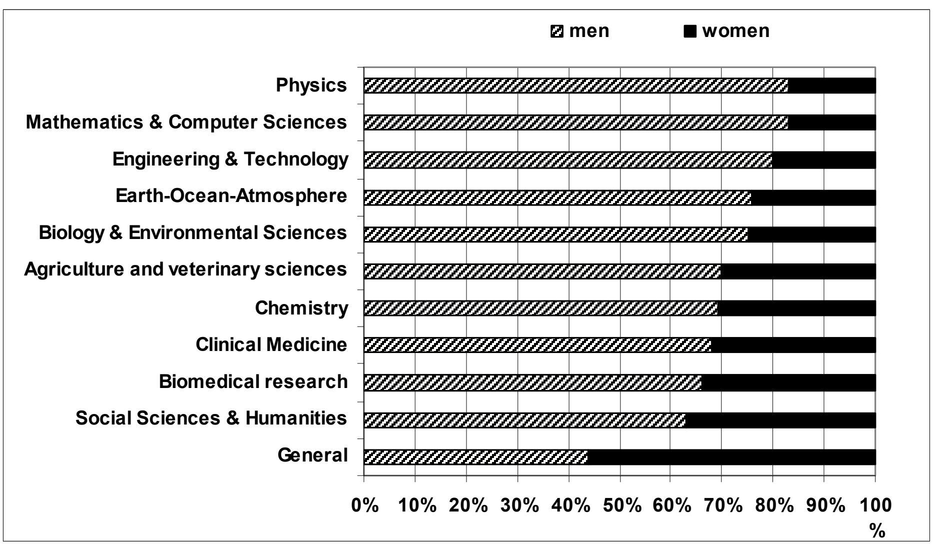
Whilst the participation of women in S&T has increased in the world during the last decades, only five countries have achieved gender parity, and they are all in Latin America: Argentina, Cuba, Brazil, Paraguay, and Venezuela[9] (UIS 2009). According to available data:

- Women represent slightly more than one-quarter of researchers (29%) worldwide (UIS 2009),
- In LAC countries 46% of the researchers are women (UIS 2009),
- In the EU (27 countries) 30% of researchers are women (OST 2008).

A recent study also indicates that female scientists are less likely to collaborate internationally than their male counterparts (NSF 2009). Thus, based on a longitudinal survey that follows recipients of research doctorates from U.S. institutions until age 76, NSF found that 30% of them collaborate internationally, (23% female and 33% of male). Assuming that this behaviour is likely to be the same in EU and in LAC countries, we can conclude that the participation of women in our survey is more or less representative of the participation of women in international S&T activities in LAC and EU countries.

The participation of women respondents, according to research discipline, also follows the overall distribution of gender in or LAC and EU countries albeit at a slightly lower level. This is also probably due to the fact that women are less likely to collaborate internationally than men (see above). Thus, the participation of women in Physics, Mathematics & Computer Sciences (17%) and Engineering & Technology (20%) is much lower than in Clinical Medicine (32%), Biomedical research (34%) and Social Sciences & Humanities (37%) (Figure 8).

Figure 8. Gender participation according to research disciplines



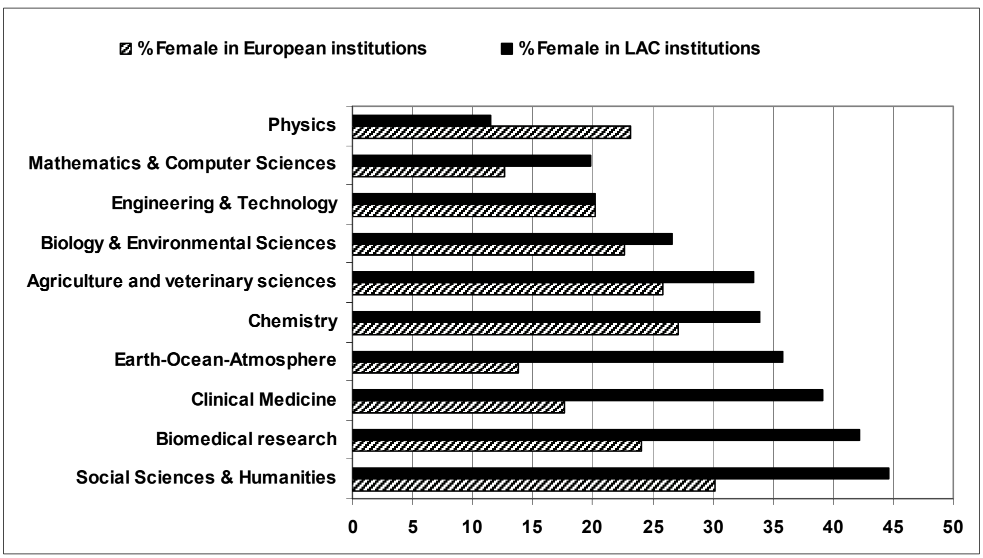
Ref: Countries of institutions

[9] In contrast, men accounted for approx. or more than 70% of researchers in Chile, Guatemala, Honduras and Mexico.

Interestingly enough, women are more likely to participate in disciplines in which, according to the NSF study (NSF 2009), they are less likely to collaborate internationally. As shown in the later study, scientists with degrees in engineering and the physical sciences are more likely to collaborate internationally than scientists with degrees in other sciences and in particular Social Sciences & Humanities.

However, the participation of women may vary substantially between Europe and Latin America, depending on the discipline (Figure 9). "Social Sciences & Humanities" is the only discipline with higher numbers of women participating in both Latin America (44.6%) and Europe (30.2%). The disciplines with the lowest participation of women in Latin America are "Physics" (11.5%) and "Mathematics & Computer Sciences" (19.8%). In Europe the participation of women is: "Physics" (23.1%), "Mathematics & Computer Sciences" (12.7%), "Earth-Ocean-Atmosphere" (13.8%) and "Clinical Medicine" (17.6%). "Engineering & Technology" is the only discipline with virtually the same female participation level in Europe (20.3%) and in Latin America (20.2%).

Figure 9. Relative participation of women according to main disciplines in EU and in LAC

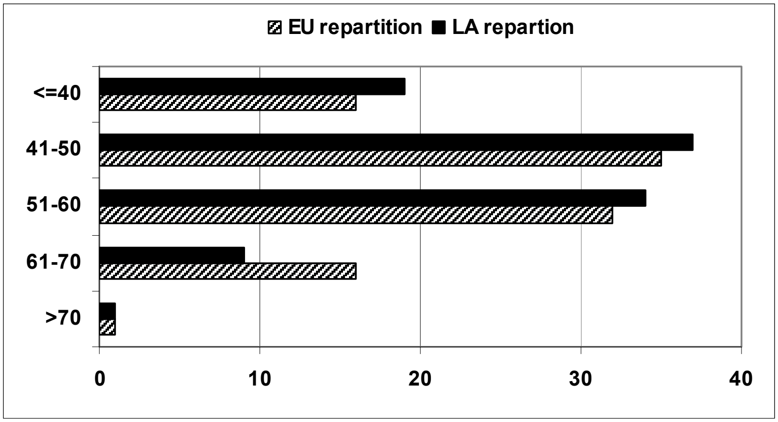


Ref: Countries of institutions

As for age, more than two-thirds of the respondents (69%) are between 40 and 60 years, the peak being in the age group of 40-49 years (36%). Only 18% of the researchers in the overall survey population are below 40 years of age, and there are no marked differences in age repartition between respondents from EU and LAC (Figure 10).

The survey population is older than the overall population of scientists in both EU and LAC (UIS, 2009). This would tend to confirm that researchers in the middle of their career (40 years and older) are more likely to collaborate internationally than those who are in early or late stages of their career.

Figure 10. Respondents' participation according to age

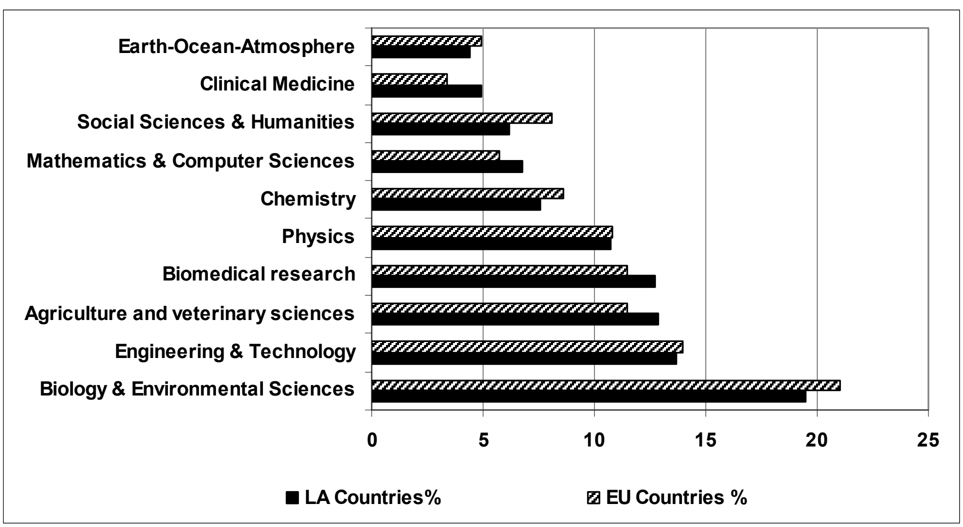


Ref: Countries of institutions

4. The scientific disciplines

The top research areas for S&T collaboration between EU and LAC countries among the respondents is "Biology & Environmental Sciences" (20.1%) followed by Engineering & Technology (13.9%), Agriculture and Veterinary Sciences (12.3%), Biomedical research (12.2%), and Physics (10.7%). In all other research areas, the respondents account for less than 10% (Figure 11).

Figure 11. Relative percentage of respondents by scientific fields in EU and LAC countries



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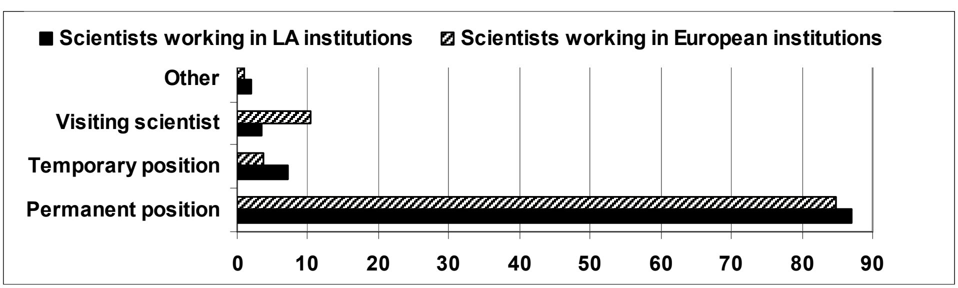
The fact that “Biology & Environmental Sciences” is the preferred area of collaboration between EU and LAC researchers is not surprising for LAC researchers, since it is the strongest scientific field for LAC countries whose scientific production, measured in number of publications, amounted to 6% of world science in 2006 (OST 2008). It is more surprising for EU for which “Biology & Environmental Sciences” is the weakest field of all, although it accounted for 35.6% of the world-share in 2006. Conversely, EU is the leading world-contributor in mathematics (42.7%), medical research (41.9%), and physics (41.1%) (OST 2008). In other words, the relative importance of the scientific disciplines in our population (*cf*. Figure 11) is more in line with the priorities of the LAC countries than with those of the EU countries[10].

Figure 11 shows that there are no marked differences between the proportion of respondents from EU and LAC countries and that the scientists in the survey participated more or less in the same proportion in all scientific fields.

5. Institutional affiliations and professional activities

The majority of the scientists who participated in the questionnaire survey have a permanent position (87% in EU and 85% in LAC) in a research or higher education institution. Relatively few are visiting scientists (4% in EU and 10% in LAC) or have a temporary position (7% in EU and 4% in LAC) (Figure 12). There are relatively more respondents with temporary positions in EU and more respondents working as visiting scientists in LAC. The category “other”, which represents an even smaller proportion (1.4%), is mainly composed of 21 PhD students, 20 retirees, and 13 Emeritus.

Figure 12. Nature of position



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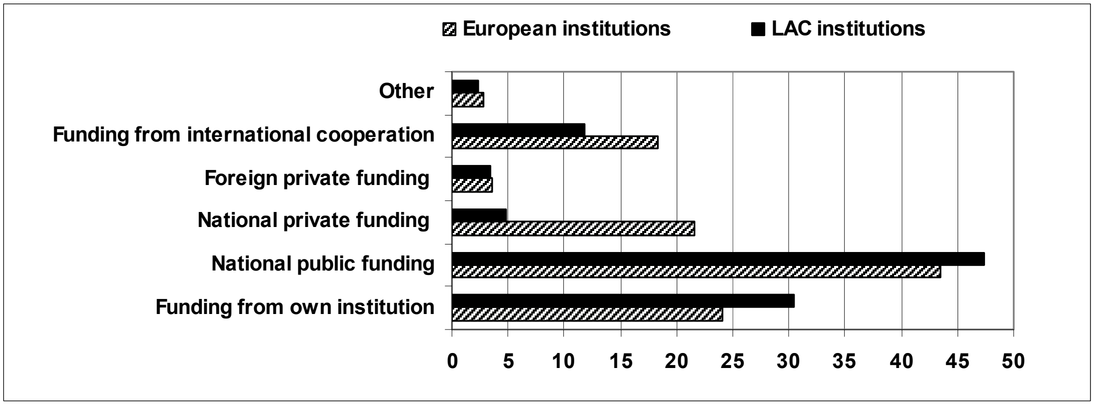
Both in LAC and EU, public or institutional funding mainly finances the research budgets. In 2009, for over one-third (36.9%) of the LAC respondents, national public funding provided 60-100% of their laboratory’s budget. The second most important funding source for both LAC laboratories (30.4%) and EU laboratories (24.1%) was “funding from their own institutions”. The main differences in funding sources for the two groups were in the two next sources, i.e. “national private funding” and “funding from international cooperation” from

[10] It should however be noted that the relative importance of scientific disciplines in our population differs slightly with the results presented in chapter 4 based on co-authorship analysis.

which EU laboratories received much more (respectively 21.6% and 18.2%) than the LAC laboratories (respectively 4.8% and 11.8% - Figure 13).

Figure 13. Relative importance of different funding sources in the laboratory's budget for 2009



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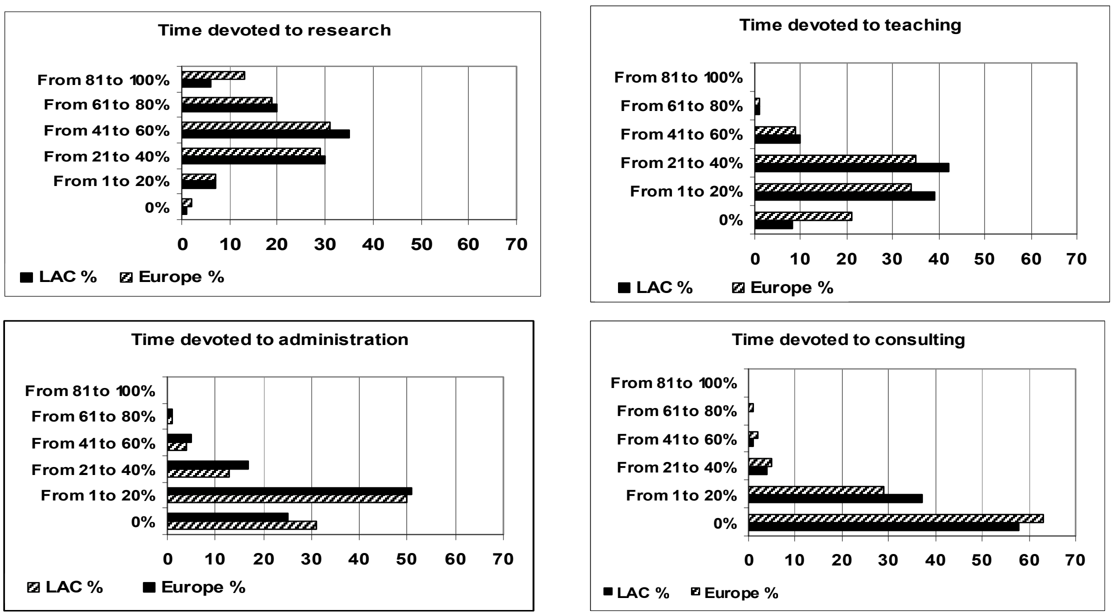
Research is the main activity of the respondents. They spend more time on research than on teaching and other activities (e.g. administration and consulting). For 60.2% of the whole group, research occupies at least 50% of the working time (for almost 77% it occupies at least 40% and for 41% of them, at least 60%).

One-third of them (35% for LAC and 31% for EU) devote between 41 and 60% of their time to research and nearly one-fifth (20% versus 19%) report spending 61-80% of their time on research. Those spending as much as 80-100% on research are relatively more numerous in EU countries (13%) than in LAC countries (6%). Very few (1.42%) state that they spend no time at all on research (Figure 14).

They spend much less time on teaching. More than 600 of the respondents (13.8%) declare that they spend no time at all on teaching. More than one-third of them (35% in EU and 42% in LAC) spend between 21-40% of their time on teaching. There are far more scientists in EU spending no time at all on teaching (21%) than in LAC countries (8%). Whereas research in LAC countries is predominantly carried out in higher education institutions, there is a significant number of researchers in EU belonging to research institutions who have no teaching obligation at all.

Time devoted to administration is even less important although 50% of the respondents declare spending 1-20% of their time on administrative duties. A large majority (59% in LAC and 63% in EU) declare having no consulting activities. The bulk of those who are engaged in consulting spend less than 20% of their time on this activity. They are relatively more numerous in LAC (37%) than in the EU (29%).

Figure 14. Percentage of time devoted to research, teaching, administration and consulting



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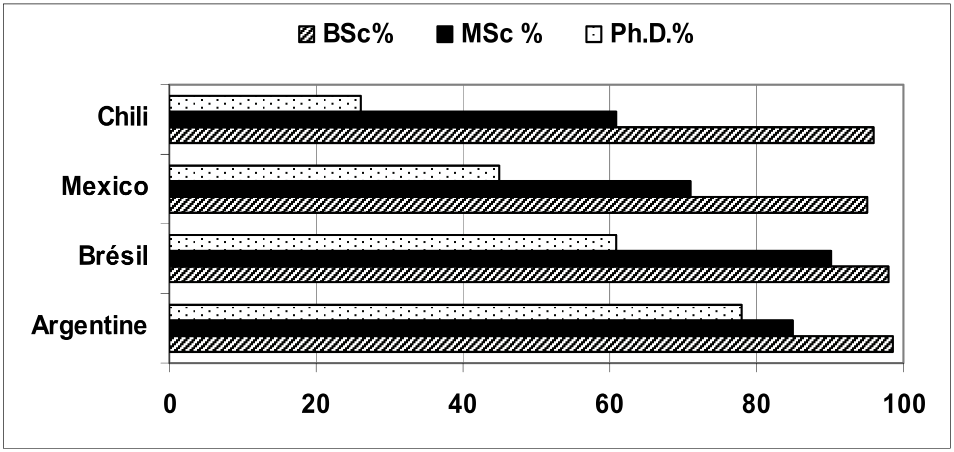
6. The history of mobility prior to international collaboration

The relative importance of studies at home compared to studies abroad for the three main degrees (BSc, MSc and PhD) in Latin America was calculated for the nationals of the four main science producer countries in Latin America (Brazil, Mexico, Argentina and Chile) which are also the LAC countries with the best developed higher education and the graduate/post-graduate systems. The results (Figure 15) show that the BSc is nearly always obtained in the country of nationality (between 95% in Mexico and 99% in Argentina) – the same holds true for the MSc although at a slightly lower level (between 61% in Chile and 90% in Brazil) – but that the four countries differ considerably for the PhD, (between 78% of national scientists who obtained their PhD in Argentina, 61% in Brazil, 45% in Mexico and only 26% in Chile).

Figure 15. Relative importance of BSc, MSc and PhD degrees obtained by scientists in their home country in Argentina, Brazil, Mexico and Chile



Ref: Countries of nationality

Overall, for these four Latin American countries, there are slightly more PhD degrees obtained at home (57%) than abroad (43%). Among the latter nearly two-thirds (64%) were obtained in a EU country, 28% in North America[11], 5% in another Latin American country (mainly Brazil, Mexico and Argentina) and 3% in another country (Japan, Russia, New Zealand, Israel and Australia). The overall relative domination of EU for PhD studies abroad could possibly be explained by the main bias of our survey population composed of LAC and EU scientists who published co-authored papers with scientists from the other region[12].

The main host countries for PhD studies in EU are, by decreasing order of importance: France, UK, Spain and Germany (Figure 16). France is first or very close to first with UK for Brazil and Mexico. Spain is the preferred country for Argentina and Chile. Germany follows but at a much lower level. These four EU countries concentrate the bulk (87.5%) of PhD studies carried out in EU. The other countries, but at a much lower level, are Austria, Belgium, Italy, The Netherlands, Norway, Portugal (for Brazil only), Sweden and Switzerland.

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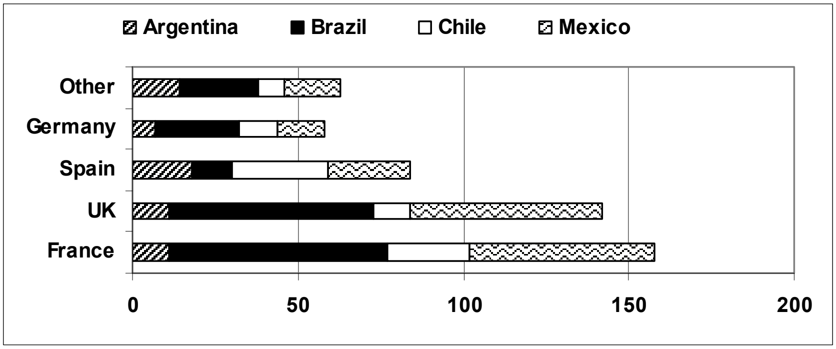
[11] Overwhelmingly in the USA (92%).

[12] Comparisons with available statistics, however, tend to indicate (at least for Mexico and Chile) that the geographical distribution of PhDs observed in the survey population is very similar to more comprehensive statistics reported for Mexico (Etienne Gérard, personal communication; Villaseñor Amésquita *et al.*, 2009), and not very far away from the results obtained in one national survey for Chile (Asenjo et Correa, 2005).

Figure 16. Main countries for PhD degree in EU for scientists from Argentina, Brazil, Mexico and Chile



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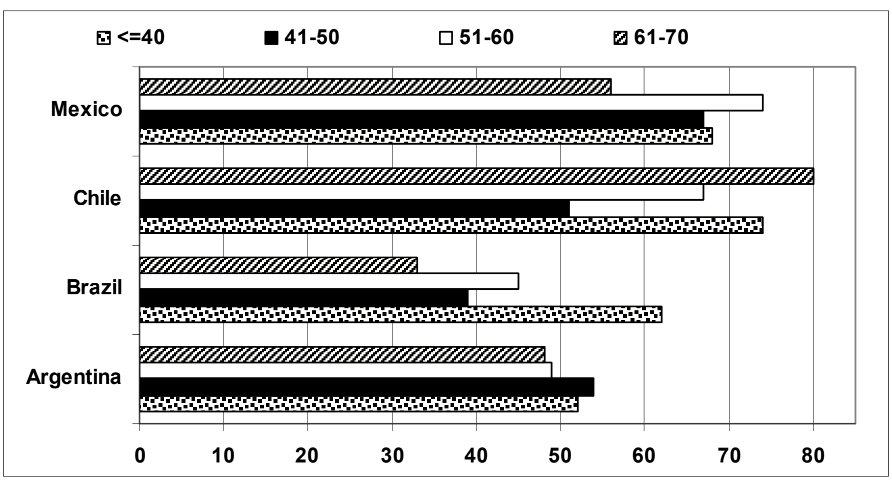
Based on the assumption that in LAC the younger generations of scientists are unlike the older generations that were more or less obliged to go abroad to study at the doctoral level because of the lack of educational facilities within the country, we tried to see if a change in behaviour could be observed in the surveyed population by breaking the results down into age categories. Surprisingly, no major differences could be noticed. Nevertheless, the following chart (Figure 17) shows that slightly more of the younger generation studied for a PhD at home, although the difference, except for Brazil, is not really significant. Consequently, in the LAC surveyed population, the decision to study abroad is not perceived today as being correlated with the level of development of the national higher education system, regardless of population age.

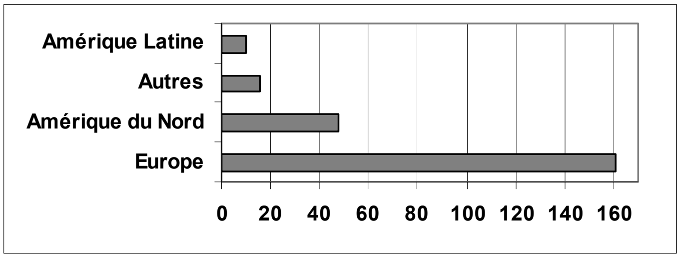
Figure 17. Relative importance (in %) of PhDs obtained at home, according to age category



Ref: Countries of nationality

A variety of situations can also be observed in the EU surveyed population where a large majority of scientists from UK (60%) and France (57%) completed their studies at home while three-fourths of the scientists in Germany (75%) and Italy (77%) went abroad. Spain occupies a position in between. About 12.53% went to another country to complete their PhD, mainly to another EU country but also to other continents (Figure 18). These results confirm that, given its age composition, the sample of EU scientist (mainly middle age scientists) is also very migratory, a trait that existed even before the development of international collaboration.

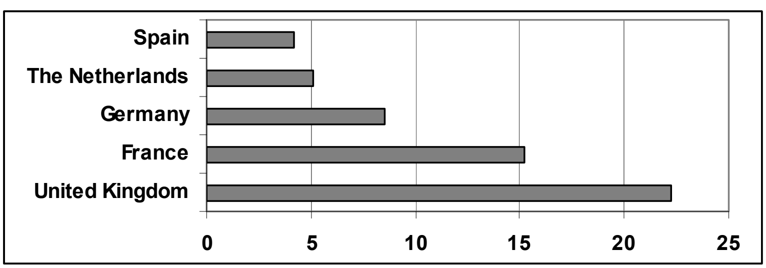
Figure 18. Receiving continents for EU PhD candidates



Ref: Countries of nationality

The receiving country for EU PhD candidates in EU in decreasing order is: UK with 22%, France 15%, and Germany 9% (Figure 19).

Figure 19. Receiving countries for EU PhD candidates (%)



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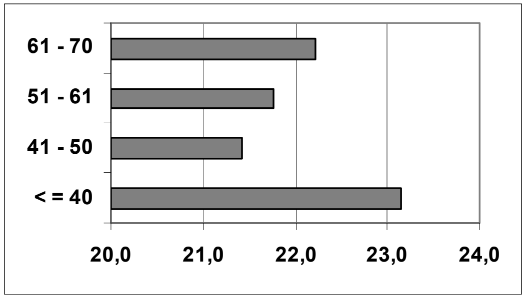
The major part of this mobility being inside EU borders, we tried to check if the EU initiatives favouring students' mobility[13] through EU could have impacted the mobility of the youngest generation of the sample, i.e. under 40 years of age.

[13] The Erasmus (European Region Action Scheme for the Mobility or University Students) programme and the Socrates programme launched respectively in 1987 and 1994.

Figure 20. Repartition by age categories of expatriation frequency for PhD (in %)



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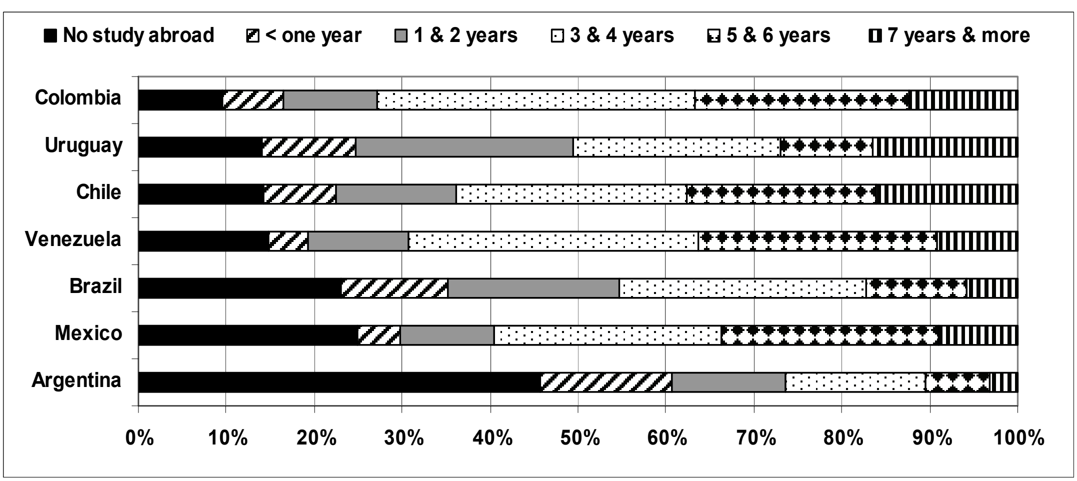
The results (Figure 20) do not reveal any major difference between generations (only one point between the youngest and the oldest generation). That is not enough to conclude that the EU programmes could have had an effect on the international mobility for PhD students in this population. This again could tend to confirm that the mobility of scientists is an intrinsic phenomenon rather than one linked to political incentives.

The time spent abroad for studies varies greatly between countries as well as between continents. In LAC, 12% of the scientists spent less than one year abroad for non-degree short-term studies and eight percent (8%) spent seven years and more abroad for studies. In between there is slight peak of around four years (11%) corresponding mainly to scientists who study abroad for their PhD. There is a large disparity between the countries: in Argentina only 26% of scientists went abroad three years and more, while a large proportion of the scientists from other countries (72% for Colombia, 60% for Mexico and 51% for Uruguay) went abroad for longer periods, between three years and over seven years (Figure 21).

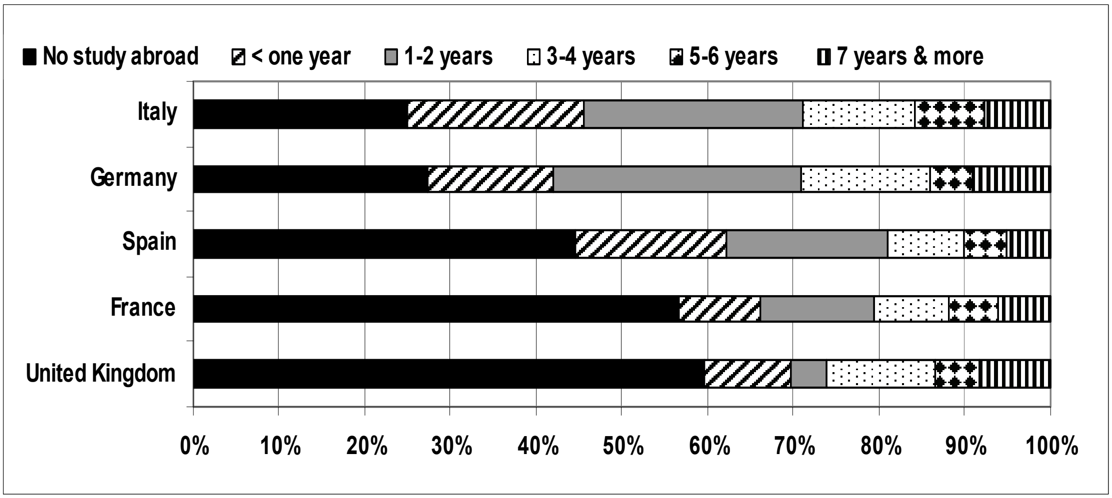
Figure 21. Relative importance of study periods abroad for some of the main Latin American countries



2144 respondents: Ref: Countries of nationality

A variety of situations can also be observed in EU, but despite student mobility, the EU sample shows less migratory movement than the LAC sample. The proportion of studies completed at home in EU countries, is much greater on average (15.1% against 6.8%) and the duration of study periods abroad is shorter (18% of LAC scientists spent 3 years and more abroad for studies as against only 8.8 % of EU scientists) (Figure 22).

Figure 22. Relative importance of study periods abroad for the main EU countrie

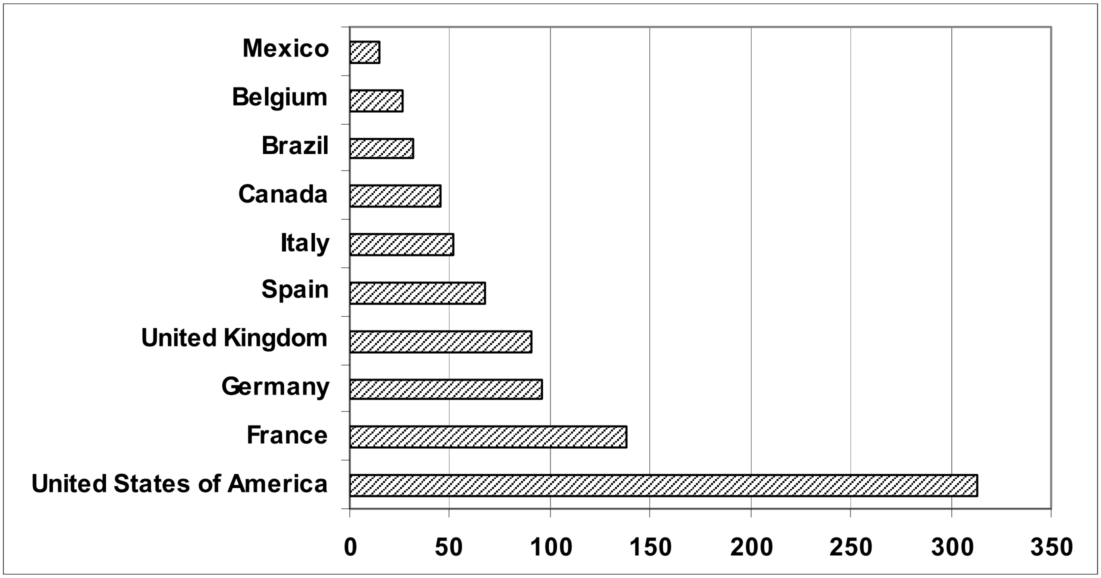


1405 respondents: Ref: Countries of nationality

This very high degree of international mobility is confirmed by the frequency of the post-doc studies carried out abroad. In the whole surveyed population, 42.2% did their post-doc abroad. There are relatively fewer women scientists (39.5%) than men (45.1%) but the difference is not as important as we may have expected. Overall, slightly more scientists based in a EU institution (45%: 46.9% male and 41.5% female) did a post-doc, compared to scientists based in a Latin American institution (40%: 43.5% male and 38.1% female). The relative frequency of post-doc studies abroad however varies from country to country: 55% of the scientists based in Spanish institutions did a post-doc, but only 27% in Italy (in between: France 52%, Germany 48% and UK 36%).

In LAC institutions, Brazilian scientists were more likely to engage in post-doc studies (53%) than scientists from other LAC countries (Argentina 48%, Mexico 33%, Chile 30%). For these four Latin American countries, Western Europe is the main destination for post-doc studies (54.3%) followed by North America (36.4%), elsewhere in Latin America (6.1%) and other countries (3.2%) (Figure 23). It is noteworthy that more than half (35 out of 60) of the post-doc studies in LAC took place in the scientist's country of work, e.g. 21 out of 28 in Brazil.

Figure 23. Top 10 host countries for post-doc studies for LAC national scientists



Ref: Countries of nationality

A comparison of earlier percentages with those observed for PhD studies shows that significantly fewer post-docs studied in EU (54.3%) than PhD students (64%) and significantly more studied in North America (36.4% compared to 28%). The number of post-docs who studied in LAC and/or other countries are more or less comparable.

For the five main science producers in the EU (Spain, France, Germany, Italy and UK), Western Europe is the main destination for post-doctoral studies, with a marked preference for another EU country (Figure 24). This confirms the importance of intra-European mobility in S&T. Overall one-third (33.2%) of the EU scientists selected North America (USA 85.4% of them) to carry out their post-doctoral studies. This percentage is comparable to the one obtained for the LAC scientists (36.4%). USA is particularly attractive for UK and France scientists. There are relatively few (6.2%) who selected a LAC country. Their preferred destinations in LAC were Mexico, Brazil, Cuba and Venezuela. When asked about motivations for study venues in LAC, 46% chose “the reputation of the host country institution likely to promote my career” and 35% “the scientific expertise developed in the host country”. 81% of them received financial assistance from the following sources: their home country, their host country, or a special fund.

Figure 24. Post-doc host regions for scientists from main EU countries (%)

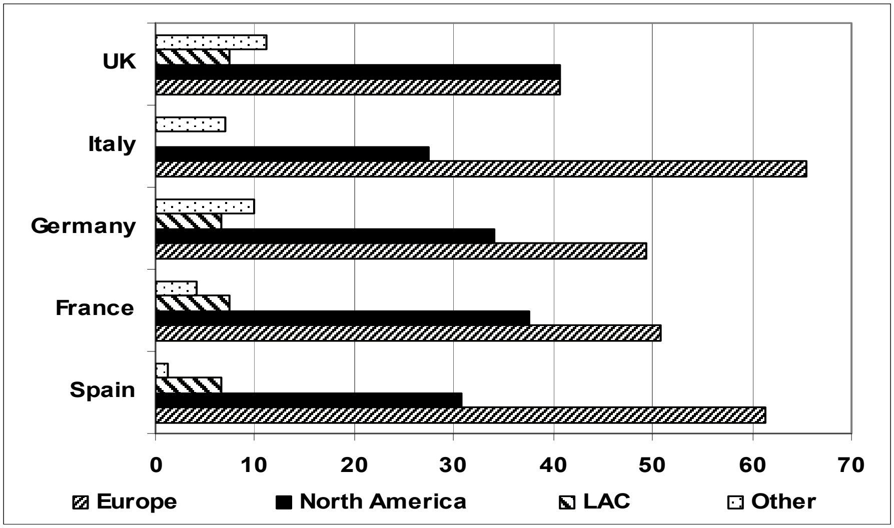


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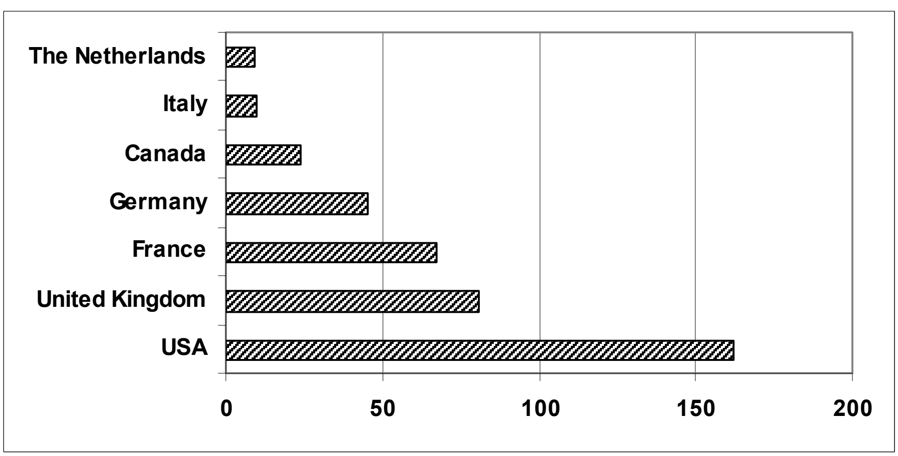
Figure 25 lists the top seven host countries for post-docs for EU national scientists from Spain, France, Germany, Italy and the UK. These seven countries host 50% of the total post-doc studies by EU nationals. USA with 20.5% is, by far, the preferred country of destination followed by UK (10.3%), France (8.5%), Germany, Canada, Italy and The Netherlands.

Figure 25. Top 7 Post-doc host countries for scientists from main EU countries



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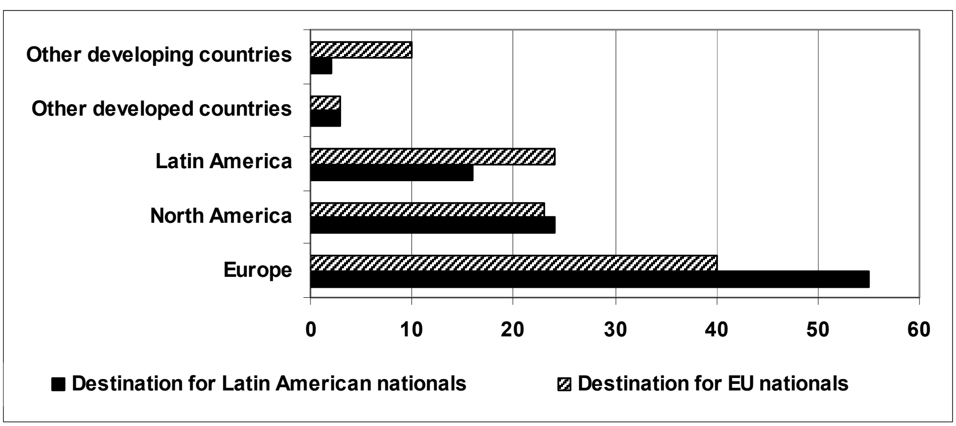
To trace the further international mobility of the respondents, the following question was asked: "Have you made other stays abroad exceeding 6 months". A third of the whole surveyed population answered "yes" (32% of the LAC nationals and 37% of the EU nationals). The results show that the nature of these stays is overwhelmingly for professional reasons (only 5% of the respondents stayed for non-professional reasons).

In the four big scientific LAC countries, Mexican scientists showed the strongest propensity to expatriate during their career. Almost 40% of them made one or more stays abroad, followed by Brazilians (32%), Chileans (31%), and Argentineans (27%). This trend is even more common in the main scientific EU countries where 44% of the French surveyed population "emigrated" during their career path, followed by Germans (38%), British (32%), Italians (31%) and Spaniards (30%).

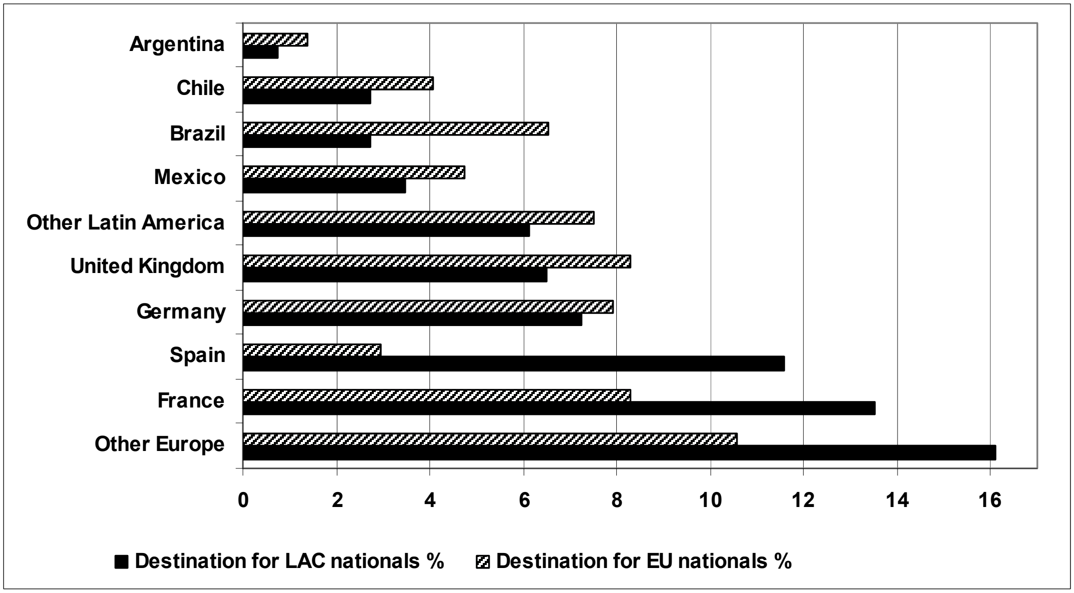
A look at the total number of expatriations, 1323 LAC scientists and 1011 Europeans, in Figure 26 shows that EU is, for both groups, the preferred destination for extended stays abroad (55% for LAC scientists and 40% for EU), followed by North America, with almost the same proportion in the two groups (LAC 20.71%, EU 20.27%). The situation is different for extended periods of stay in LAC (16% for LAC scientists and 24% for EU) and even moreso in the developing countries where it appears that the quota of EU scientists prone to travel to these countries is much higher (10% of EU and only 3% of LAC scientists). Of course this situation can be traced to one of the biases of the sample, which was constructed on the bases of scientific collaboration between LAC and EU. But the fact that the EU scientists are staying for long periods of time in Latin America, as well as in Africa (7% of the whole EU group) indicates the interest of EU scientists who answered the survey to collaborate with scientists from countries less scientifically developed than their own.

Figure 26. Regions of destination for long stays abroad (in %)



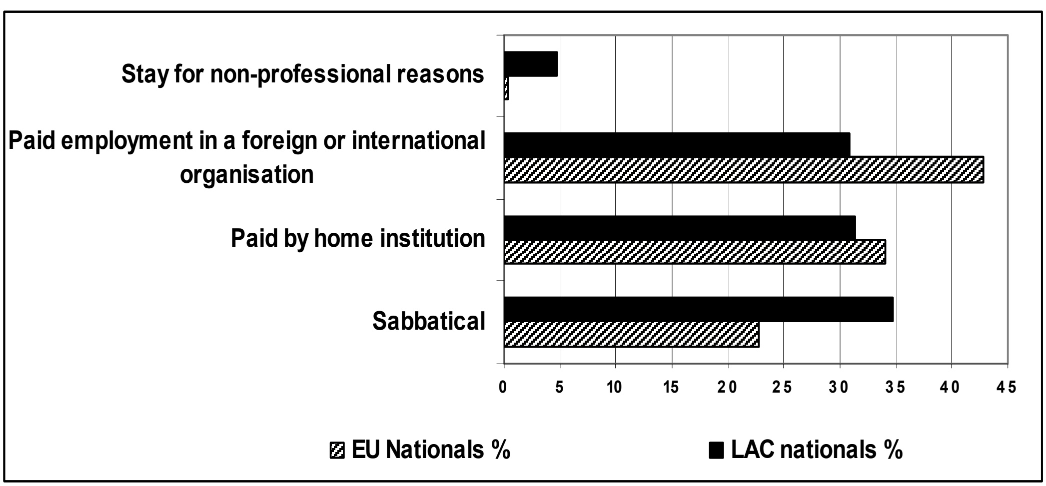
In Europe, France is the preferred country of destination for the two groups of expatriate scientists (LAC 13.4%, EU 8.3%). UK presents the same level of attraction for EU scientists (8.3%), followed by Spain for LAC scientists (11.6%). In LAC, Brazil is the most attractive country for EU scientist (6.5%), followed by Mexico (4.75%) and Chile (4.6%) (Figure 27).

Figure 27. Preferred countries of destination for stays abroad exceeding 6 months, in %



The nature of these stays is largely for professional reasons. The major differences between the two groups can be seen in "Sabbatical", an opportunity used by 35% of the LAC sub-group to migrate (23% for the EU sub-group) and "Paid employment by foreign or international institution" which benefits 43% of EU sub-group against 31% of the Latin American group (Figure 28).

Figure 28. Nature of stays abroad exceeding 6 months (in %)



1479 respondents

Almost 20% of this population claims “other reasons” for extended stays abroad (12% of the EU nationals and 26% of the Latin Americans). Surprisingly, the main reasons mentioned are still of a very scientific and professional nature: “visiting scientist, visiting professor or visiting fellow”, “scientific training”, “scientific exchange”. When these reasons are listed under “Other reasons”, they probably take place within the framework of academic exchanges with bilateral funding. Inter-institutional agreements generally stipulate a breakdown of the costs according to the following: travel and local salaries are often paid by the sending institution while additional wages and accommodation allowances are provided by the institution of destination. “Fellowships” are also mentioned quite often (47 times for LAC nationals and 16 times for EU) since the scientist may not consider them as salaries. International cooperation is mentioned 15 times (10 times by EU scientists and 5 times by Latin Americans).

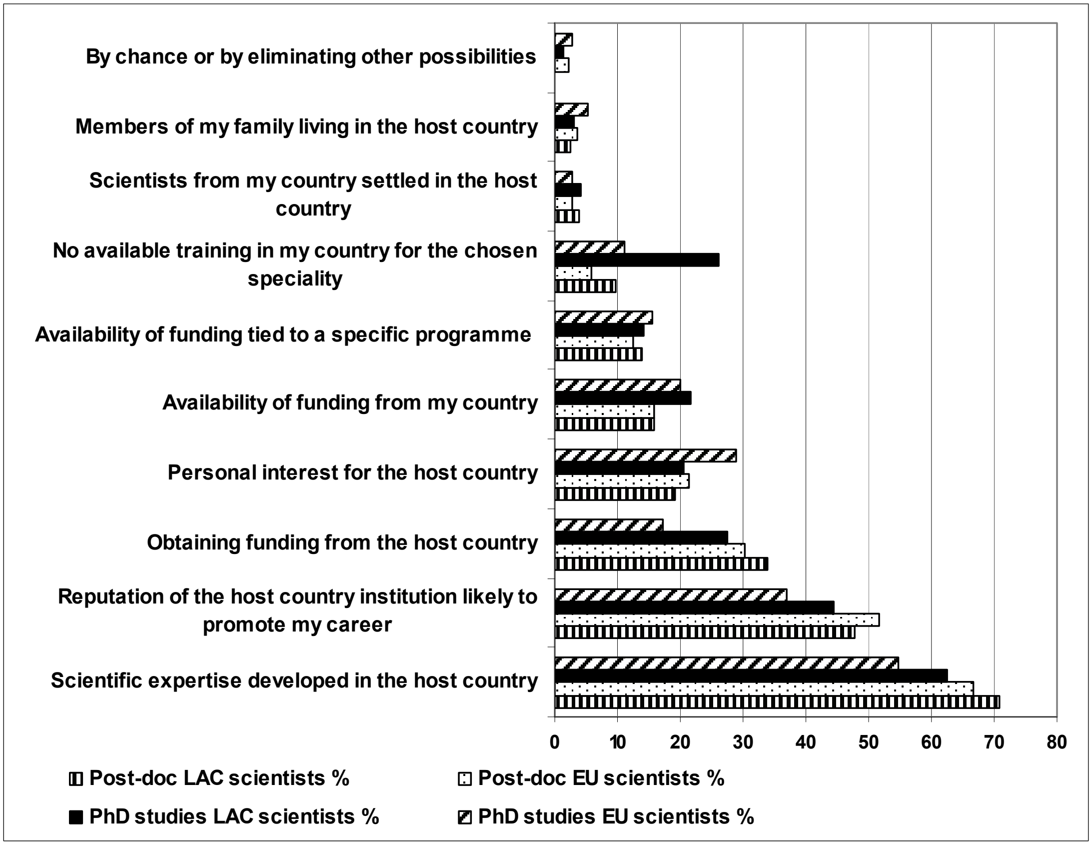
7. Main reasons for international scientific mobility

The questionnaire on international scientific mobility proposes several – scientific, personal, other – reasons for going abroad to study and for staying abroad for post-doc studies. –The respondents were free to select as many reasons as they wanted. Remember that a large majority (68.8%) of the scientists from both continents left their countries to study abroad mainly at the PhD level (76.8% LAC and 58.5% EU) and close to half of them (41.9%) went abroad for a post-doc (40% LAC and 44.4% EU).

The responses quite clearly showed that this migration was strongly connected to a scientific goal (Figure 29). The dynamics of the mobility were not based on what the scientists wanted to escape from but on what they hoped to gain by moving, e.g. a minority of the respondents (apart the category of LAC scientists who went abroad for studies) gave “no available training in my country for the chosen speciality” as the reason for going abroad. Although the older generations of scientists in almost all LAC seemed more or less forced to go abroad to study at the doctoral and postdoctoral levels because of lack of available training in their home country, they did not express it that way in general not even at the post-doc level; only 9.7% of the LAC scientists selected this reason as motivation for their expatriation.

The main motivations for the two groups were related to the scientific gains they expected from their stay abroad; this was more strongly felt by the group working in LAC. As observed in other case studies, (Millard 2005, Zucker and Darby 2006) the search for excellence was the main determinant in mobility. “The scientific expertise developed in the host country” received the highest votes with 70.9 % of positive answers from LAC scientists at the post-doc level and 62.6% at the PhD level, and 66.8% from EU at post-doc level and 54.6% at PhD level. In the same vein, “the reputation of the host country institutions likely to promote my career” was underscored by almost half of the population (respectively 47.7 % and 51.6 % at the post-doc level and 44.4% and 36.9% at the PhD level). The least important reasons by far were linked to the fact that the scientist had relatives and acquaintances abroad: “members of my family living in the host country” or “scientists from my country settled in the host country” was mentioned on average 3.6% for LAC and 1.6 % for EU. The latter result tends to indicate, despite the fact that a tangible number of scientists are working in a country other than their country of nationality, that the family and S&T diasporas play a very marginal role in the choice of going abroad and selecting an institution for PhD and post-doc studies.

Figure 29. Reasons why scientists went abroad for PhD and post-doc studies (in %)



Countries of institution

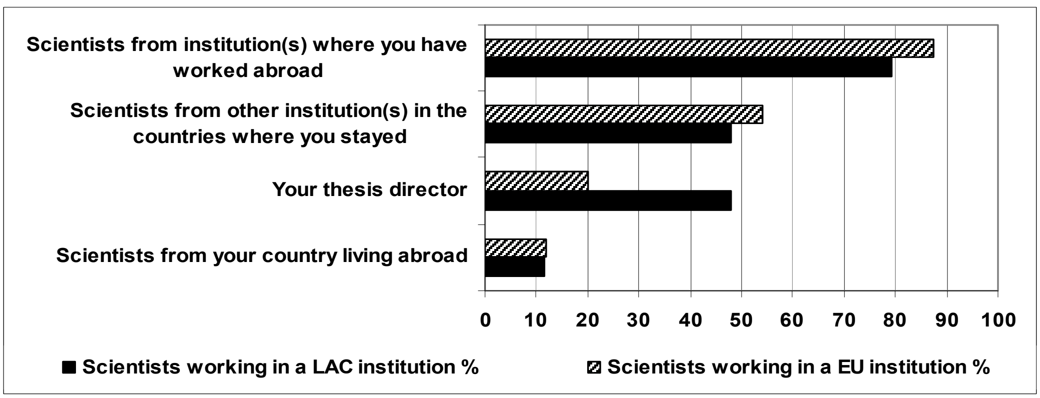
In between, there are a number of additional reasons considered as important such as "personal interest for the host country" with 28.8%, for EU at PhD level. It is noteworthy that most of the EU scientists could choose "Excellence" as the reason for their studies without needing to travel abroad if they so wished. "Funding obtained from the host country" is also an important reason for moving abroad. An average of 27% of the surveyed population selected this reason for expatriation, but there was a major difference between continents and between levels of study: 17% of the EU at PhD level and 34% of Latin Americans at the post-doc level. "Availability of funding from my country" received an average of 18.3%. This motivation seems to be more important at the PhD level (around 20% for both groups) than at the post-doc level (around 16% for both groups). If the three questions related to the availability of funding ("from home country", "from destination country" or "tied to a specific programme") are combined, an average of 63.5% of the LAC scientists and 55.5% of the EU scientists link their time abroad to the accessibility of funding. For the EU scientists, the percentage is even higher; 81% for scientists who made extended stays (studies and other reasons) in LAC. This aspect gives another perspective to the factors determining international mobility.

8. International collaborations: nature, frequency and permanency

Altogether, 3814 scientists (86.2%) of the surveyed population (88.8% of LAC scientists and 82.8% of EU) spent long periods of time, i.e. over 6 months, abroad for study or post-doc. To what extent did these stays abroad contribute to the promotion of international collaboration? With whom and in what institutional context did these collaborations take place? How permanent are they?

First of all, more than nine out of ten (90.3% for LAC scientists and 92.3% for EU) have published scientific papers with colleagues met during long stays abroad. Undoubtedly, this first result confirms that going abroad for studies and post-doc research or extended stays significantly contribute to the publication of scientific papers in co-authorship with foreign scientists met during these stays abroad (Figure 30).

Figure 30. With what colleagues known or met abroad did you publish in co-authorship (%)?

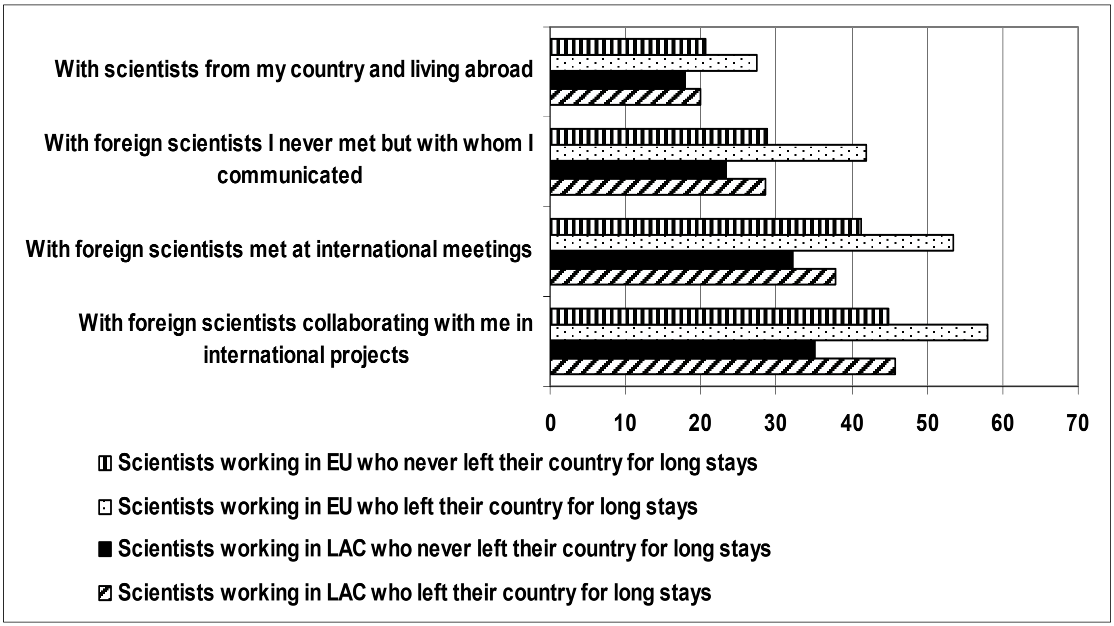


The percentage of the surveyed scientists who have not gone abroad for extended periods of time is, on average, only 14% (11.4 % in LAC national groups and 17.3 % in EU), but obviously, these scientists also collaborate and co-publish with foreign colleagues (Figure 31).

Who are the foreign colleagues with whom these scientists collaborate or co-publish? Figure 30 shows that they are, to a very large extent, colleagues from institutions in which the scientists have worked abroad (79.4% of scientists working in LAC institutions and 87.3% of their colleagues working in EU institutions), followed by colleagues from other institutions in the countries where the scientists stayed (48% LAC and 54% EU). It is surprising that 48% of the scientists working in LAC institutions have co-published with their thesis director while the figure for Europe is only 20%. Collaboration with the members of the scientific diasporas is the last choice of the respondents: around 12% for both groups.

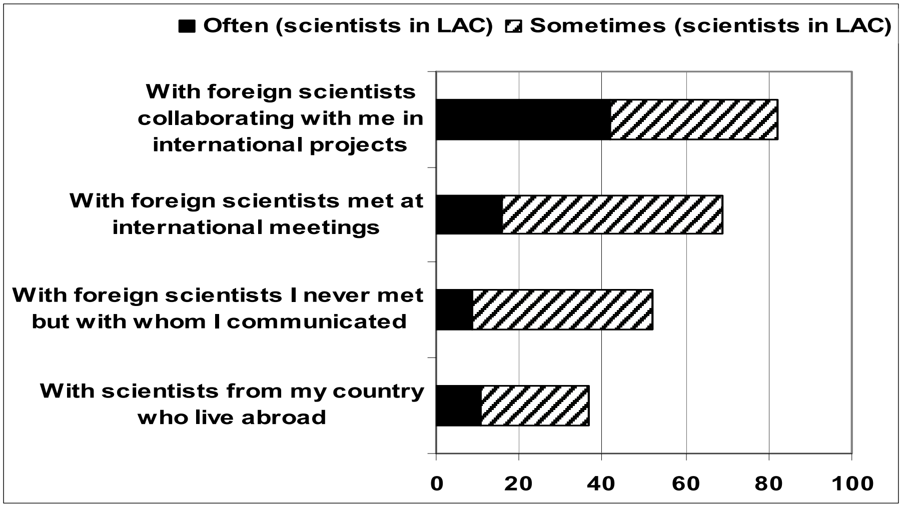
The surveyed scientists were also asked whether they collaborated or co-published with scientists abroad who they had not met during their extended stays abroad. The majority of them (54% for LAC and 63% for EU) did in fact collaborate or co-publish sometimes or often with scientists abroad who they had not met during their extended stays abroad. These foreign colleagues (or colleagues living abroad) are by decreasing order of importance: "foreign scientists collaborating with them in international projects" (49.2% of the whole sample: 55.6% of scientists working in EU and 44.5% of those working in LAC), followed by "foreign scientists occasionally met at international meetings" (43% of the whole sample: 50.9% EU and 37.3% LAC), then by "foreign scientists they never met but with whom they communicated (e.g. through internet)" (27.4 % of the whole sample: 26.5% in EU and 28.1% in LAC), and in some cases, "scientists from their country living abroad" (22.7% of the whole sample: 26.5% in EU and 20% in LAC) (Figure 32).

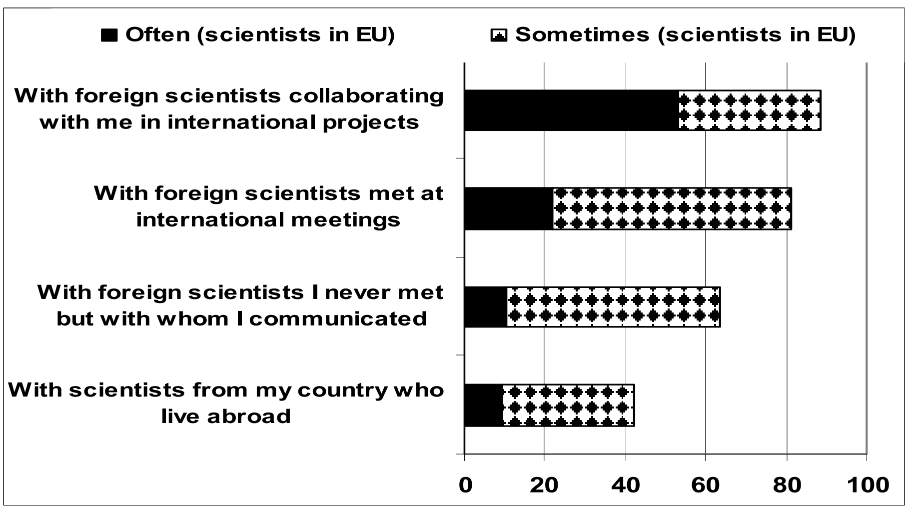
Figure 31. Collaborations with colleagues not known during extended stays abroad, in %



In order to find out how international mobility can impact collaboration with colleagues not encountered before collaborating, we broke the sample into two groups: the internationally migratory scientists (those who had emigrated for more than 6 months to another country, regardless of reason) and the sedentary scientists who did not leave their country for extended stays (13.7% of the whole sample, 11.2 in LAC and 17.2% in EU). The results show, sometimes with a fair margin, that international mobility stimulates international collaboration with people not known prior to collaboration (Figure 31). In the two continents and for all types of collaboration, the "extended stays abroad" scientists collaborated more with colleagues not known or occasionally met shortly prior to collaboration.

Figure 32. Frequency of collaboration with scientists not known during extended visits abroad (in % of selected group)





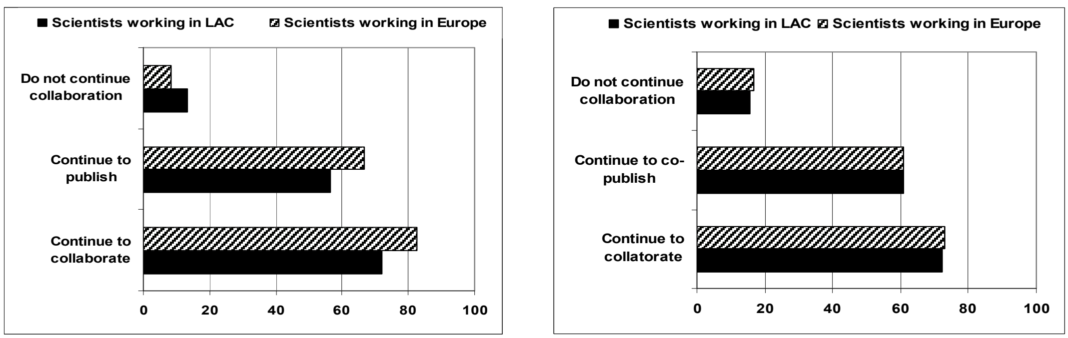
The collaboration observed in the two groups (Figure 32) shows, once again, that the difference between the scientists working in LAC and those working in EU is not significant since 44% of the scientists working in LAC and 55% of those working in Europe collaborate either often or sometimes "With foreign scientists in international projects". Since international projects aim at creating international links of cooperation, it is not surprising that in both groups collaboration with colleagues not known prior to collaboration was given top priority in these schemes. Conversely, again in relation to the total surveyed population, only one-fifth of the scientists working in LAC and slightly more than one-fourth of those working in EU collaborated either often or sometimes with members of their national scientific diasporas.

These collaborations are mainly longstanding (Figure 33). Only a small number of scientists on both continents ended collaboration after it had begun: 15.7% of the scientists working in a LAC and 16.2% of those working in Europe put an end to their collaboration with people they knew from their extended stays abroad, and 13.4% in LAC and 8.2% in EU terminated their collaboration with people they had not met during their extended stays abroad.

Figure 33. Persistence of collaboration (%)

Collaboration with colleagues known during long stays abroad

Collaboration with colleagues not known during long stays abroad

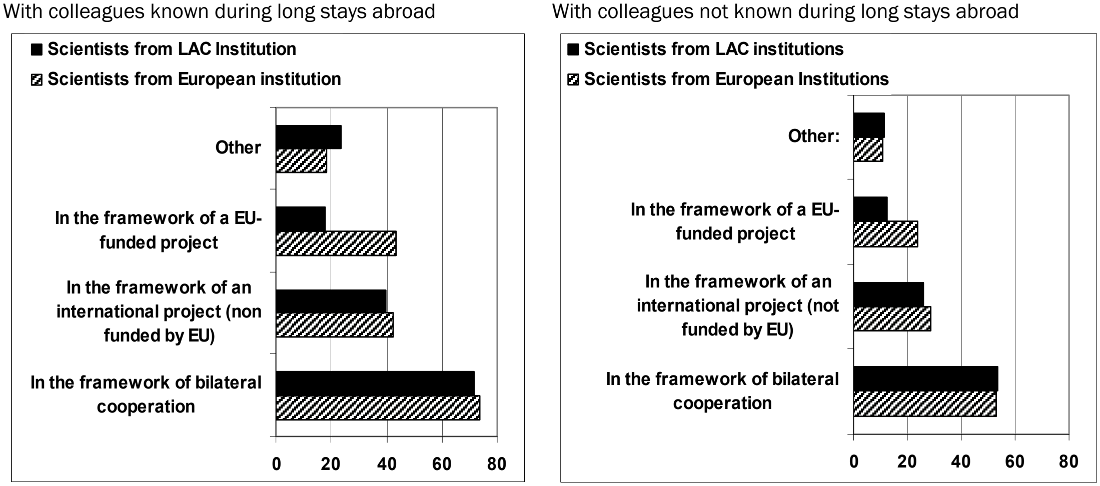


The major part of these collaborations takes place, as shown in Figure 34, as part of bilateral cooperation and even more so for collaborations with colleagues not known during long stays abroad. Many countries have developed such bilateral cooperation schemes over the last two decades, and numerous universities, both in EU and LAC promote these collaboration opportunities.

Figure 34. Institutional framework for collaboration (%)

With colleagues known during long stays abroad

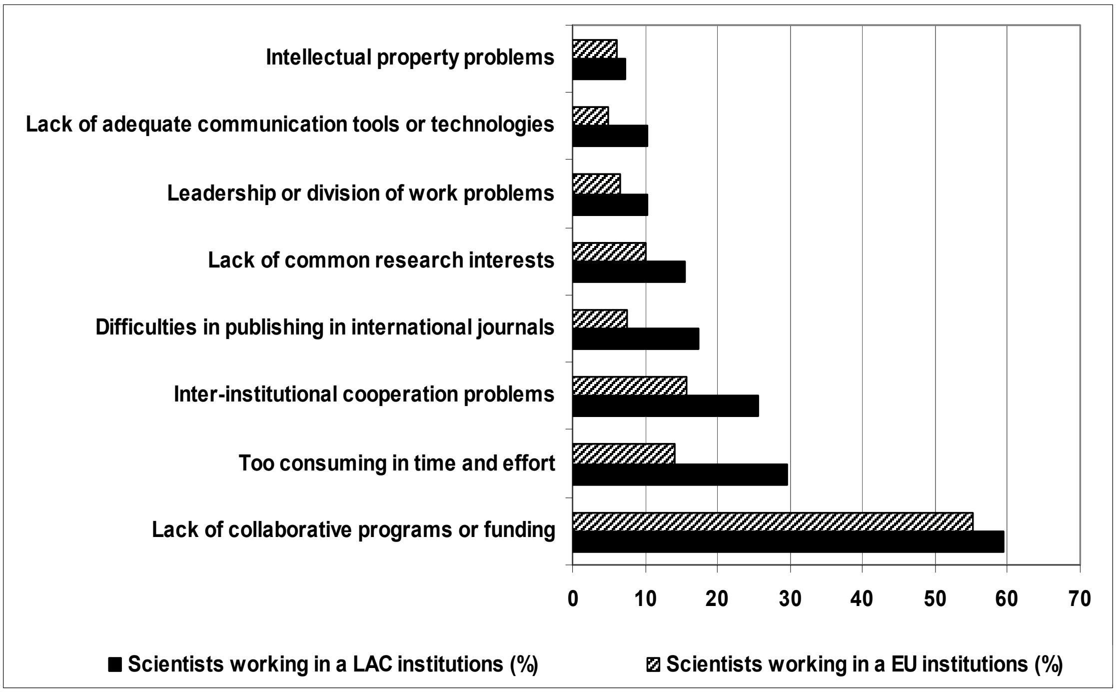
With colleagues not known during long stays abroad



The second most important institutional framework is an international project (not funded by EU) with the same relative importance in Europe and Latin America. EU-funded projects are in third position, but benefit scientists working in EU far more than scientists working in LAC.

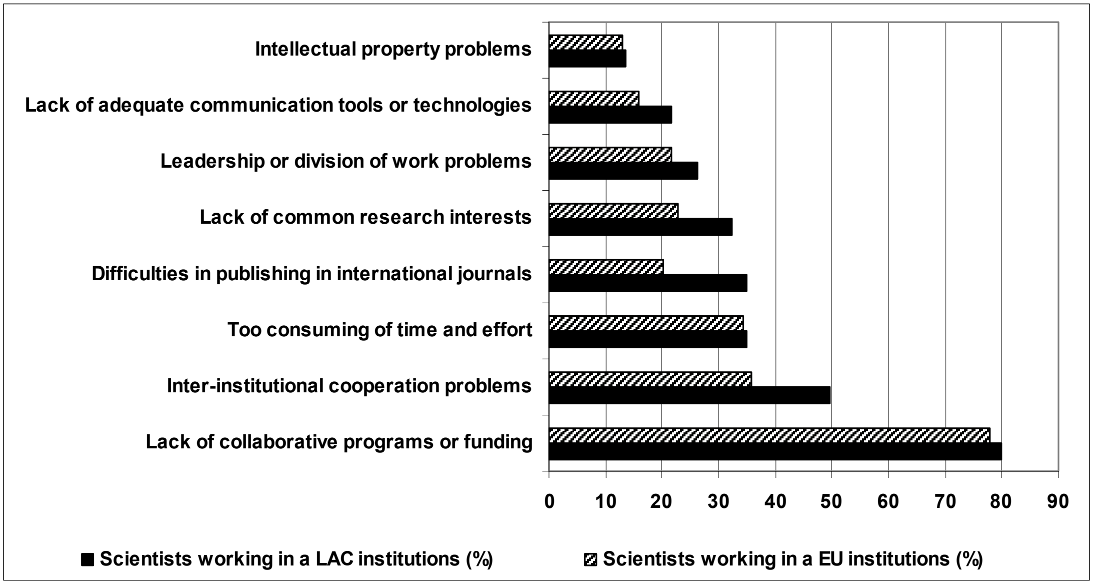
A series of perceived difficulties were proposed in an attempt to measure the main constraints to collaborating or co-publishing with foreign scientists. They were rated from 1 = insignificant to 5 = major. Here again, the responses do not differ greatly between the scientists working in EU and in LAC (Figure 35).

Figure 35. The main difficulties in collaborating or co-publishing with foreign scientists (in % based only on responses "important")



Actually, most of the proposed potential difficulties were not perceived as such by the respondents except for "lack of collaborative programmes or funding" that was considered as a main difficulty on both continents. Analysing the results obtained when adding the response "moderately important" to the ones computed in Figure 35 (i.e. "important" and "major") gives a different figure and the "inter-institutional cooperation problems" becomes a difficulty for half of the scientists working in LAC countries (compared to 36.8% for scientists working in Europe). "Too time- and effort-consuming" is evenly perceived as a problem for a large third of each group (35% in LAC and 34% in EU) while "difficulties in publishing in international journals" and "lack of common research interest" are considered more as problems by scientists working in LAC countries (respectively 34.7% and 32.4% in LAC versus 22.9% and 20.2% in Europe).

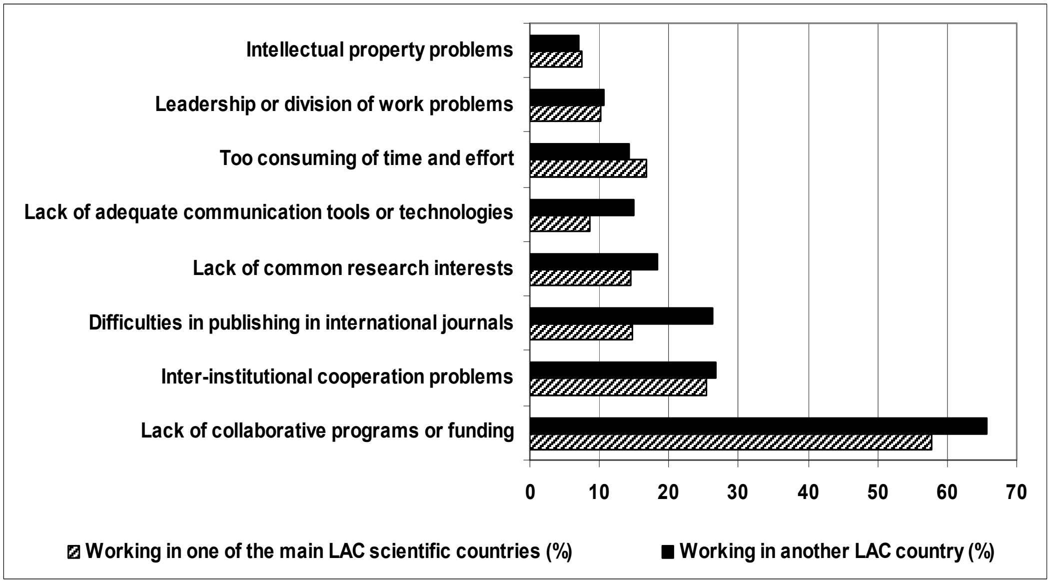
Figure 36. The main difficulties in collaborating or co-publishing with foreign scientists (in % based on responses "moderately important", "important" and "major")



To refine these results, we sub-divided the surveyed population and only selected the main scientific countries on both continents (4 in LAC and 5 in EU[14]). But amazingly, the results were not very different, apart for the proposed reason "too time and effort-consuming" that remained exactly at the same level for scientists working in Europe but decreased significantly for those working in LAC (from 30% to 17%). The four main scientific LAC countries and the remaining countries of the continent were then further sub-divided in order to test the homogeneity versus heterogeneity of the results over the whole Latin American and Caribbean region. The results (Figure 37) show three significant differences: the scientists working in the less developed scientific LAC countries expressed more "difficulties in publishing in international journals", than their colleagues working in more developed scientific LAC countries (26.2% versus 14.7%), the "lack of collaborative programmes or funding" also affected them to a larger extent (65.6% versus 57.7%) as well as the "lack of adequate communication tools or technologies" (15% versus 8.7%).

[14] Argentina, Brazil, Chile and Mexico for LAC; France, Germany, Italy, Spain and United Kingdom for EU.

Figure 37 The main difficulties in collaborating or co-publishing with foreign scientists (in % based only on "important" and "major") for scientists working in LAC countries

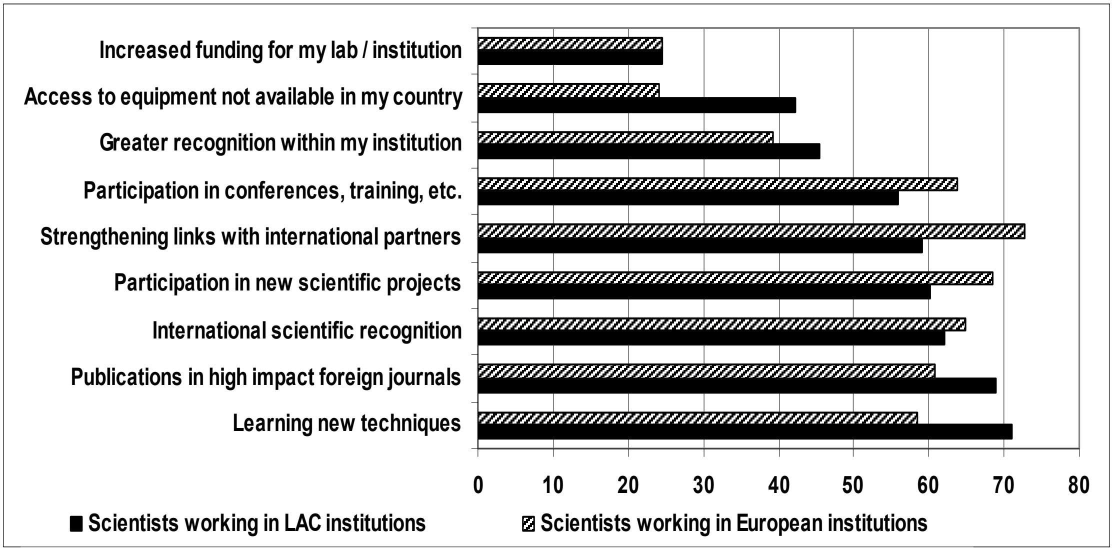


9. International collaboration: impacts and outcomes

In an attempt to characterise the main outcomes of international collaboration, a series of outcomes were proposed to the surveyed scientists from which they could choose everything that applied to their specific situation (Figure 38). Although the relative importance of many of the proposed outcomes is not very significantly different for LAC and EU scientists, there were some distinct trends. The main outcomes for EU scientists were related to social and scientific networking activities: "strengthening links with international partners" (72.7%), "participation in new scientific projects" (68.4%) and "participation in conferences, training, etc." (63.8%). For LAC scientists, international collaboration tended to generate more tangible outcomes such as "learning new techniques" (71%), "publications in high impact journals" (69%) and "access to equipment not available in my country" (42,3%).

Other outcomes of importance for both groups of scientists were "international scientific recognition" (62% LAC and 64.7% EU and 62% and to a lesser extent "greater recognition within my institution" (45.5% LAC and 39.3% EU) and eventually, "increased funding for my lab / institution" (24.4% LAC and 24.6% EU).

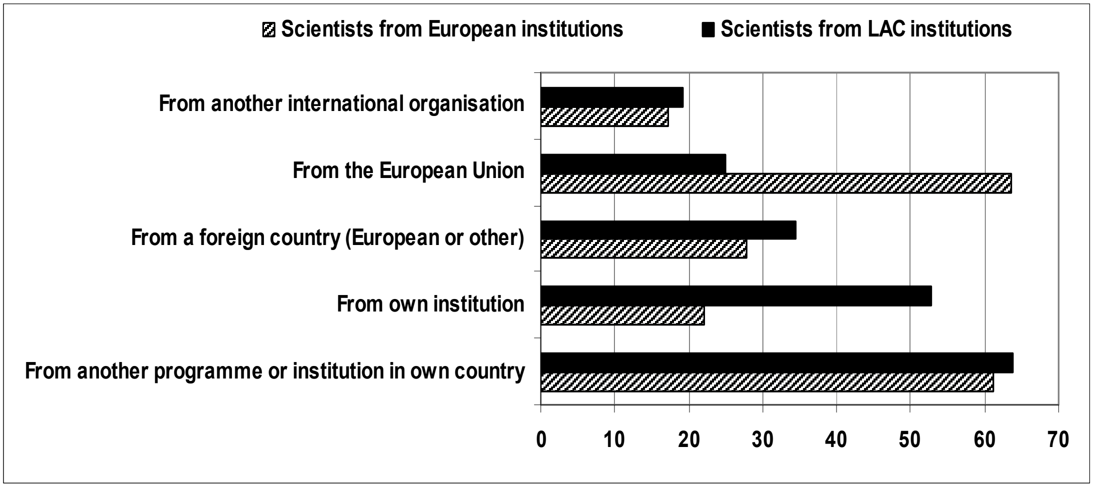
Figure 38. Main outcomes of international collaboration (%)



As for the preceding question, a breakdown was made of both the four main scientifically-developed LAC countries and the other countries in the continent in an attempt to investigate whether the level of scientific development of the LAC countries could impact the scientists' perception of the outcomes derived from international collaboration. The results showed that the answers from the two groups were quite similar but with a slightly higher percentage of positive opinions in the scientifically less developed countries. These positive differences range from 1.4% for "strengthening links with international partners" to 5.5% for "learning new techniques", 6.2% for "access to equipment not available in my country", 6.6 % for "increased funding for my laboratory / institution", 7.4% for "publications in high impact foreign journals" and 11.1% for "participation in conferences, training etc.".

For 1084 respondents (24.5% of the surveyed population), international collaboration resulted in increased funding for the scientists' laboratories or institutions (Figure 39). Nevertheless, very clear differences are to be noted between EU and LAC groups for two funding sources: the European Union and the home institution. Not surprisingly, increased funding from the European Union is particularly important for EU institutions (63.6%), and much less important for LAC institutions (24.9%). Conversely, increased funding "from the home institution" is much more important for LAC institutions (52.7%) than for EU institutions (22.0%), and increased funding "from another programme or institution in the home country" is important for both LAC (63.7%) and EU (61.2%) scientists. Finally, increased funding "from a foreign country (EU or other)" is of lesser importance (34.5% for LAC and 27.8% for EU) and increased funding "from another international organisation" is even less important (19.1% for LAC and 17.1% for EU)

Figure 39. Main sources of increased funding for my laboratory / institution resulting from international collaboration (%)

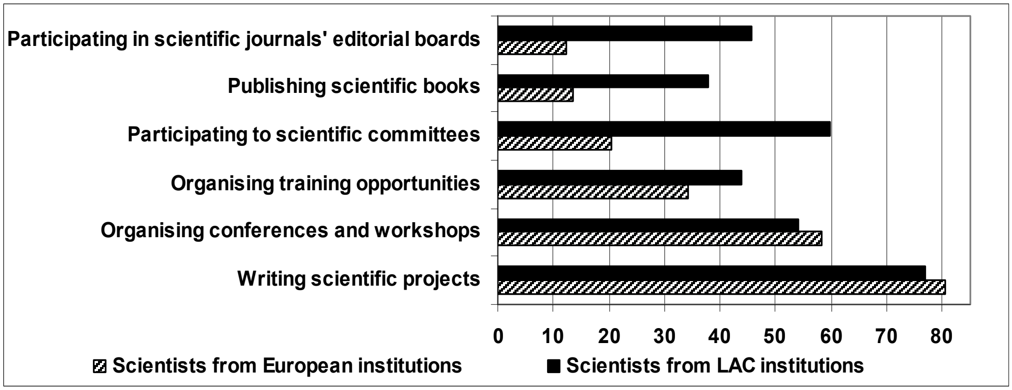


Among other additional scientific outcomes that are generated by international cooperation (Figure 40), the most important for both groups is “writing scientific projects” (80.6% for those working in Europe and 76.9% in LAC). This result very strongly confirms the common allegation on the subject: the more you collaborate internationally, the more opportunity you have to meet new colleagues, exchange ideas, “write new projects” and access new funding schemes in collaboration with foreign colleagues. The second is ”organising conferences and workshops”, which is almost at the same level on the two continents (58.1% in EU and 54.1% in LAC).

The other four additional outcomes identified are far more important for scientists working in LAC, in particular, “participating in scientific committees” and “participating in the editorial boards of scientific journals” (positive opinions respectively LAC 59.9% and 45.8%, Europe 20.4% and 12.3%). “Organising training opportunities” and “publishing scientific books” (respectively LAC 43.8% and 37.8%) are also two important outcomes of international collaboration for scientists working in LAC. It is worth highlighting that the four last outcomes bring recognition of the scientist by the international scientific community.

We again divided the two LAC groups and again – apart from “participating in the editorial boards of scientific journals” which dropped to 4.2% in the scientifically less developed countries – all the results showed a slightly but real intensification of the positive perception of outcomes by this group, the major difference being the increased levels of agreement for “organising workshops” (+14.9%) and “organising training opportunities” (+10.7%).

Figure 40. Additional outcomes of international cooperation



10. Collaboration and publications

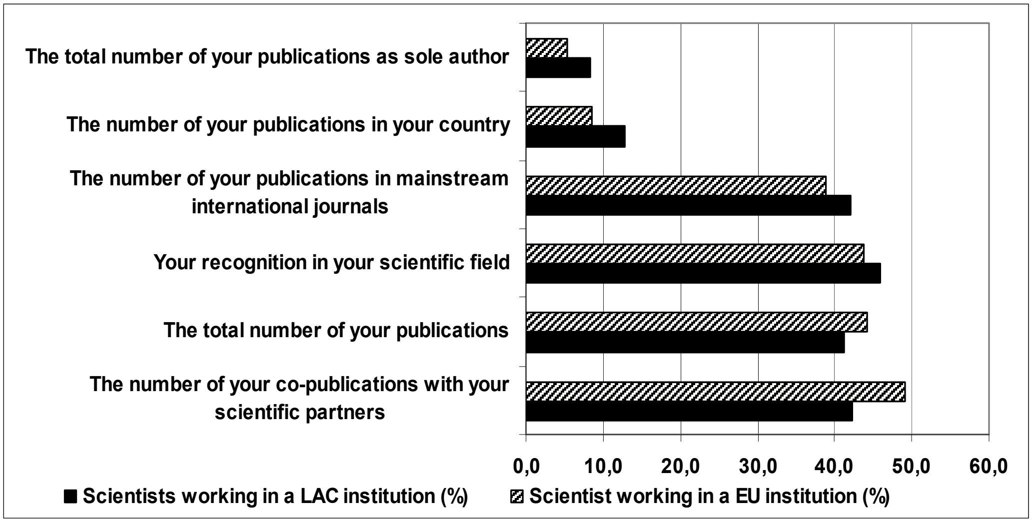
More than half of the LAC scientists (52.9%) and more than two-thirds of the EU scientists (70.5%) publish in more than one language. English is the first language of publication[15] followed by Spanish, French and Portuguese. Two-thirds (66.3%) publish in English and half (50.9%) publish in Spanish[16]. One-tenth only publish in French (10.6%) or Portuguese (10.5%) and even less are limited to German (5.9%) or Italian (4.2%).

Since scientific publications are one of the main outputs that scientists generally expect from collaboration, we examined how international collaboration between the two regions could contribute to increasing personal publication levels. According to a very large majority of the respondents, collaboration contributed (with a marginal difference between the two regions) to increasing their publication rate. More than 70% of the two groups acknowledged that collaboration contributed to increasing, either "moderately" or "a lot", their "recognition in their scientific field" (75.1% in LAC, 77.6% in EU), "the total number of their publications" (72.2% in LAC, 70.9% in EU), "the number of their co-publications with their scientific partners" (70.8 in LAC, 77% in EU) and "the number of their publications in mainstream international journal" (69.7% in LAC, 76.7% in EU). Not surprisingly, only their "publication in their home country" and "the total number of their publications as sole author" generated a small number of positive opinions. International collaboration, thus, is a win-win process in which the partners on both sides can benefit substantially.

[15] English is used as the first publication language by more than half (55.5%) and as a second language by more than one-tenth (13.1%) of the LAC scientists compared to half (53.7%) and one-tenth (9.8%) of the EU scientists.

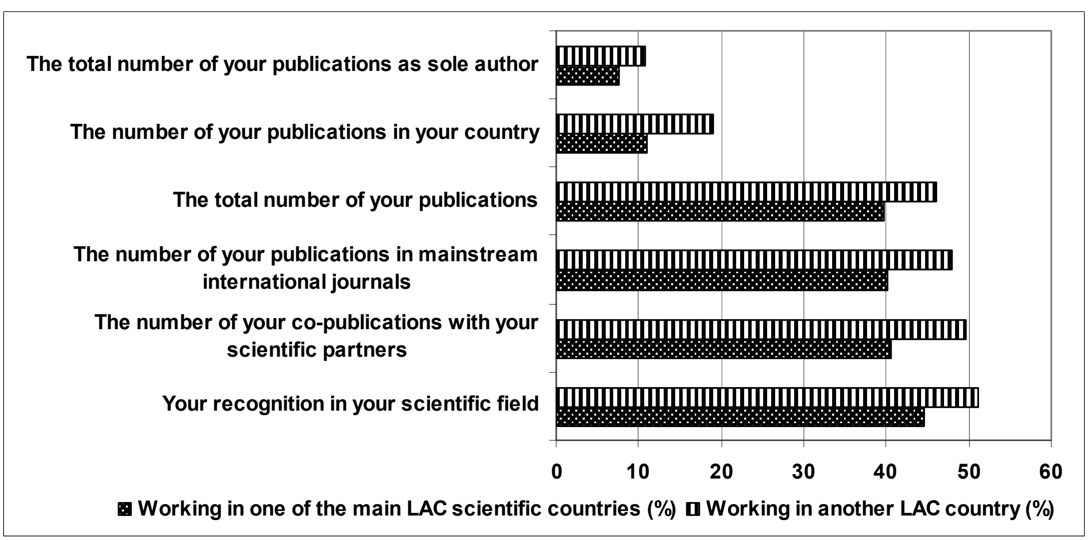
[16] Spanish is used as the first language by 31.5% and as the second language by 39.5% of the LAC scientists. Not surprisingly Spanish is not widely used in publishing by the EU scientists either as their first language (10.5%) or their second language (13.6%).

Figure 41. Scientific activities that collaboration with foreign scientists contributed to increasing "a lot" (% of scientists working in LAC and EU).



Whereas scientists working in EU are generally more numerous in recognising that collaboration helped them either "moderately" or "a lot", isolating the response "a lot" gives a slightly different perspective. It shows that more scientists working in LAC felt that collaboration contributed to boosting their publication outputs. This is supported by Figure 41 that presents the statistics based exclusively on the response "a lot".

Figure 42. Scientific activities that collaboration with foreign scientists contributed to increasing (% of two groups of LAC countries).

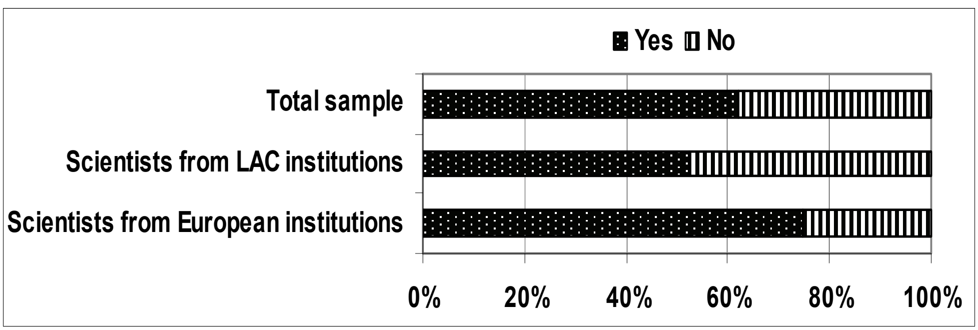


The latter is amplified by the breakdown of the LAC population into the two sub-groups (the most scientifically developed countries and the other countries). The results (Figure 42) tend to prove that the contribution of international collaboration to helping scientists get published is greater in countries that are scientifically less developed.

11. Involvement in calls for proposals to promote international scientific collaboration

While a large majority (61.9%) of scientists in the surveyed population responded to calls for proposals involving international scientific collaboration, the magnitude of this participation differed between the two regions: 74.8% in EU, 52.4% in LAC (Figure 43). The proportions were the same for the main scientific countries in both continents (4 in LAC and 5 in EU). The breakdown between the four main scientific LAC countries and the other LACs shows, surprisingly, that the propensity to respond to calls of proposals tends to be slightly higher in the scientifically less developed countries (56.7%) than in the four main scientifically developed countries (51.5%)[17].

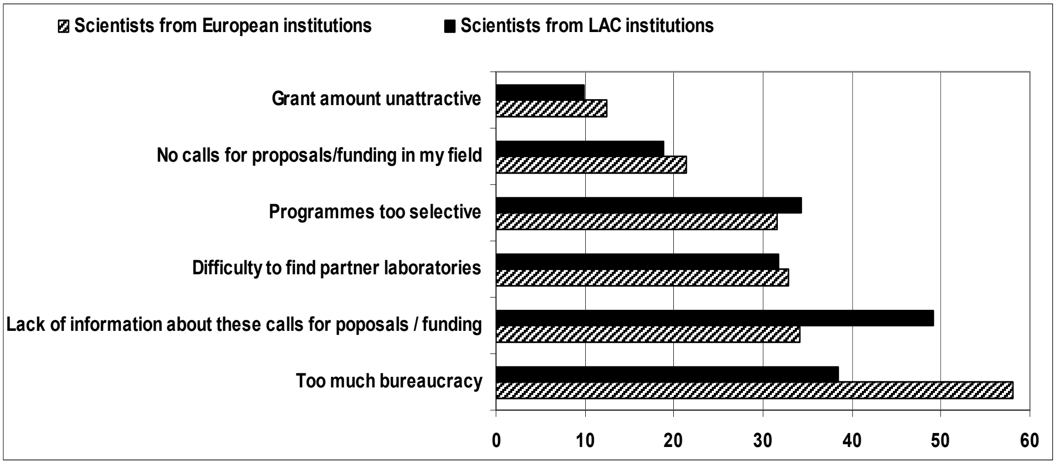
Figure 43. Responses to calls / tenders involving international scientific collaboration



The 1686 scientists (38.1%) who reported that they had never participated in any calls for proposals provided responses that followed a very similar pattern in LAC and EU, except for the two most important reasons: “too much bureaucracy” and “lack of information” (Figure 44). More than half of the scientists working in EU institutions (58.1%) selected “too much bureaucracy” while the figure in LAC institutions was slightly over one-third (38.4%). Conversely, “lack of information about these calls for proposals / funding” was a more important reason for scientists working in LAC (49.2%) than in EU (34.1%).

[17] This point may confirm that scientists working in the scientifically more developed LACs are slightly less dependent on international funding and have more access to national support schemes.

Figure 44. Reasons why scientists do not participate in calls for proposals involving international scientific collaboration

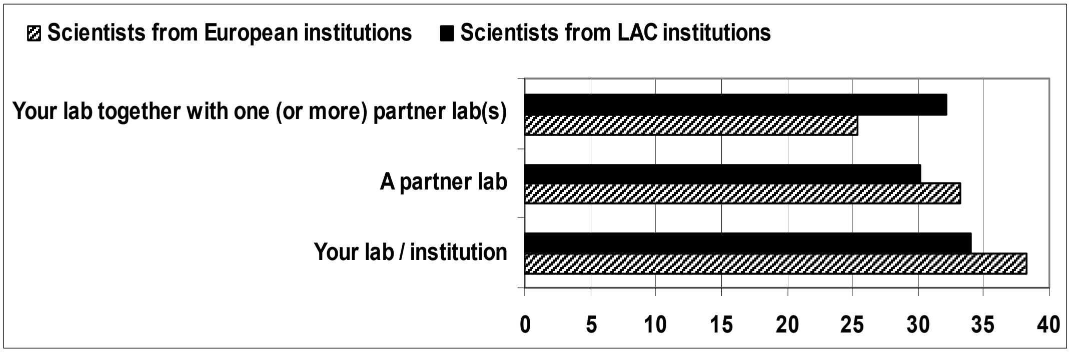


“Difficulty to find partner laboratories” and “programmes too selective” were reasons brought up by approximately one-third of the respondents, in both regions. The last two reasons “no calls for proposals / funding in my field” and “grant amount unattractive” were less often applicable with positive answers of about 20% and 10% respectively. A number of other reasons were also provided by a minority of scientists (6%). The most important “other reasons”, by order of importance, were lack of need, lack of interest, lack of time, language problems, and enough funding available from national or bilateral funding programmes. Some scientists also blamed the programmes themselves: “non-transparent and confusing decision process”, “most programmes support travel grants while we need funds for field work and analysis” or even “EU-Framework Programmes are a complete bluff and do not stimulate real collaboration”.

In an attempt to estimate the level of participation of the respondents in these international collaborative programmes, a series of questions were asked about the functioning of the projects: distribution of roles, tasks and budget. The scientists were asked to tell about their most recent involvement in a call for proposals. Only non-EU international calls for proposals are presented here in order to avoid the systematic bias caused by the unequal collaboration between EU and non-EU laboratories in EU projects.

The responses to the question “who initiated the project?” indicated that projects were initiated in approximately the same proportion in both surveyed regions by the scientists’ laboratories and institutions (EU 38.2%, LAC 34.0%), a partner laboratory (EU 33.3%, LAC 30.2%) or the scientists’ laboratory together with one or more partner laboratories (EU 25.4%, LAC 32.2%). In sum, for approximately two-thirds of the scientists (LAC 66.2%, EU 63.6%) the project was initiated by their laboratory or institution alone or together with one or more partner laboratories (Figure 45). Here again, the responses provided by scientists in EU and LAC institutions were very similar.

Figure 45. Who initiated the project (all calls for proposals combined)



Although the majority of the scientists (EU 56.0%, LAC 53.4%) participated as partners in the projects, a large percentage of them (EU 41.8%, LAC 41.0) considered themselves to be project coordinators. Very few, as shown in Figure 46, are (or were) sub-contractors (EU 2%, LAC 2.1%).

Most of the scientists in the two regions were directly involved in the budget allocation: EU 84.5%, LAC 72% (Figure 47). For 21% of those working in Europe, this decision was taken by their own laboratories while for 63.5% of them it was taken jointly by their own and their partner laboratories. To a lesser degree, this was also the case for scientists working in LAC (own lab 18.6% and own + partner labs 53.4%

Figure 46. Roles of participants in the projects (in %)

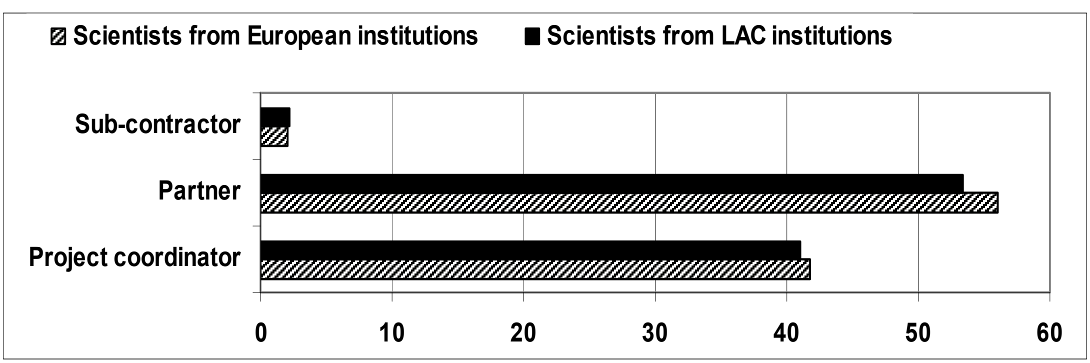
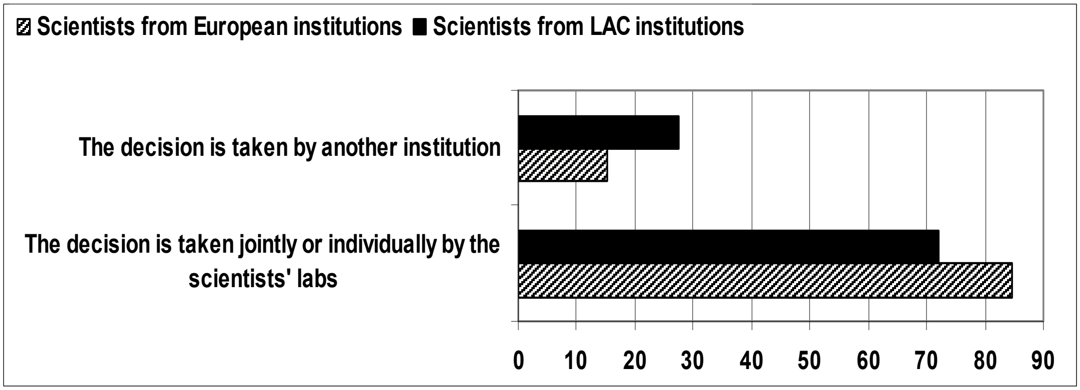


Figure 47. Who decided (or decides) about budget allocation



On the other hand, budget allocation was more likely to be decided by "other" in LAC (27.7%) than in Europe (15.2%), namely by "one or more partner laboratories" for 22.5% of scientists working in LAC and by "other" in 5.2% of the cases, while in Europe we find 12% for scientists working in EU and 3.2% for "other". Since the difference in responses between the two continents was greater for this activity than for any other (12.5%), we tried to find an explanation by breaking down the results of the two LAC groups. But the results showed no difference at all between the two groups of countries (the scientifically more developed and the other countries)[18].

The question about the "decision of distribution of tasks" (Figure 48) shows a much similar pattern, with a large majority of the scientists being involved in decision-making: EU 89.4%, LAC 81.3%. For 16.7% of those working in Europe the decisions are taken by their own laboratory while for 72.6% of them it is taken by their own laboratory together with the partner laboratories. This is also the case for scientists working in LAC, but to a lesser degree (respectively own lab 15.6%, own + partner lab 65.7%). Conversely, this decision is more likely to be taken by "others" in LAC (18.7%) than in Europe (10.6%).

On the whole, the responses concerning decisions about the distribution of roles, budgets and tasks in international projects between EU and Latin American scientists tended to indicate that the asymmetric relationship, which was a burning issue in the 1970s and 1980s, has changed into a more equal partnership.

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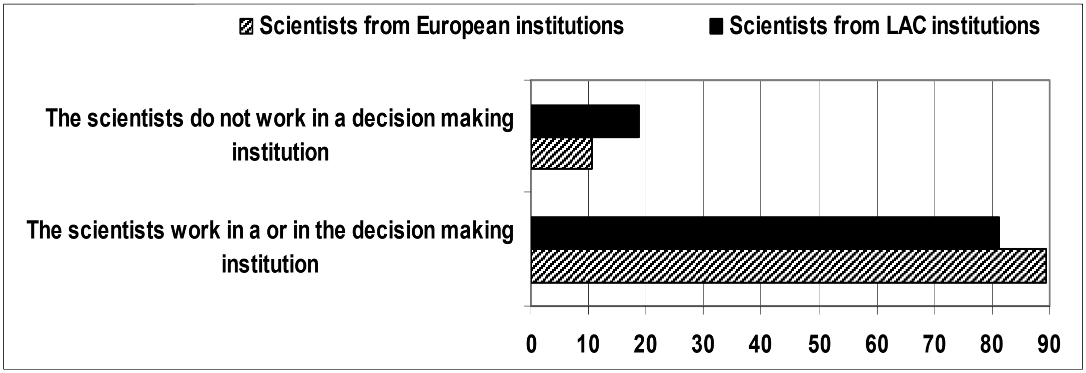
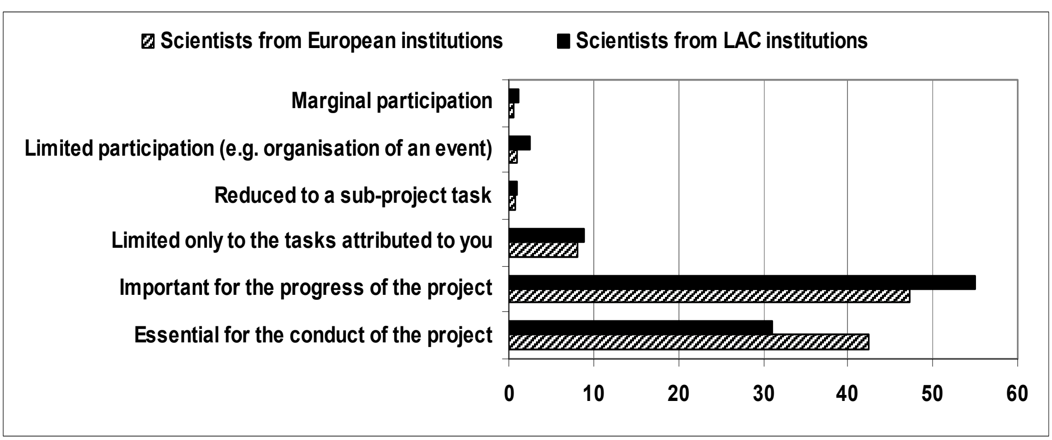
[18] This aspect has been discussed many times by the interviewed scientists in LAC, who observed, with regret, that their lack of participation in budgetary decisions put them in a position inferior to that of their foreign partners.

Figure 48. Who decided (or decides) about the distribution of tasks? (all calls for proposals combined)



A range of questions linked to the quality of involvement and contribution were asked in an attempt to check the level of satisfaction in participating in international programmes. The results show a very high level of satisfaction with the involvement in the projects in both regions; 83% of the scientists in LAC and 88% of the scientists in EU felt that they were able to get involved as much as they wanted. For the respective 17% and 12% who could not, their main reason was linked to lack of time, followed by insufficient support from their home institution and a somewhat deficient level of communication between the partners. The other reasons we heard were more marginal (around 20 people each): these people would have gotten more involved if "the subject had been different", if they "had better mastered the process flow" or if they "had been involved from the project design stage".

Figure 49. Level of contribution to projects



The responses given in the two regions about the level of individual contribution to the projects (Figure 49) almost follow the same pattern, but indicate that scientists working in Europe are more likely to rate their contribution as “essential” (Europe 42.4%, LAC 31.1%).

Nevertheless, the majority of the respondents (EU 89.6%, LAC 86%) rate their contribution to the project either “important for the progress of the project” (EU 47.5%, LAC 54.9%) or “essential for the conduct of the project”. The other levels of contribution proposed were considered as much less important. A small number of respondents (under 10%) felt that their contribution was “limited only to the tasks attributed to them” and even fewer, that their contribution was a “limited participation”, “reduced to a sub-project task” or even “marginal participation” (around or under 1%). Here again we made a breakdown of the results between the two LAC country groups and once again the differences were very marginal. The scientists working in the more scientifically developed countries tended to give slightly more value to their role in the collaboration: 91.3% rated their contribution as either “essential for the conduct of the project” (36.9%) or “important for the progress of the project” (54.4%), compared to 86% for the scientists working in the other scientifically less developed LAC countries: “essential for the conduct of the project” (35.2%) or “important for the progress of the project” (50.8%).

A number of reasons were suggested to characterise motivations to participate in an international call for proposals (Figure 50). Almost all the motivations were considered as “important” or “essential” by the majority of the respondents in the two regions, apart from “access to new technologies / competences not available in my country” which, not surprisingly, is the last one given by people working in EU (45.3%) but ranked second for people working in LAC (74.8%). In both regions, the most important criterion was money: ”access to international funding” (EU 80.9%, LAC 75.7%). Globally, the proposed motivations are more explicitly acknowledged in LAC (between 61% and 76% of positive opinions expressed for all proposed motivations): “participation in an international expert network” ranked third in the LAC region (74.6%) and second in EU (67.3%), followed by “greater mobility through PhD programmes, fellowships, research grants, etc.” (LAC 73.1%, EU 62.5%), “increased scientific visibility” (LAC 71.9%, EU 66.1%), “publications in mainstream scientific journals” (LAC 68.7%, EU 55.1%) and last, “making my research fit into a more global scheme on, e.g. climate, energy, biodiversity, etc.” (LAC 60.9%, EU 53.9%).

The breakdown between the two LAC groups shows no major differences in the LAC region apart from “access to international funding” that is more important for the scientifically less developed countries (75% against 66.6%), thereby confirming that scientists working in the scientifically more developed LAC countries are slightly less dependant on international funding and have more access to national support schemes. For the other motivations, the repartition is quite (more or less) even between the two sub-groups.

These motivations are curtailed by difficulties that restrict the scientists’ involvement in such projects (Figure 51).

The limiting factors are not the same in the two continents but five reasons were supported by more than 50% agreement in both continents (there are seven reasons in Europe): “calls / tenders are too selective” was considered as a limiting factor by more than 60% of respondents (Europe 64.5%, LAC 62%) followed by “difficulties in finding partners / building consortium”, which is more frequent for LAC scientists (69.2%) than for their colleagues in Europe (57.2%). The third limitation, “difficulties related to accounting and financial rules in my institution" is, surprisingly, acknowledged equally by scientists in Europe (53.5%) and in LAC (55%). The last two reasons were supported by more than 50% on both continents, but with major regional differences: "poor knowledge of scientific calls / tenders" is much more of a problem in LAC (73.3%) than in Europe (51.5%). The same applies to "lack of knowledge or training on how to submit a project proposal" that is a difficulty for 58% of the scientists working in LAC and 50.1% of those working in Europe. "Lack of time", the predominant reason for scientists in Europe not to engage in such projects (69.6%), is less important in LAC (41.3%). "Insufficient amount of funding" was supported in over half the answers in Europe but not in LAC (Europe 51.8%, LAC 41.3%).

Figure 52 shows that scientists working in scientifically less developed countries have less opportunity to participate in international calls for proposals. Although the differences between the two LAC groups are rather small, the results suggest that international collaboration is even more needed in the scientifically less developed countries, especially because of the difficulties listed below, as well as the motivations and above all, the outcomes and benefits.

Figure 50. "Essential" and "Important" reasons that motivate scientists to participate in international calls for proposals (in %)

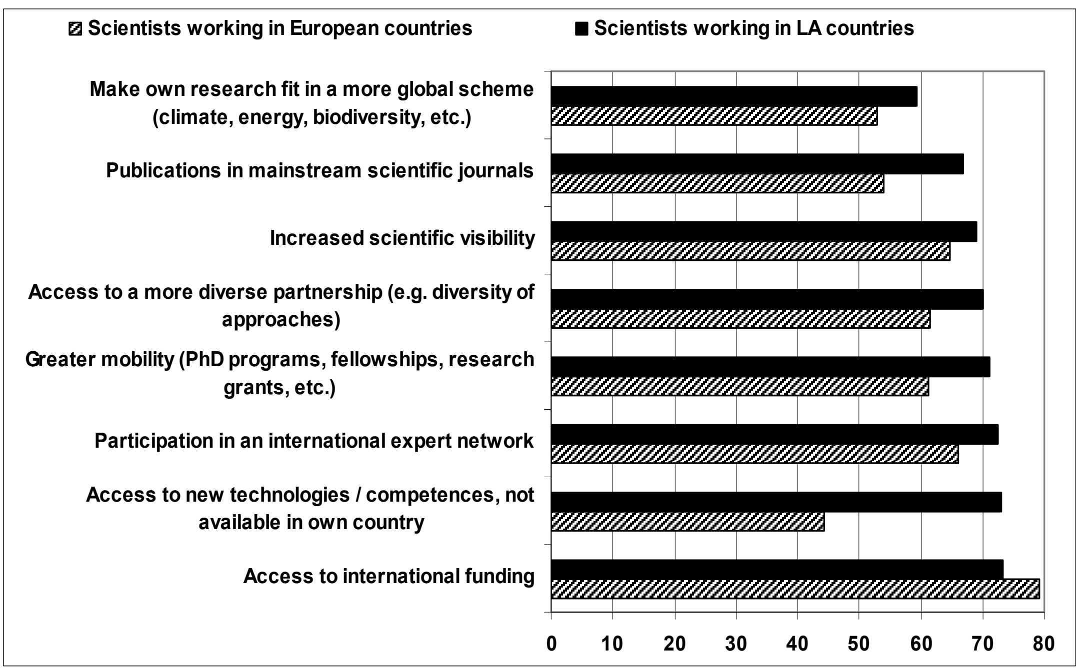


Figure 51. "Restrictive", "very restrictive" and "crippling" reasons that limit scientists' participation in international scientific calls for proposals (in %)

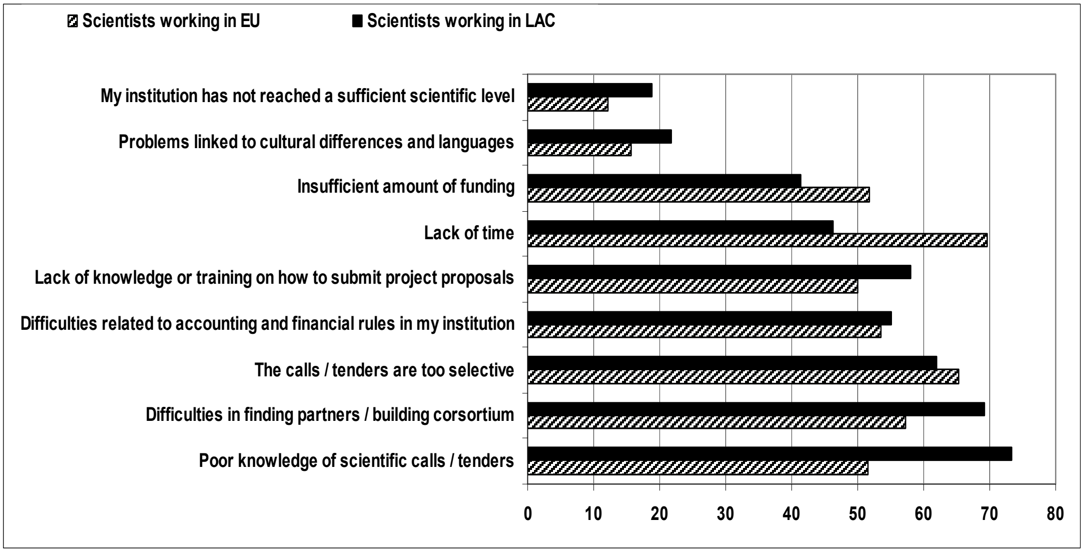
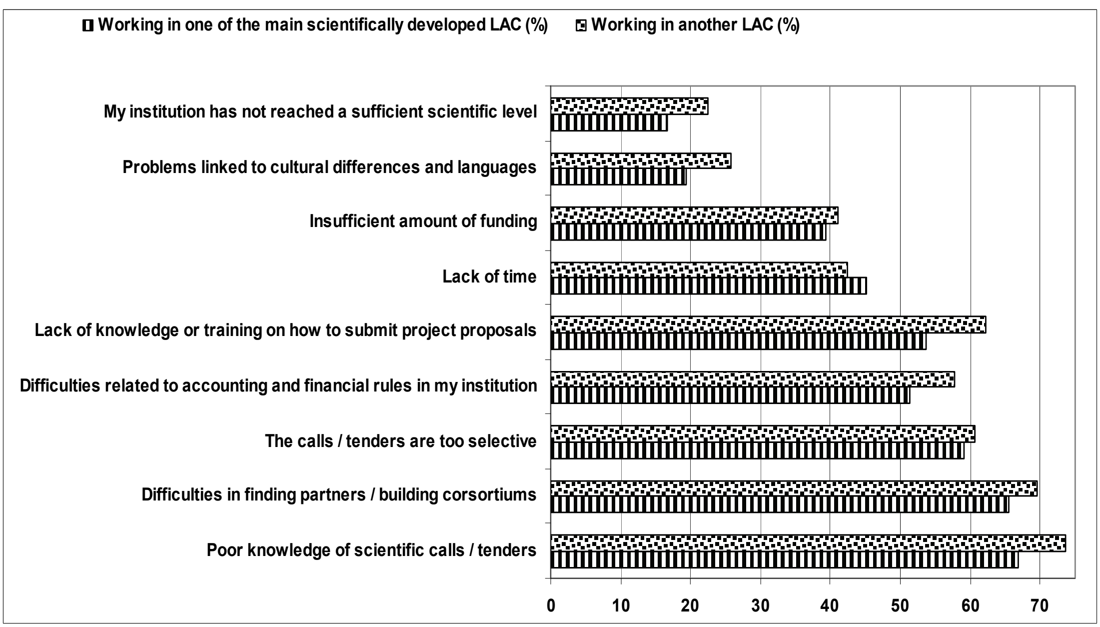


Figure 52 "Restrictive", "very restrictive" and "crippling" reasons that limit scientists' participation in international scientific calls of proposals for the two LAC country groups (in %)



Conclusion

The main findings of this survey on international collaboration between LAC and EU are summarised below and developed more extensively in this concluding section:

The asymmetry of collaborations, which was recognised as a source of tension and a burning issue in the 1970s and 1980s, has developed into a more equal partnership.

The relative importance of scientific disciplines concerned in the collaboration is more in line with the LAC priorities than with the EU's.

The surveyed population is older than the overall population of scientists in both EU and LAC. This would tend to confirm that researchers in their mid career stages (40 years and above) are more likely to collaborate internationally than those who are in their early or late career stage.

The survey confirms that female scientists are less likely to collaborate internationally than male scientists. Interestingly and perhaps logically, they are more likely to participate in disciplines in which they are less likely to collaborate.

International mobility correlates with increasing international collaboration.

International collaboration is a win-win process that benefits all the partners.

International collaboration, once established, is a longstanding activity.

The more scientists collaborate internationally, the more opportunities they have to meet new colleagues, exchange ideas, write new projects, and access previously unsolicited funding schemes.

The motivations and expectations related to participation in international calls for proposals involving scientific collaboration are very high, and the declared derived outcomes are very significant in both continents.

The motivations, expectations and benefits of collaboration but also the difficulties of collaboration are higher in the scientifically less developed LAC countries than in the four major LAC scientific countries (Argentina, Brazil, Chile and Mexico).

The diaspora plays a very insignificant role in the decision to undertake extended stays abroad for scientific studies and a limited role in the decision to collaborate.

International collaboration addresses and involves very dedicated and goal-oriented individual scientists in all countries, scientists who seek to increase and improve their scientific capacities and develop greater international recognition.

Apart from the fact that the preferred areas of collaboration between EU and LAC researchers are related to the scientific fields which are predominant in LAC[19], the major result of this survey, reported as no.1 in the list above, tends to prove that in the main sectors of international scientific collaboration, the asymmetry of relations, which was highlighted as a burning issue in the 1970s and 1980s, has been turned into a more equal partnership between the two continents. This has been clearly demonstrated in several

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[19] Like "Biology & Environmental Sciences", which is the strongest scientific field for LAC countries whose scientific production measured in number of publications corresponded to 6% of world science in 2006 (OST 2008).

sections of this chapter on the various stages of collaborative scientific activities, e.g. decisions about the distribution of roles, budgets and tasks in international projects. This also appears throughout the survey in the way scientific activities and interests in cooperation as well as advantages and disadvantages of such collaborative schemes are perceived in the two regions.

The 4475 scientists who answered the survey[20] belong to quite homogeneous categories in the two continents. There are no marked differences in age repartition between respondents from EU and LAC countries[21] and in the two regions; the surveyed group is also older than the overall scientific population. This would tend to confirm that researchers in mid career stages (40 years and above) are more likely to collaborate internationally than those who are in the early or late career stages. Women represent slightly over one-fourth of the respondents[22]. Research is the main activity of the respondents, i.e. they spend more time on research than on teaching and other activities such as administration and consulting)[23].

The survey confirms the great mobility of scientists even prior to international collaboration, although with differences depending on the country and the continent. At the time of the survey, slightly less than 10% of the surveyed population could be considered as being part of the S&T diaspora (meaning that they are living in a country other than their country of nationality). Compared with the figures on high-skilled migrants reported today, this percentage is very high (particularly for the five scientifically most advanced LAC countries), but since the sample is not representative, this high rate of expatriation can only confirm the strong propensity for mobility of the surveyed population, which is composed of active researchers eager to collaborate internationally. It may however introduce a more general question: is the S&T PhD holder category potentially more internationally mobile than the rest of the highly qualified populations? The answer is “most likely yes”.

International mobility is also a permanent feature throughout the scientist’s career: altogether 86.3% of the survey population spent long periods of time abroad (for study, post-doc or other stays exceeding six months), namely, 88.8% of LAC national scientists and 82.8% of EU. For both continents, EU countries are the preferred destination for extended stays abroad for 48.6% of the scientists (LAC 55%, EU 40%) followed by USA (20.5% with almost the same breakdown in both continents). The situation is slightly different for long stays in LAC or in other developing countries; the percentage of scientists working in Europe who are likely to live for extended stays in these countries is much greater (EU 24% against 16% in LAC, and EU 10% against 3% in other developing countries).

Professional advancement is, by far, the main reason for this strong migratory trend. The dynamics of mobility are not based on what one wishes to escape but on what one wishes to

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[20] The best response rate was from LAC countries with an average of 44.8% compared to EU countries with an average of 27.7%. This can probably be correlated to the fact that researchers in LAC show greater motivation to participate in international collaborative programmes and greater satisfaction regarding the outcomes of their participation.

[21] More than two-thirds of the respondents (69%) are between 40 and 60 years old, the peak being in the category 40-59 years old (36%). Conversely, researchers below 40 years of age represent only 18% of the overall surveyed population.

[22]A recent study indicates that female scientists are less likely to collaborate internationally than male (NSF, 2009). Thus, based on a longitudinal survey that follows recipients of research doctorates from U.S. institutions until age 76, NSF found out that while 30% of them do collaborate internationally, respectively 23% of female and 33% of male do so.

[23] For 60.2% of the all group, research occupies at least 50% of the working time (for almost 77% it occupies at least 40% of their time and for 41% of them, at least 60%).

gain from the move. Seeking "the scientific expertise developed in the host country" is the reason that attracts the highest rate of positive opinions among both LAC and EU respondents, especially among the post-docs (68.8% for the group as a whole). Even EU scientists who prepare their PhD or post-doc in one of the four main LAC scientifically developed countries explain that their mobility is motivated, but to a lesser extent, by the assumption that "the reputation of the host country institution will promote my career" (46%) and because of "the scientific expertise developed in the host country" (35%). Nevertheless for this group, the main reason relates to funding[24].

S&T diaspora living in the countries of destination play a very insignificant role in scientists' mobility choices and a limited role in initiating and establishing collaboration. Overall, very few scientists connect their choice of destination with the existing diaspora in the target country (respectively 3.4% for PhD students and 3.3% for post-docs). When it comes to collaboration or co-publications with members of the diapora, the proportion varies from 12% (equally distributed between the two regions) for collaboration with previously known countrymen abroad, to 18% to 24% (the latter for EU scientists) for collaboration with countrymen settled abroad who were not known previous to collaboration. This helps put the impact of the S&T diaspora in international scientific activities into perspective showing that it is not of major importance in decisions of scientific migration and scientific collaboration.

Scientific collaboration between the two continents is often the result of scientists' mobility. Over 90% of the scientists have published scientific papers with colleagues met during long stays abroad[25]. The latter are mostly colleagues from institutions in which the visiting scientists have worked while abroad (48%)[26], followed by colleagues from other institutions in the countries where they stayed (54%). A relatively high percentage (48%) of the scientists working in a LAC institution co-published with their thesis director while the figure was a mere one-fifth (20%) for their colleagues working in Europe.

While results emphasise the fact that stays abroad boost international collaboration, another important finding of this survey shows that collaboration today is not necessarily connected with personal links established during stays abroad (or during visits by foreign colleagues to the scientist's institution). Actually, the large majority of scientists surveyed (61% LAC scientists and 63% EU scientists) did collaborate or co-publish with scientists abroad whom they had not met during their extended stays abroad[27].

Although mobility is not enough to explain international collaboration, it amplifies its magnitude. In the surveyed population the scientists who had never gone abroad for long stays (13.7% of the total sample) collaborated and co-published less than their colleagues who emigrated during or after their studies. The latter co-published and collaborated more frequently not only because it was easier to develop partnerships with colleagues met during their long stays abroad (for more than 90%) but also because they were more prone or had

[24] 81% of them received funding from their home country, their host country, or a special fund.

[25] 90.3% for scientists working in LAC and 92.3% for scientists working in Europe.

[26] 79.4% for scientists working in LAC and 87.3% for scientists working in Europe.

[27] These foreign collaborators (or collaborators living abroad) are by decreasing order of importance: 1) foreign scientists collaborating with them in international projects (53.2% for EU scientists and 41.6% for LAC scientists), 2) foreign scientists met at international meetings (22% for EU-based scientists and 15.8% for LAC-based scientists), 3) scientists from their country living abroad (9.6 % for EU and 10.9 % for LAC), 4) foreign scientists they never met but with whom they communicated e.g. through internet (10.5% for EU scientists and 8.7% for LAC scientists).

more opportunities to team up with colleagues whom they did not know prior to collaboration (colleagues participating in the same international projects, colleagues met occasionally at conferences, or colleagues who they did not meet but with whom they communicated)[28].

Once collaboration has been started it usually lasts[29]. Collaboration is generally organised within the framework of bilateral cooperation (71% in LAC and 74% in EU), or else as part of international projects (20% in LAC and 25% in EU). On both continents, the only reported difficulty in collaborating or co-publishing with foreign scientists that was perceived as "important" or "major" by more than 50% of the respondents was the "lack of collaborative programmes or funding"[30].

This collaboration was roundly supported by a very high level of positive opinions at both ends of the collaborative chain. It was recognised as a true win-win process in which scientists reported that they benefited greatly e.g. from the outcomes. Despite a very high level of satisfaction on both continents, some distinct trends could be identified. The main outcomes for scientists working in EU were related to social and scientific networking activities[31] while for those working in LAC, satisfaction was correlated more with tangible outcomes[32]. More than 70% of the two groups acknowledged that collaboration had helped them in their scientific activities[33].

While a large majority (61.9%) of scientists in the overall survey population responded to calls for proposals involving international scientific collaboration, the extent of this participation differed clearly between the two regions: 74.8% for scientists working in EU institutions, 52.4% for those working in LAC. Those who never participated in any calls for proposals explained their non-participation in a similar manner on both sides of the ocean: "too much bureaucracy" and/or "lack of information". Unexpectedly, more scientists working in EU (58.1%) than in LAC (38.4%) felt that the programmes suffered from "too much bureaucracy". Other reasons like "difficulty in finding partner laboratories" and "programmes too selective" were given by approximately one-third of the respondents in both regions.

Analysing the scientists' participation in calls for proposals gives a very balanced picture of the two country groupings. The responses indicate that for approximately two-thirds of the scientists (LAC 66.2%, EU 63.6%) the project was initiated by their laboratory or institution

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[28] The margin between the two groups ranges from 2.1% for collaboration with expatriate LAC countrymen (who were not known previous to collaboration), to 35.4% for collaboration with colleagues participating in the same international project.

[29]A small percentage of the scientists on both continents ended their collaboration: 15.7% in LAC institutions and 16.2% in Europe for collaboration with people the scientists knew from their long stays abroad and respectively 13.4% and 8.2% for collaboration with people the scientists did not know during these stays.

[30] The other proposed difficulties did not receive strong support from the surveyed population apart from "too consuming of time and effort" for the scientists working in LAC (almost 30%) and "inter-institutional cooperation problems" which were perceived as an important or a major problem by more than one-fourth of the respondents in the two continents (25.4% in LAC and 26.8 in EU).

[31]Like "strengthening links with international partners" (72.7%), "participation in new scientific projects" (68.4%) and "participation in conferences, training, etc." (63.8%).

[32] Such as "learning new techniques" (71%), "publication in high-impact journals" (69%) and "access to equipment not available in my country" (42.3%).

[33] The collaboration helped to increase either "moderately" or "a lot" their "recognition in their scientific field" (LAC 75.1%, EU 77.6%), "the total number of their publications" (LAC 72.2%, EU 70.9%), "the number of their co-publications with their scientific partners" (LAC 70.8, EU 77%) and "the number of their publications in mainstream international journals" (LAC 69.7%, EU 76.7%).

alone or together with one or more partner laboratories. While the majority of the scientists (EU 56.0%, LAC 53.4%) were partners in the projects, a large proportion of them (EU 41.8%, LAC 41%) reported that they were project coordinators. The vast majority of the scientists in both regions were directly involved in budget allocation (EU 84.5%, LAC 72%) and task assignment EU 89.4%, LAC 81.3%).

On "involvement in the projects", the results show a very high level of satisfaction in both regions;83% for LAC scientists and 88% for scientists working in Europe felt that they were able to get involved as extensively as they wanted. For the LAC 17% and EU 12% who could not, the first reason they gave was linked to "lack of time", followed by "insufficiency of support by their home institution" and a somewhat "deficient level of communication between the partners". The responses given in the two regions about the level of individual contribution in the projects almost follow the same pattern, but scientists working in Europe were more likely to rate their contribution as "essential" (EU 42.4%, LAC 31.1%). Nevertheless, a large majority of the respondents (EU 89.6%, LAC 86%) rated their contribution to the project either "important for the progress of the project" (EU 47.5%, LAC 54.9%) or "essential for the conduct of the project" (EU 42.4%, LAC 31.1%).

The leading reason for scientists to participate in such international schemes in both regions was money, i.e. "access to international funding" (Europe 79.3%, LAC 73.2%). The second motivation was not the same for the two regions: "access to new technologies / competences not available in my country" motivated 72.9% of the scientists working in LAC, but, not surprisingly, ranked last for the scientists in EU (44.4%). Globally LAC scientists seemed more highly motivated to participate in international calls for proposals than their colleagues in EU; all the motivation questions (except "access to international funding") received more positive answers from scientists in LAC than in EU[34]

Although many scientists are highly motivated to respond to calls for proposals involving international collaboration, their participation is often restricted by a number of difficulties. The limiting factors are not the same in nature or scope in the two continents, but at least five reasons received over 50% agreement on both continents: "the calls/tenders are too selective", scientists have "difficulties in finding partners/building consortiums", and "difficulties related to accounting and financial rules in their institution" (the latter equally in the two regions). Particularly in LAC countries, scientists reported to have "insufficient knowledge of scientific calls/tenders" and "insufficient knowledge or training on how to submit a project proposal".

Acknowledgements

The authors wish to thank Shirley Ainsworth for the selection from the WoS (Web of Science) of scientists in EU countries and LAC countries who had published at least one publication indexed in the Web of Science in co-authorship with a scientist from the other country grouping (EU countries and LAC countries).

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[34] "Participation in an international expert network" came in third position in the LAC region (74.6%) and second in EU (67.3%), followed by "greater mobility (PhD programmes, fellowships, research grants, etc.)" (LAC 73.1%, EU 62.5%), "increased scientific visibility" (LAC 71.9%, EU 66.1%), "publications in mainstream scientific journals" (LAC 68.7%, EU 55.1%) and eventually "make my research fit in a more global scheme (climate, energy, biodiversity, etc.)" (LAC 60.9%, EU 53.9%).

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Chapter 6

Drivers and outcomes of S&T international collaboration activities. A case study of biologists from Argentina, Chile, Costa Rica, Mexico and Uruguay

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Abstract

This article is based on 74 interviews of Latin American scientists conducted in 2009 and 2010 in Argentina, Costa Rica, Chile, Mexico and Uruguay. All interviewed scientists are working in the field of biology applied to agriculture (or agriculture-related sciences) with a particular emphasis on animal and aquatic resources production and reproduction. They all have (or had) scientific relations with Europe at some stage in their careers. It will also draw on the results of a questionnaire survey (Gaillard, Gaillard and Arvanitis, 2010) carried out at the end of 2010 and answered by 4425 scientists (2550 in Latin America and 1875 in Europe)[1].

It aims at analysing and gaining a better understanding of the importance of S&T collaboration at the level of the individual researcher in Latin America through the reconstruction of their personal scientific histories. In particular, it seeks to understand the main determining factors initiating, promoting and enhancing international collaboration in S&T. It also aims at establishing to what extent mobility boosts internationalization their profile and contributes to placing their institution (even their country) in the global stream of scientific knowledge circulation.

The analysis of the interviews concludes that there is no single factor driving S&T international cooperation. In most cases, there is a cumulative set of factors and/or actions by multiple actors as well as a range of circumstances that shape the geographical, institutional and thematic focus of international cooperation in S&T. Yet, the most powerful drivers are scientific excellence, mobility and networking capacity. The networking power of conferences and post-doc stays abroad are specifically recognised as crucial instigators of long lasting scientific collaborations. A good personal relationship is also of paramount

[1] This work was developed in the framework of a coordination and support action programme funded by the Framework Programme 7 (FP7-SSH-2007-1) of the European Commission completed in December 2010. The project's full name is: "Connecting Socio-economic Research on the Dynamics of the Knowledge Society in the European Union and Latin American and Caribbean Countries (EULAKS)". The 74 interviews and the questionnaire mentioned here are part of the Work Package 1 (WP1) for the proposal of policy-oriented analysis to be used as an information base for the other Work Packages and to develop policy recommendations for strengthening international co-operation between the Member States of the European Union (EU) and the countries of Latin America and the Caribbean (LAC) (see chapter 5 in this book).

importance in scientific collaborations. Ultimately, “You collaborate with friends” and meeting people through collaboration is also acknowledged as a very important reward.

THE DRAFTING OF THE RESEARCH

1 – State of the Art, aim of the study and methodology

Individual interviews were carried out with biologists from Latin America on their international scientific collaborations. The idea behind this empirical approach was to gain a better understanding of the dynamics and the effects of these collaborations on their careers. It also sought to throw light on the determining factors behind these collaborations. Why do scientists and researchers continue the long tradition that since ancient times has set them on the path to international collaboration and engaged them in sometimes long life correspondence with colleagues beyond borders?

A number of factors are well known: a love of science and the hope of its dispersal across frontiers for the benefit of humankind (Loemker, 1976)[2]. The quest for excellence and the need for visibility: the Mediterranean scholars went to Alexandria to meet and study in the renowned Ptolemaic Library (Parson 1952). Scholars moved between European universities in the Middle-Ages (Kibre, 1948). On the other hand, it is now considered that collaboration enhances scientific production (Landry et al. 1996, Lee, Bozeman. 2005, Duque *et al.*, 2005, Shrum et al., 2007)[3]. Likewise, the use of Internet is also reported to enhance international collaborations and scientific production (Vasileiadou, Vliegenthart, 2009). Networks also play an important role (Liberman, Wolf, 1998). They accelerate academic careers (Van Rijnsoever F.J., 2008) and play a facilitating role in finding new contacts and funding (Nieminen, Kaukonen, 2001, Harman, 2001).

In addition to the benefits linked to the different aspects and forms that shape scientific partnership nowadays, collaboration has become an absolute necessity due to the growing complexity of research and the very high-cost of much of the equipment and infrastructure. In this context, less developed scientific communities have much to gain from international collaboration in the sense that it may increase their scientific capacity and integration into the international scientific community, while promoting professional mobility among their members, their visibility and enhancing their scientific work. (Osca-Lluch J. et al 2007). There is also a clear growing need for regional and international studies to solve transnational and global challenges. These global challenges such as climate change, global health, biodiversity, to name just a few, transcend national boundaries and pose a significant threat to societies and ecosystems. Global challenge science requires international collaboration on a large scale because of the nature and magnitude of the potential consequences of these problems (see for example The Royal Society, 2011).

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[2] Reference is made to the famous letter from Leibniz on the subject of “making sciences flourishing”: “In this I make no distinction of nation or party … The country which does this best will be the country dearest to me, since the whole human race will always profit from it” (Foucher de Careil, 1712, Oeuvres de Leibniz, VII, 503) cited by Loemker, 1976.

[3] This is not confirmed in all situations: Ynalveza et al 2011 find in a case study from the Philippines that there is no evidence of any association between collaboration and productivity in resource-constrained research institutions in developing countries.

Up to date, many bibliometric studies have been conducted on international scientific collaborations using mainly co-authorship analysis (see chapter 3 in this book). Co-publication can tell us something about the relative importance of international collaboration that leads to tangible outputs (publications) and the nature of the cooperation in terms of countries and disciplines (Glänzel 2001; Adams et al. 2007; Edler et al. 2007; Schmoch/Schubert 2008; Mattison et al. 2008). Today, 35% of articles published in international journals have authors from two or more countries, compared to slightly more than 10% in 1988.[4]

Despite all this accumulated knowledge very little is known about the factors that may induce a young or an established scientist to collaborate at international level and, to our knowledge, very few if any, empirical studies have been conducted on this issue. The aim of this present study therefore is to fill this gap and to come as close as possible to the scientists' real life situation in order to capture the qualitative nature of such choices and their consequences on a personal level as well as on the course of their scientific careers.

This chapter is primarily based on 74 interviews with Latin American scientists. It also draws on selected results from the questionnaire survey (2550 researchers working in Latin America) presented in chapter 5 to provide a quantitative perspective to the issues discussed.

The two studies were conducted at the same time (2009-2010) and were designed to be articulate responses. Within this setting, the interviews were aimed at illustrating the points of view of the Latin American researchers with respect to their international collaborations: what are their motivations and challenges? What benefits can be gained and what is the impact on their scientific careers?

Surveyed populations are obviously not identical and therefore not comparable. Neither sample is controlled and cannot claim to be representative. Nevertheless, they can complement each other: both are focused only on researchers collaborating with colleagues working in Europe, both involved the same questions and followed the same logic. The interviewed scientists are working in the biological sciences which is the main field of the respondants in the on-line survey (with 35.6% from Latin America).

The results obtained give on the one hand, useful quantitative information based on a comprehensive sample (2550 in Latin America), which, although not representative, is sufficiently large to provide dependable results. The qualitative sample (74 scientists) reached in the main the point of theoretical saturation (Glaser B.G., Strauss A.L., 1967) meaning that at the end of the survey no new themes or types of information were emerging from the interviews. The results of the interviews can therefore be considered as reliable.

2 – The selection and presentation of the sample of scientists interviewed

Scientists interviewed in 5 Latin American countries

Eleven interviews were conducted in Mexico in February 2009. Twenty nine took place in Argentina, nine in Uruguay, fifteen in Chile during November and December 2009 and the last ten were conducted in Costa Rica in July 2010.

[4] In recent years, international co-publication has increased in all countries except China, Turkey and Brazil.

Except for Mexico, the selection of scientists to be interviewed was based on:

- visibility in the WoS (Web of Science) as authors co-publishing with European scientists
- former grantees of the International Foundation for Science (IFS) who had co-published with European colleagues
- their willingness to spare the time to be interviewed

Visibility was granted by the selection from the WoS of the top publishing scientists with European colleagues during the last ten years. In Mexico, they were selected on the personal network of one of the authors of this article on the basis of several long stays in Europe (more than 6 months), either for formal study or for professional reasons.

All scientists were contacted by e-mail to check their willingness to be interviewed. Most of them responded positively with the notable exception of some of the most productive scientists who never responded. Whenever possible, “friendly pressure” was exercised through the network of former grantees of the International Foundation for Science (IFS)[5] to convince the non-respondents to participate.

Most interviews took place in the scientist’s institutions. A structured questionnaire with fourteen questions was systematically used to ensure that all issues were covered. The style of the interviews was rather semi-directive allowing scientists to express freely their opinions. The interviews were recorded and later on transcribed. The CV and list of publications of the scientists interviewed were systematically collected at the beginning of the interviews when they were not available prior to the interview. Most of the interviews lasted between one and one and a half hour. Some of them were completed through e-mail exchanges.

The data collected from the CVs and publication lists were processed by means of a database (Access) and the transcribed interviews were analysed by HyperResearch software for qualitative analysis. The results presented below derive from these two complementary approaches.

Age, gender and academic profiles

The bulk of the scientists interviewed (80%) are between 40 and 59 years old, the peak being in the category 50-59 years (45%). Conversely, researchers below 40 years old and above 60 years old are relatively few, i.e. respectively 7.8% and 12.9% of the 74 scientists interviewed (Figure 1). This population is slightly older than the overall population of scientists in Latin America, thus confirming that researchers in mid career stages (40 years and above) are more likely to collaborate internationally than those who are in early or late career stages. The age distribution matches quite well with that of the online surveyed population of biologists working in LAC countries (see chapter 5 in this book). This point has no statistical value given the size of the interviewed sample and the way it was selected but it shows that the opinions expressed in the quantitative and qualitative surveys refer to quite similar populations in terms of age.

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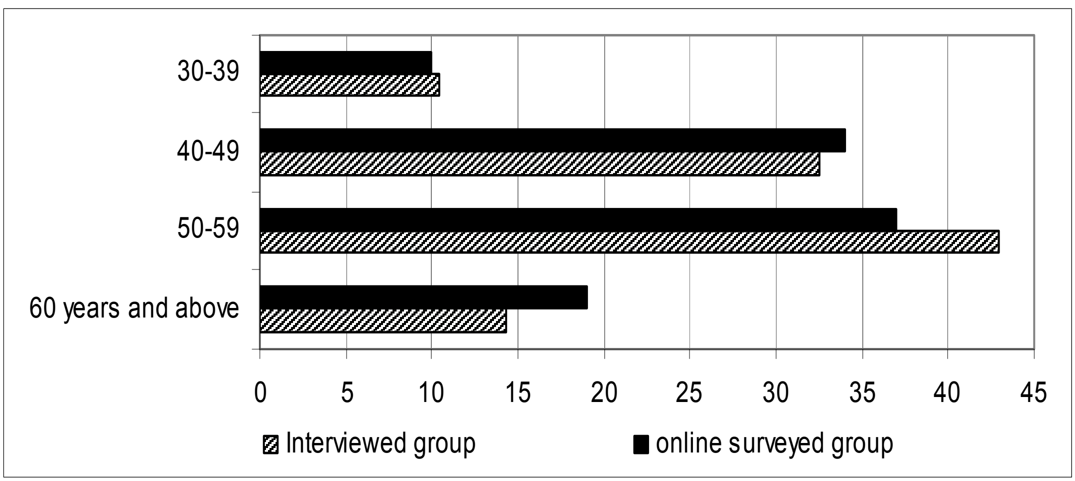
[5] One of the authors is a long-standing staff member of the International Foundation for Science (IFS) and another one has served as IFS Scientific Adviser in the field of animal production.

The large majority are men: 66.3% (compared to 70.6% in the online surveyed population). The relative percentage of interviewed women (33.7% versus 29.3% in the online surveyed group) is slightly lower than that of women scientists in Latin America, i.e. 46% (UIS, 2009). This would also tend to confirm that women scientists are less likely to collaborate internationally than men (NSF, 2009). Most of the interviewed scientists (70 out of 74) have a PhD degree. The largest group (48%) received their highest degree in their home country followed by those who received it in Europe (40%) and in North America (9%). Argentina is by far the country where most of the PhD degrees are obtained at home (83%)[6]. Not surprisingly, given the way the sample of scientists to be interviewed was selected, the relative importance of PhD obtained in Europe is overrepresented. One third of them (32.5%) did a postdoctoral stay abroad[7]. Post-doc stays are much more frequent in Argentina (53%) than in Chile (27%) and in Mexico (23%) while these do not seem to form part of the academic culture and practice of Costa Rica and Uruguay[8].

Figure 1 Age of the scientists at the time of the interview compared with the age of the online surveyed scientists in the field of biology



[6] This is corroborated by the results of the online survey showing that 78% of the Argentinean group remained at home for their PhD.

[7] Except one who did his postdoc in his own country, i.e. Chile.

[8] The only one who went abroad for a postdoc from Costa Rica is a Mexican-born scientist who went to Germany a few years after his PhD in USA. The only scientist from Uruguay did his post-doc in Spain while he was there as a political refugee.

Figure 2 Age average by country at the moment of the interview

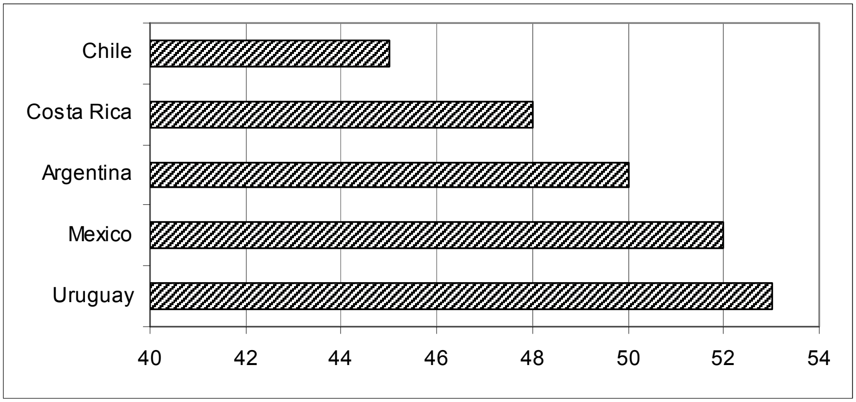


Figure 3 Age at highest degree

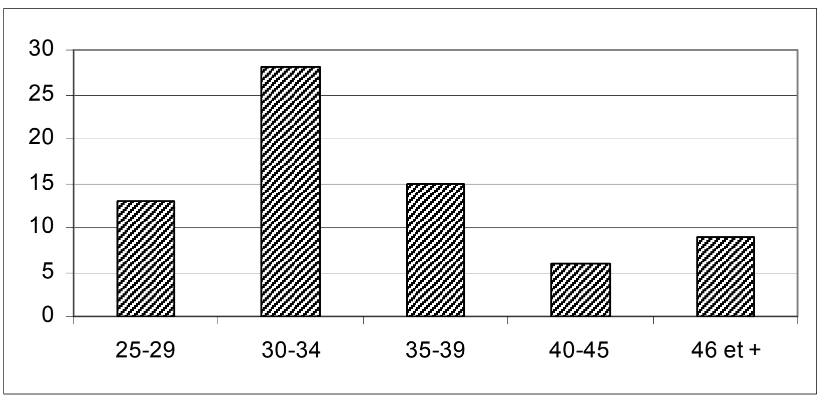
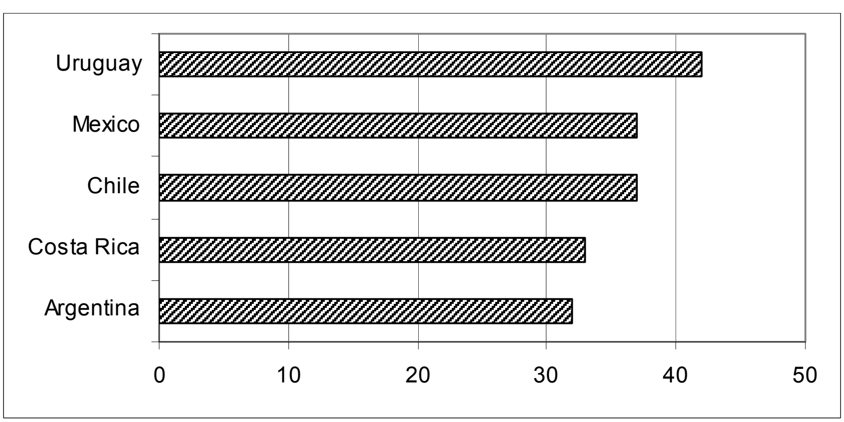


Figure 4 Age average at highest degree



One can see that the Argentineans and Costa Ricans scientists in the sample have a more conventional type of career than their colleagues from the other Latin American countries in our sample who tend to do their PhD at an older age.

This can be partly explained by the fact that in countries like Mexico, Uruguay and Chile, educational policies changed during the preceding decades, producing a climb in the academic levels of teachers in higher education. Some of the interviewees were already in their forties or fifties, when they decided to embark on a PhD either to keep their jobs as university teachers or to gain promotion.

Migratory profiles

The sample consists of almost nine-tenths of interviewed researchers who decided to go back home after their time abroad. Only 10 out of 74 did not spend long stays abroad (representing 13.5% of the group). In the large online survey the quota is slightly smaller: 11.44% did not leave their countries for long periods (over 6 months). That means that in the two surveys the large majority of the respondents / interviewees were not brain drained. The reasons given in the interviews to explain this can be classified in three categories:

1-Unwillingness to be brain drained,

2-The guarantee of an academic position and a salary in their home country

3-Personal or family wishes, ties or obligations at home.

Given the age and the nationality of the interviewees, a sizeable share of them left their countries for political reasons and obtained the status of political exiles while studying abroad[9]. One dominant feature for the refugees is the desire to go back home once a return is politically possible. Nevertheless, not all refugees went back. Depending on a lot of different reasons (professional, personal, cultural etc.) they may well have decided to settle definitively in the host country (Gaillard AM, 1997). Those in the group who went back home after a return to democracy argued a sense of duty to serve their native country. This way of thinking was not exclusive to the political exiles but spanned the entire sample. Even if it was not given as the main reason to return home most often it was a contributing factor as expressed in many interviews: *"Our country needs us, if everybody remained abroad who will then participate in the development of our country?" "I knew that alone I could not do much, but you see, drop by drop..."*

This should also be taken into consideration when explaining why those who had an academic position and salary secured in their host country[10] decided to go back home. Among them many had been offered a job abroad. "*But, if you want to return home, at one moment you have to say 'no' to a job offer, even if you have to say 'no' to a better income* ". We can say that most of the people in the two groups who participated in the surveys (online and interviews) while being convinced of the international nature of science, were "patriots" at heart dedicated to their country and disposed to contribute to its development.

[9] Particularly in Chile, Argentina and Uruguay affected by dictatorial regimes during the seventies and the eighties.

[10] This was the case of the large group of interviewees in Mexico, Chile and Uruguay

THE RESULTS

1 – Why science and why a scientist?

The first question asked by the interviewers "How did you become a scientist? Why science?" was primarily conceived as an easy starter to give a clear signal to the interviewees that the questionnaire related more to their own life history than their scientific interests or outcomes. Despite not being intended to be used in the report, the answers to this question give an interesting image of the group. Fist of all, the commitment of the interviewees to science is clearly manifest. Selected on the basis of their co-publication with European partners in the majority of cases, the responses to this first question plainly indicate a group of gifted people, dedicated to and often passionate about their chosen career

A question of personal interest

Some of the determinants to become a scientist are of a general nature and are probably found all over the world: "curiosity already as a child", "asking questions", "experimenting" (poor insects or worms !), and "verifying the names of the things", "interested in scientific TV programmes" etc. Some of them never asked themselves about their career options: becoming scientist should be the only goal. Whatever their age, the families influence their choice, especially for those having parents or relatives who are scientists, or for those coming from professional middle class backgrounds who, talented at school, had the opportunity to further their studies. *"When I finished university it was a natural process to continue studying".* Nevertheless, family is not always a determinant and among the interviewees upward social mobility is mentioned several times. The right to higher education in the five Latin American countries at the time of study and the availability of scholarships made possible this social mobility.

The impact of the environment

The reference to the figure of well-known scientist or teachers matters also. Most of the Argentinean and Uruguayan biologists interviewed, having done their studies during the seventies, named the Nobel Laureate Luis Federico Leloir[11] as their role model (a number of them did actually study or work in his research institute, the Fundacion Campomar in Buenos Aires). The encouragement of dedicated teachers is also often mentioned. *"I had a science teacher at school who promoted some kind of special sessions that were unconventional. I enjoyed those activities very much, so I discovered that I had some affinity for scientific curiosity and then when I entered the University I looked for some career that was compatible with research"*.

But even on the path of a scientific career, research was not always the first choice. Clinical or applied laboratory work has often been the starting point but was not considered satisfying for inquiring minds: "*I started to study medicine but during training in a lab I discovered that research was very interesting, always new aspects, you have to read a lot, know what happens in your field day by day". "As I was working with a veterinarian, I noticed that nobody did anything in order to know what virus or what disease affected the animals. It*

[11] Born in Paris in 1906, Luis Federico Leloir was awarded the Nobel Price in Chemistry in 1970.

was frustrating for me. I wanted to know what happened with the disease, what viruses are and how we could work against them". Other scientists were attracted by very different, creative and demanding professions such as musicians (flute, piano) philosopher (But *"before you can become a philosopher, you have to understand reality")*. Others were obliged to work either to follow in their parents' professional footsteps (business manager) or to help their parents and family to survive. In the two latter cases as well for eight other professionals (technicians, engineers, teachers) having switched to academic research career later on, one can see the determining role of prominent foreign scientists visiting local universities, discovering these talented people and offering them training and PhD studies abroad. Linked to this role, the provision of a research grant is of course also significant.

A series of opportunities usually paves the way

Except for the group who followed an academic career without question, research became an option thanks to a series of opportunities: invitations for training, to participate in projects, availability of grants, job offers, etc. For senior researchers in several countries (Mexico, Uruguay and Chile) a PhD became a requirement late in their career as well as research activity. Amazingly, only two in the group stated clearly that their choice of a scientific research career was to make a contribution to the development of their country. An Argentinean biologist explained *"I wanted to find ways to help poor campesinos. For me, research is a tool to find sustainable solutions for the problems of the campesinos*. The other advocate of the same idea, a Chilean biologist sees his work as *"a way to reach a goal, to contribute to improving the quality of the environment"*.

2 – First possible stage of internationalization of a scientific career: PhD study at home or abroad?

This question may very logically be asked and the interviews would tend to confirm the hypothesis that a PhD is a first step towards internationalization. A particular feature of the group of interviewed scientists is the rather early stage of internationalization of their scientific outputs compared to the year they obtained their highest academic degree. The average time between the year they obtained their PhD and 1) the year of their first co-publication in an indexed WoS journal and 2) the year of their first participation in an international conference, are

2 years and 1.8 years, respectively before obtaining the PhD for those who remained at home to study

4.5 years and 5.6 years, respectively before obtaining the PhD for those who studied abroad[12].

Thus, the scientists who studied abroad started on average to internationalize their scientific activities and outputs long before they got their PhD[13].

In the interviewed group, 52% obtained their PhD abroad whereas the results of the online survey show that for the interviewees of four of the five countries[14] the PhD is not always

[12] This is an average which includes positive values (some interviewees did not publish nor participate in international conferences before they got their PhD) but the computation of all values gives a negative figure.

[13] One has to remember that some of them were senior researchers when obtaining their PhD.

obtained abroad. For the Argentineans the degree is largely obtained at home (78%) while the contrary is observed in the three other countries: 55% of Mexicans earn their PhD abroad, compared to 61% for the Uruguayans and 74% for the Chileans. Among the PhDs obtained abroad, European countries come first (85% for Chile, 70% for Uruguay, 63% for Mexico and 58% for Argentina) followed by North America, mainly the USA (39% for Chile, 34% for Mexico, 27% for Uruguay and 24% for Argentina). The strong dominance of the European countries is most likely the result of the selection of the surveyed population based on researchers having co-published papers with EU researchers (for LAC scientists and conversely for their European colleagues) as well as researchers having submitted projects to the European calls for tenders. The same bias can be observed in the interviewed group and among the 73 researchers having a PhD, 39 were obtained in their own country, 27 in Europe and 7 in North America.

Reasons to earn a PhD at home

The reasons to study for a PhD at home are numerous but the most striking is the local availability of training. Despite the fact that this point is not obvious from the quantitative survey (see chapter 5) the interviews made clear the difference between countries where quality PhD programmes were available and countries where they were not. Argentina is a good example with the Nobel Laureate Leloir's Fundacion Campomar, where four of the biologists from the group were trained during the seventies. One of them, today internationally recognized, claimed that *"everything I learned, I learned in Argentina: languages (French, English and Portuguese), biology, etc."* He continued *"I think that today for young Argentineans going abroad for a PhD is not ethical, even in the framework of sandwich programmes. The students work on subjects without relevance for our country and obtain an Argentinean academic title. This is not right"* Another researcher declared *"If your intention is to work in Argentina, you should do the PhD here and the postdoc abroad, because if you do the PhD and the postdoc abroad, then you have been more than 8 years out of the country, and you will have no contacts at home if you decide to return. Consequently, if you do your PhD abroad, the most probable thing is that you won't come back"*. Another one said *"Since I wanted to work with national species I had no interest to obtain my PhD abroad"*

The search for scientific excellence

The election of excellence has not always been equally achievable (and still is not) in the five countries and in all disciplines and areas of expertise. For a number of students or young professionals in the group, the only way to become a researcher was to go abroad. *"When I began my PhD study, science was very much underdeveloped in my country. Basic sciences, maths, chemistry, physics, were very much under-supported until the creation of a programme for the development of basic sciences in 1986 (PEDECIBA - Programma de desarrollo de las Ciencias Básicas). Unfortunately, the head of our department did not want to join PEDECIBA. I understood then that I would have no opportunity to develop a research career in Uruguay and decided to go abroad for further study"*. Even when the scientific authorities are more predisposed to change, the required expertise for training at home is not always available. *"At that time, I was one of the first people in my country applying*

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[14] No reliable statistics are available for CostaRica due to the small share of respondents from this country in the online survey (28 people).

molecular markers in insects and I went three times to INRA Rennes in France during my PhD to learn techniques about molecular markers, population genetics etc."

Even today, despite the fact that in the five countries the educational system offers the possibility of obtaining a PhD at home, sometimes in the framework of inter-institutional agreements with foreign universities, study abroad often remains an option. The reasons given are mainly twofold: on one hand, the search for excellence and on the other, a question of opportunity.

The search for excellence, as old as scientific mobility itself[15] and today more vibrant than ever, is usually the major motivation for doing a foreign PhD (as for other scientific stays abroad). While the results of the online survey give a rate of 62.6% for LAC scientists having emigrated at the PhD level for "the scientific expertise developed in the host country" and 47.7 % for "the reputation of the host country institutions likely to promote my career" (the respondents could choose several answers), this motivation is also clearly expressed in the interviews. *"I went to Oklahoma State University because I wanted to earn my PhD with a professor who at that time published the most interesting papers on the effects of snake venoms on tissues".* The search of excellence is linked to the fact that in a more advanced scientific environment you are more stimulated and learn more *"I decided to study in France since the country had a high level of knowledge on goat breeding. I did my PhD in this country. I could learn not only techniques that I did not know but I found out how to better problematize the issues of goat breeding and production under Mexican conditions"*.

Numerous opportunities to study abroad

The opportunity to go abroad has often been, as already indicated, the consequence of an offer made by prominent foreign scientists visiting the country. *"The key event in my career which made the real switch from technician to researcher happened when, in a conference in the north of the country, I met a Canadian psychologist, one of the best in the discipline at that time who, having read some of my papers offered to help me. He came back to my university some time later and invited me to do a PhD in Canada. The Canadian institution would offer me a grant and pay the tuition fees but even if it was not enough to take my family with me, I accepted on the spot, thinking that chances like this do not happen twice"*. The opportunity is sometimes provided by local professors deciding to mentor their students, helping them to internationalize their scientific path through their own scientific networks. *"My supervisor here in Mexico offered me the chance to do a PhD but he thought that I needed to learn new techniques not available in Mexico. He put me in contact with a French researcher frp, INRA that he knew. I was accepted to train there. We signed an agreement between CONACYT and ECOS France. That was the legal framework and a scholarship was provided from the two parts to make possible several periods of training in France. Altogether I spent 3 months in France per year between 2005 and 2007"*.

Bilateral cooperation between countries also benefited many other students and scientists in the surveyed group enabling them to gain their first international experience. These programmes are considered by them as providing great opportunities. *"I did my undergraduate studies here at the University of Costa Rica and I went on to a master's degree. But I did not finish this degree in my country because I was offered a fellowship to go to the Karolinska Institute (Sweden) and train for a master's degree there. Thus I went to*

[15] Already in the third century BC, Alexandria, its library and Museum were the target of the scientific migration for the Mediterranean scholars (Parson 1952).

Sweden, got my master's degree and then I continued with a PhD in biological infections. It was a full time job thanks to the fellowship I received from the Swedish government". *"At that time there was a German doctor connected to the German Embassy who sought candidates for a German fellowship. With another colleague we were asked if we were interested. We said yes. I received a fellowship from the German Government, went to Germany and eventually we both obtained a PhD from the University of Essen.* A lot of other programmes, public or private, bilateral or not, also played a role allowing students and scientists to go abroad for short or long periods such as the US Fulbright scholarship that helped many people in the group to go to the United States and train at different levels during their studies.

Lots of PhD degrees were obtained in the framework of "sandwich programs" initiated through bilateral cooperation or deriving from bilateral agreements between universities. *"I did my PhD through a sandwich programme: I did the research in Costa Rica, then I went to the Netherlands for six months writing my protocol, then I came back to Costa Rica to do my field research and returned to the Netherlands for theory and lab work. Altogether I spent fourteen months abroad. This stay was funded by a Special Fund for Building Capacity".* Regardless of the opportunity, studying in the framework of a sandwich programme is not always an easy task: *"I spent 18 months in Sweden during six stays, travelling back and forth between Uruguay and Sweden. I defended my PhD thesis in 2001. I needed to keep a position here at home and therefore had to come back and teach"*. These sandwich programmes are, according to the participants, more or less tailored to fit, allowing them to follow their own paths and fulfil their particular needs. *"During the five years I was enrolled for my Ph.D. I spent altogether 10 months in Sweden. I did my field work in Uruguay and I came to Sweden with samples to analyse and take lectures on methodology"*. Doing it that way, the young scientists know that while following their own interests, their research subject is in line with their country's scientific priorities.

Sandwich programmes are not always the consequence of national or bilateral policies. Often they are the result of individual commitments. Such a case is the agreement between the Swedish University of Agricultural Sciences (SLU) and the University of Montevideo (Veterinary Faculty) resulting from the personal commitment of a Swedish biologist pledged to improve veterinary science in Uruguay[16]. Making use of the IFS granting programme for local experiments,[17] he enabled a group of professors and students from the Veterinary Faculty in Uruguay to obtain their PhDs in the framework of a sandwich programme organized between the two academic institutions. The role played by the Swedish professor continues to be highly appreciated among these scholars who are called "the Swedes" by their local colleagues. Still today, they share values and ways of thinking that they attribute to their common experience abroad.

Maintaining contact and collaborating with colleagues from the time of the PhD

Do they keep in contact with their supervisors and colleagues abroad once returned home? The general response is yes. Apart from some exceptions, the relationship remains alive at least during the first years of repatriation after the PhD, most often because they continue to

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[16] Mats Forsberg is now retired

[17] The International Foundation for Science is a capacity building program that awards individual grants to young promising scientists in developing countries www.ifs.se

co-publish on the PhD research subject. Not surprisingly, given the age of the interviewees, the relationship with their supervisor was often finished long before the time of the interview, the latter being retired and sometimes deceased. This is the main reason why one of the interviewed scientists said that he advises his students to choose a PhD or a Postdoc supervisor in mid-career, *“not a star, but a growing star, in order to maintain the contact and collaboration with him or her for long periods of time”*.

To continue to collaborate they have to share common scientific interests. The labs where they worked abroad often hosted several foreign students who, once back home changed their scientific subjects *“The Karolinska Institute is very international but most of the students that were there were foreigners. Now they have different posts, some of them are in the States; some are in Norway, in Sweden, in Austria as well. I keep contact with the Austrians. We always talk about collaborating but we do very little”*. Nevertheless, it happens that a well established collaboration may continue despite divergent interests: *“our research agendas may have diverged. The Austrian group opened a new line in ecotoxicology, in which I never participated. On the other hand, I also began to do research with mathematical models without collaborating with them. But besides that, there’s still a common area of research between our two groups where we can maintain the collaboration”.*

As a matter of fact, the relationships and collaborations are often vibrant, longstanding and sometimes carried out on a very regular basis.*” Soon after I came back from theUK, my university went on strike and my UK colleagues invited me to come back to the UK and work there until the strike finished. Eventually I accepted and I went there for four months. During this stay, I prepared an application to get a fellowship to come back to the UK the following year, which I did. Since then, I keep in touch with them regularly and continue to write articles with them on a yearly basis”*. The fact that colleagues abroad move between different institutions widens the institutional networks for international collaboration. *Actually, I am working with the same people but not with the same institutions. Although the experiments changed, our main common research interest remained the same.* The relationship is not only longstanding and fruitful but it may also open other paths and give rise to other collaborations *“I continued my interaction with Hermann and also with Jean-Christophe. With Jean-Christophe, we have accumulated 14 years of long standing and fruitful collaboration (5 co-authored publications and book chapters). I went three more times on study visits to their lab to work with him and a colleague. Now I am starting a new collaboration with his colleague”.*

It is not uncommon that international collaboration started with colleagues met when studying abroad develops into inter-university agreements. “*I kept collaborating with my PhD supervisor and now we exchange people for doctoral activities with different universities in Spain. In 1999, we got a fellowship from the Agencia Española de Cooperación Internacional para el Desarrollo (AECID) for the exchange of Professors. I went to teach for three months at the University Miguel Hernández of Elche (Alicante) and a Professor from this university came to teach in Cordoba. I had teaching activities and supervised doctoral students’ research work. I co-wrote another reference book as an outcome of my collaboration at Miguel Hernández University”*.

The networking effect of study abroad

International networking activities as well have often started when studying abroad: "*It was very important in my lab to keep in contact with other scientists and institutions working on the same subject. We had very productive contacts with many groups working in Europe. My best paper from that time was produced in collaboration between the lab where I was working in the Karolinska Institute and a research group from the University of Uppsala. We also had good collaboration with a group in Italy. This collaboration has facilitated further contacts with other scientists in Sweden and later in other countries of Europe".* Early scientific contacts may also evolve into international expert networks. *"Doing my PhD in Spain I met other students from Latin America, from Chile, Uruguay … I also met a scientist from Mexico who was in Spain on her way to a congress in the Netherlands. We started to collaborate and the collaboration prospered. We have now published a book together with many co-authors from Mexico, USA, Canada, Spain and Korea. We developed a network of experts working on different meat products".*

Studying abroad can also contribute to the building of national networks such as alumni associations whose visible or invisible role can impact national scientific life*. "I keep close contact with former PhD students from the time I myself was a PhD student. They are now scattered in different universities throughout Chile. We have several joint projects and now we are applying for a national funded programme to establish an Insect Centre for Research on Plant Insect Interactions (ICROP or High Crop) to provide a formal framework for our national and international collaborations".*

These early contacts (as young students) also provide a useful understanding of the different cultural contexts of research facilitating further cooperation with colleagues from different places in the world. *"Through my PhD supervisor I was invited to an interesting endocrinology course taking place in Budapest. All students except me were from Eastern Europe. We had two excellent teachers from the Netherlands. I participated again in this course two years later and there I met a French professor from INRA Clermont-Ferrand who is one of the best animal production scientists I know. After that, I started collaborating with the Hungarian scientist who organized the course and with this French professor. It was difficult to collaborate with him. Science is very much affected by the societal considerations. If you go to Sweden you don't quite know who the boss is. When I was in France it was exactly the contrary, nothing could be decided without the boss getting involved. When he decided something in the framework of the collaboration project, he was very inflexible. We learned to collaborate. We got a grant for an exchange programme (ECOS programme). I went several times to Clermont-Ferrand together with some of my Uruguayan colleagues and the French scientists came to Montevideo. Eventually we published three papers together".*

3 – Post doctorate abroad, a possible springboard for collaboration at the highest scientific level

As for the PhD, doing a post-doc abroad appears from the interviews to be a very efficient way of internationalization of collaborations. A third of the interviewed group (27 out of 74) did a post-doc abroad; the big part most of them Argentineans (18 out of 27). As a way of comparison, the online survey gives a more elevated rate with 42.2% of the respondents going abroad to do a post-doc (48% of Argentineans, 33% of Mexicans and 30% of Chileans).

The interviews clearly show the prominent role played by a post-doc abroad to facilitate the initiation, the duration and the development of scientific international relationship.

Most often the interviewed scientists went abroad for a post-doc after having done their PhD at home (only nine did a post-doc after a PhD abroad). The reason given is most often the search for excellence. They organized the post-doc by meeting scientists in congress or by writing to heads of laboratories. Two of them happened to do it while following their spouse abroad and one joined a professor in Cambridge, UK who happened to be a countryman that he met at a congress in Buenos Aires.

Working in the specialty developed abroad once back home?

In most cases, when they returned home, they wanted to continue to work in the speciality field they developed abroad. Those who knew that the challenge could not be met because of too large a gap between their research area and the state of art in their home country tried to adapt their knowledge and skills to new approaches in a different field. "*When I returned to Argentina in 1985, I knew that I could not continue to work in neurobiology because it was too expensive to develop a field of research such as this here and because I wanted to work in a field related to my country's economy. I started to build a new research team in molecular virology, the first I think, or one of the first in Argentina. I took advantage of my background knowledge to apply this new subject to plant biotechnology. Today I still continue in this research area at the frontier between biotechnology and neurobiology, but with emphasis on biotechnology".*

Nevertheless, most interviewed scientists came back and worked in the speciality field developed abroad. Often, the host institution abroad played a role by supporting them and offering them different types of assistance to settle back home. For instance a German institute awarded a grant to a post-doc from Argentina whose mission was to establish a local research group aimed at enabling future partnership. Another researcher puts it this way: "*The strong motivation for the internationalization of my career was my post-doc. I went to Denmark thanks to a researcher I met in Argentina at the end of the eighties when he visited the country. He was working in a prominent laboratory in Denmark, colleague of a researcher who won a Nobel Prize in 1997 and I was doing my PhD here in biochemistry. He invited me to do a post-doc in his country. I went there. Two years later, this lab in Denmark received a grant from the European Union in the framework of the FP6 for a joint project between Europe and Latin America. This grant was very important for me because at that time no funding was available in Argentina and it helped me to return and to start my own lab here, allowing me to buy all the equipment I needed. Given that our part in the project was a continuation of my post-doc research, I could easily work on it in Argentina. The methodology had been developed in Denmark and we applied and improved it. Thanks to that, we became a reference laboratory.*

Networking among alumni circles

Those who had the opportunity to do their post-doc in an internationally renowned laboratory agree that it generates prestige, a kind of "label of excellence", and creates links based on mutual recognition between the "lucky ones" who all over the world shared this fortune. *"The lab where I did my post-doc in the USA is the best in its field and almost all renowned scientists working in the field have been there at one moment or another. Just now I am working closely with a Spanish lab whose head also did his post-doc in this lab". "I began to* *liaise with them because of the affinity of our research interests; it is the best group internationally in the area in which we work. And also because I met the boss of that group when I was at Yale University; he was also doing his post doc there".*

Doing a post-doc in a lab that is internationally recognized is also a powerful means of building a scientific network at a high level. *"Right after the PhD I did a post-doc in the US. It was in a good lab and my supervisor was well-known and had just become elected a member of the National Academy of Sciences (NAS) because of his contribution to his field. There I met a lot of people. We were two hours away from Boston and every week we had people coming from Boston or flying from California, « big names », to give talks. A lot of social interactions occur when conferences last for five days. You have time to talk to people. You can talk to somebody and the next day you can talk again. So you get time to develop your ideas and you can keep on discussing in greater detail. It is different if you meet somebody for just one hour and meet this person again six months or a year later".*

The links created through the post-doc institution are perpetuated by the next generation of students who are readily accepted for scientific visits and post-docs within the network which has been developed around the post-doc lab. "*I usually send my students to laboratories that I know and with whom I have already collaborated"* (the collaborations of this researcher taking place, as she said earlier in the interview, mainly in the environment of the network built around the post-doc fellows). *"It will be easier for students or researchers to be accepted if they present references from known researchers. Personal contacts with the director are very important".*

Trained to compete at international level

Access to funding is also facilitated by the experience obtained during the course of a post-doc or as a member of networks. It may be private funding: "*I did a post-doc to study in depth questions that couldn't easily be answered here. But the most important was the opportunity to do other things around this research. I was, for example, involved in the first stages of a big industrial project to develop vaccines. It is certainly a big advantage for me to remain connected to this lab which is public but raises a lot of money from private sources*". Another very important way to secure international funding and to extend collaboration is through the experience gained by applying to international calls for tenders. *"An additional consequence of my association with the institute where I did my post-doc is the collaboration which was initiated with European partners once I returned to Argentina. In the framework of an INCO European programme, a collaboration gave me the opportunity to work with 17 other laboratories in Europe and Latin America, as well as with three labs in the USA whose role, in this context, is to advise on the INCO project group"*.

The conclusion on the global benefit that one can draw on from doing a post-doc abroad is given by this researcher who claims its necessity to understand scientific production and science itself. "*Doing a post-doc abroad is essential, because people who stay in their own country are too often ignorant of how science really works. People who are not exposed to the major centres of international research have huge problems understanding that science is an international, multidisciplinary and team produced activity which requires a critical mass of researchers and a certain level of interaction. Only cosmopolitan groups can reach the level required to approach scientific problems from different viewpoints*."

4 – Other stays abroad, a more uncertain way to gain recognition and find international partners

While 35 % of the Latin American researchers who filled in the online survey used the sabbatical system to make long scientific stays abroad very few people (only four) in the interviewed sample used this leave of absence for scientific stays abroad. Therefore it is difficult to discuss the relevance of sabbaticals abroad as renewed opportunities for further training and international collaborations. As a matter of fact the four interviews give an unclear picture, more on the negative side, which makes it difficult to describe the issue without risk of characterization.

One question is why so few people in the sample used the sabbatical as an opportunity to go abroad? One answer is that the system is well established only in Mexico (where 11 interviews were conducted and where the four examples come from). In the four other countries the system effectively exists but, for many reasons, is very rarely used (lack of time, of funding, difficulty to be free from teaching duties etc.).

The need for sharing interests in a win-win process

Nevertheless, other types of scientific stays abroad were mentioned during the interviews but it seems that those that are not based on pre-established networks struggle to develop lasting relationships through occasional and sporadic stays in laboratories abroad. First of all, it is not very easy to find partners for those who are not included in collaborative networks. *"I tried to find partners from different countries in scientific congresses. Unfortunately when I asked if I could go to work or learn techniques most people were very sceptic».* To use again one of the preceding excerpts it can be difficult to find partners and be invited to laboratories abroad when you are not recommended by known researchers.

Not only reliable references are needed but also overlapping scientific interests and the capacity to converse at an acceptable level. When a young scientist with not much experience or self-confidence arrives at a big renowned lab to learn techniques and with samples to analyse, the risk is tangible that his (or her) value is restricted to the sample material especially if the person has no special coaching and human talent to initiate the relationship. The risk is high when during this short period of time a win-win process cannot be initiated. "*My first involvement with Europe was within an INCO project. I came into this project thanks to a colleague who put me in contact with a famous laboratory in Paris. I went there for one month to learn new techniques. But, I did not interact much with the French scientists. I was very disappointed with this aspect, but have to recognize that we had not much in common. We produced a co-authored publication and that was that".*

Several other young scientists mentioned having experienced the same kind of frustration. *My training led to a first joint publication with English colleagues on the taxonomy of the samples that I brought with me to analyze in London. We then planned to collaborate on another project and a British scientist came to my lab to teach and work with me. Another co-authored paper was published from this second period of collaboration. But since that visit it has always been a one way communication. I try to have regular contact with them, ask for papers, for advice, I send specimens for identification but nothing happens from the other side. My British colleagues seem to have lost interest since they visited us".*

A young Argentinean woman who went to the US with a Fulbright and had several other stays abroad expressed it in this way: *"I would be very interested to enter into an international network on my scientific interests but nobody comes and asks me to collaborate. Until now each exchange of information or communication that I had with foreign colleagues is all one-sided"*. Judging from the interviews this attitude tends to be more frequent among women than men

The relationship has to develop, and not only professionally

The fact is whatever the nature of these stays abroad (invitation by a foreign scientist, participating in international scientific projects, benefiting from colleagues' networks etc.) the scientific relation needs some ingredients that are both professional and social in order to grow.

To ensure continued collaboration, researchers have not only to share common scientific interests leading to reciprocal professional enrichment but also (it will be stated more strongly later) they need to develop some sort of personal relationship based on mutual empathy and friendship. In other words it. has to be a win-win professional exchange in which friendship also develops. When one of those two ingredients is missing, the scientific partnership cannot grow into a more established collaboration and is likely to remain a one time or intermittent event.

5 – Building networks with international partners without scientific stays abroad

As reported previously 10 out of 74 interviewed researchers (13.5%) did not spend time abroad, not for study, post-docs nor for training. However they gained considerable benefit from the international input in the course of their collaborations. Some of these advantages are apparent from the interviews and are presented below.

Benefiting from colleagues' partners

The association and collaboration with national colleagues who have themselves well established international collaborations may also facilitate entrance into international collaborative networks. "*I went to teach and collaborate with colleagues in another university in the south of the country. They had a long lasting collaboration with German scientists. I embarked on the project and we then started a new stage of collaboration between my university and these German colleagues*". To gain entrance into such arrangements, researchers have to present profiles or research topics that are of interest and can attract the foreign partners for further collaboration based on a win-win process.

Working in relevant research topics

These research subjects, often connected to local conditions (altitude, latitude, ecological environment, populations, endogenous fauna and flora etc.), allowed some scientists in the group who had no previous international connection, to benefit from international programmes such as the International Foundation for Science's (IFS) grants programme, as well as several schemes developed by international organizations like the International Atomic Energy Agency (IAEA), the World Health Organization (WHO) and the Food and Agriculture Organization (FAO)[18]. "*A joint programme from IAEA and FAO offered a course in*

[18] The list is of course not exhaustive, only the organizations mentioned in the interviews are reported here.

radio-immunoassay in New York. As they were too many applicants, the Agency decided to send an expert to interview them. At that time, I was planning a project to study vicuna (a wild camelid) living in the north part of Chile in the high plateau. The expert told me to write a project on the reproduction of vicuna that would give me a 99%chance to get a research grant. That was the way I came in". Another researcher explained: "I contacted the group in Lyon due to my participation in an Alpha project related to the study of the effects of high altitude on human physiology. The project involved France, Italy, Germany, Chile, Peru and Bolivia. Our studies were relevant as a model".

Being at the right place at the right moment

Some researchers benefitted from the chance opportunity to work in the right place at the right moment. *"I moved to the south to the Strait of Magellan to a newly established multidisciplinary institution (zoology, botany, archaeology, experimental green-houses etc.). The mission of this institute was to provide basic information to better understand the development of the Strait of Magellan. … We worked on three main aspects: biology of important commercial species (e.g. Chilean king crab), red tides, and oil pollution effects. Work on the two latter phenomena started when we were there. The first red tide appeared in the Strait of Magellan when I was there. Local people died after eating molluscs. At that time we came in contact with foreign scientists from the UK and Norway who came to visit the institute. That was also the time when the 2nd workshop on Harmful Algal Blooms (HAB) was organized. A world known taxonomist from Argentina also came to visit us. At that time we also had collaboration with the University of Concepción. Some of the studies were conducted together. Personal relationships were very important at that time. It was not as formal as today".*

This scientist and his institution greatly increased their international recognition and collaborations thanks to private funding for just being at the right place at the right time. *"For the oil pollution studies we got foreign funding from a big oil company. On August 1974, we had a big super tanker accident in the eastern part of the Strait of Magellan. One of the biggest oil spills: 50,000 tons … Being in a very remote area, we didn't specialize in one given area but contributed to all. We integrated different teams to study the fate of the oil. We were pressed by the circumstances to try to understand what was happening. We also had the possibility to go to England and Wales, and we visited different places during 6 months, establishing contacts and learning techniques. I went with another colleague, an ornithologist to Plymouth and to visit an oil pollution centre located in Wales, North West University, Newcastle and I finished in a laboratory belonging to the States in Southern England". "I became associated with a number of international red tide networks e.g. the UNESCO red tide programme. I was introduced by a French IFREMER scientist to the steering committee of the Global Ecology and Oceanography in Harmful Algal Bloom (GEOHAB). Through that committee, I was in contact with many scientists in different parts of the world not too much related with research but rather related to planning and monitoring activities related to red tides".*

Attracting peers' attention during scientific meetings

The last reason mentioned in the interviews is recognition by peers at international meetings. "*My first international trip was to attend an international meeting on marine plants in Liverpool in 87-88. It was a very important meeting for me. All the big names I* *knew from the literature were present. I received good comments on the work I presented and I felt encouraged. I met a French scientist in another aquaculture conference. He invited me to IFREMER, in Brest, in France. My collaboration with international colleagues started at that moment*".

A scientific activism on social and environmental issues

Scientific activism for local development and progressive involvement in regional cooperation through NGO networks may also awaken and facilitate international interest and attract international funding and collaborations. *"My interest in scientific activities for development drew me into an international network where I developed collaborations. Firstly, I was part of a regional group that linked my university and another Argentinean university to a Peruvian one and to two NGOs (Bolivian and Argentinean). The aim of this group was to help poor pastoral people have better incomes in terms of production, transformation of products and access to markets. In 1981 and 1982 this group was invited to* Italy and Germany. This travel gave way to a multilateral collaboration between us and two European universities in Italy and Spain".

6 – Formal frameworks and/or unofficial ways of collaboration

In the online survey 52.4% of the scientists from Latin America answered calls for tenders involving international collaboration. In the interviewed group, the majority seem to give priority to small scale sometimes bilateral collaborations based on personal relationships.

Participating or not in international calls for tenders

The reasons given by the interviewed researchers to explain why they do not participate in international calls for tenders/proposals are approximately the same as those seen in the online survey. First they consider that to be involved they have to be informed (this was the first reason given in the online survey by 49.2% of Latin American scientists). On the other hand those who apply for international tenders (and sometimes are successful) watch out for these, are told by foreign colleagues or hear during international conferences. The second reason given in the online survey for 38.4% of respondents is "too much bureaucracy". This is also frequently mentioned in the interviews. *"Involvement in some programmes implies a tremendous bureaucratic-administrative job for a relatively uncertain result"*. The third reason "too selective programmes" which received the agreement of 34.1% of the respondents in the online survey and is often mentioned by the interviewees. "*We applied with a German laboratory to a European Community's programme. People came to teach us how to work within the framework of this programme. But it is very difficult because if you are not working exactly with the subjects they have predefined you cannot even apply*". Like 32% of the online survey respondents, the interviewed researchers think that they have "problems finding partner laboratory". *"It is very difficult to find a counterpart, a very strong counterpart who wants to do a project, who knows how to write it and who knows you enough to involve you in the game".*

Among the other reasons given to explain why some researchers have little inclination to submit applications to calls for tender is the availability of national funding programmes for science in the five countries where the interviews were conducted. An Argentinean researcher talking of European funding programmes expressed it clearly: *"In the middle of the 90s local funds became available at national or regional levels or within universities…*

Funds of other kinds also became available, and that rendered the European Union's programmes less desirable". The question of language is not trivial when deciding to collaborate internationally, especially for people who did not spend long periods of time abroad (13% in the interviewed group and 11.5% in the online survey respondents). "*To publish in English and work in English is very difficult for me. Nobody can help me. Some of my colleagues have partners in the US who help them to correct or rewrite their articles. I may be a good scientist, but without English I cannot be a good partner".*

For several of interviewees, scientific interest in such programmes is not even mentioned. "*I have the feeling that these kinds of projects are not very productive from a scientific point of view. There is a lot of travel but not much result. Another problem is the complexity of the organisation. The funding benefits are low in comparison to the effort in time and work necessary to be the successful applicant. . Small projects with two or three partners seem to me more effective*". Another researcher is of the same opinion: *"I am a little bit reluctant to embark on such collaborations. From what I have seen, these big projects involving many labs are also big headaches... I do not plan to do that for the coming years. ... This is not a spontaneous way of working and most of the money from projects is going towards travelling, workshops, meetings. Yes, the bigger part of funds is used for airfares and per diem, not for research."* On the top of that, the more partners in a project the more difficult it is to reach consensus. *"I have been a member in a project involving a large network. Many people were active and I became discouraged because it was not possible to reach a general agreement on ideas. I realized that lots of people means lots of troubles. I prefer working in smaller groups"*.

These views are tempered by other researchers who while recognizing a scientific interest in big international projects suggest that they are not the rightful place for knowledge production. "*I am now participating in a big European scientific programme and I recognize that it is a good breeding ground. But in my experience it is not the place for scientific exchange. The real place is the inter-laboratory relationship. When you have a question or a problem to solve you seek 'the expert', even if he or she is on the other side of the world. This is the only person who can really help you and with whom you will have a gainful exchange".* The bilateral collaborative framework is undoubtedly the preferred mode of collaboration of the interviewed researchers. This is also the most frequent framework for collaboration for people who answered the online survey (71.5% in Latin America). As said before, the interviewed scientists show strong international collaboration practices based on existing networks often deriving from studies and post-docs done abroad which may give rise to bilateral or inter-university cooperation schemes.

Inter-university agreements

These bilateral agreements specially the inter-institutional ones seem to be for the interviewees the preferred instrument to conduct international collaborations. These agreements provide them with a flexible framework that allows international exchanges for both students and professors by funding travel and accommodation costs. They also promote new collaborations (provided that new colleagues belong to the partner institutions). Nowadays the multiplication of these inter-institutional agreements while being often a result of international collaborations contributes also to reinforce the building of new scientific networks which in turn increases the circulation of both scientists and knowledge.

Collaborations outside official frameworks

However in the online survey as well as in the interviews researchers emphasize the fact that often international collaborations take place outside formal frameworks. Of the 11.3% of scientists in the online survey who answered that they did not collaborate within the framework of official agreements, more than half (59%) mentioned a number of reasons that could be grouped under the generic category « without or outside any institutional framework». These would include reasons such as "mutual or shared personal scientific interests", "friendship" and "spontaneous collaboration". Collaborations developed on a personal basis may however progress into a more formal collaboration involving international funding schemes at a later stage as shown in the following excerpt from the interviews. *"Besides those well-established relations with Europe we have more casual relations with several groups. We have worked with German labs, with French and other research groups in Spain and Slovenia. All these collaborations have been more on a personal level without pertaining to specific projects or official frameworks. Lately we have started a very good collaboration with a very good lab in Italy [22]at the University of Padua. One of the experts in bacterial toxins, aware of our work wanted to spend four months with us. It was a big honour for us. He came very informally. After his visit we started a more formal collaboration with his lab under the framework of European funding".*

7 – The networking power of conferences and communication

As expressed previously (point 5), scientists who did not spend long stays abroad can still get involved in international collaboration using other means. This is especially the case of conferences where conversing with peers they decide to exchange information, start collaboration, organise student exchange or decide to create consortium to submit to scientific calls for tender. This is obviously not only the case of scientists who never studied or worked abroad. The fact is well-known among scientists that scientific workshops, seminars and conferences offer meeting platforms creating links both at professional and personal levels. "*A lot of collaborations start like that: you have a meeting somewhere; you have a nice time together with colleagues, with science as a common interest. You say: 'yes, let's see if we can come upm with an idea to make the things more formal' and that's it".*

Collaborations with people met in conferences

More than a third of the online surveyed Latin American scientists (37.3%) had collaborated or co-published with foreign scientists that they occasionally met at international meetings. The first reason given for attending international scientific conferences is the acute necessity for some of them to compensate for the narrowness of their scientific discipline locally. "*Especially in my field, it is important to attend international conferences since I am the only one working in fungal research in my country". It is also a big source of stimulation: "You get a feeling about what's going on in the world and you come back home with a lot of ideas".* Another researcher puts it in terms of the boundaries of knowledge: "*this is also important to get a feeling where the frontier is in your field of research".*

Surprisingly the collaborations started with people unknown to the scientists before the meetings are often long-term ones. The responses given to the online survey show that only 13.4% of the Latin American scientists involved in this type of collaboration do not continue the association while 84.6% continued working in partnership. The major part of these lasting collaborations (71.5%) continues within the framework of bilateral agreements. *"I met* *my more durable French partner at the first meeting I was invited to in the Canary Island. We knew each other's work and despite our different disciplines and approaches we got along so well that both of us had the feeling that we were old friends. We decided at once to work together and combine our approaches. We wrote a proposal on the spot, we got grants and the project started. Since then, we meet at least once a year and we have organised a common PhD curricula between our two universities. In 2005 we signed an agreement to train students from both universities. We really raise a new breed of students: multicultural and multidisciplinary".*

Recognition by peers

As stated before, to be invited to a scientific meeting is often a mark of peer recognition and the proof that scientists from less scientifically developed countries can remain at home and still be excellent researchers. *"The first meeting I participated in, was a conference in California where I was invited to give a lecture on seaweeds. The paper was very well received. That was for me a confirmation that I could do research while remaining in my own country"*. This recognition is often a prerequisite to start and extend networks: "*When I started to work internationally it was only with people from the United States. Then I started to work with the International Atomic Energy Agency and in this project we happened to work with some Swedish people. Then I went to an international congress to present the results of our work and there I was surrounded with lots of people from Latin America and the Caribbean and from many other countries and that was the beginning of a larger network".*

Nevertheless, as shown by the results of the online survey, the propensity to start collaboration with unknown colleagues is slightly more evident among scientists who have experienced migration. The previous mastering of a foreign language is obviously a plus and people with personal experience of multiculturalism and of international exchange feel more confident when embarking on collaborations. *"Since I came back from Oklahoma, I have continued working on research and publishing. I started to go to scientific meetings and I came in contact with people from many other countries and I asked them if they wanted to work with me. I made proposals: "we have this toxin; I know that you have already published on characterization of other toxins, why don't we do this and that together? I had real suggestions and often we agreed to collaborate. I like to collaborate; I like to interact with people in general and in science in particular. I find that these encounters are a very rewarding aspect of my work".*

Collaborating through Internet without knowing people

Of course, scientists meet not only physically at conferences or seminars, but as they have always done since the beginning of science, they also communicate by writing. On this aspect, the ease of written communication since the advent of the Internet is a multiplier of their predisposition to work with colleagues from abroad (known or unknown). Of the Latin American scientists who answered the online survey 28.1% had collaborated or co-published with foreign scientists that they had never met but with whom they communicated through the Internet. The following long extracts from an interview conducted in Chile illustrate clearly the power of the Internet to initiate scientific cooperation.

"I met a scientist in Dartmouth who went there to give a lecture. He was working with something that caught my attention. After a while I contacted him by Internet, reminded him

that I was interested in his work and asked a number of questions. He was nice enough to answer me, saying something like "well it is interesting but my plate is full right now and I have no time to collaborate but I know somebody else who could be interested" and sent me the e-mail address of this scientist. I wrote to him although I had never met him. He got interested and sent me a letter of support and a proposal to participate in my grant project as an external collaborator from the United States".

"Contacting people through the Internet happened to me a second time: A year ago, I was reading a newspaper report about an American scientist who had discovered a fungus in Patagonia that was able to produce micro-diesel. This person had already published on the subject and his findings were replicated in the newspaper. In the article the scientist pointed out that he made three visits to Chile without meeting any Chilean scientists. He just came here to collect samples and went back to the States. I started to read more about him and discovered that he was a rather big name in the ecology of fungal species. Then I decided to contact him to say that I was interested in meeting him next time he was in Chile. He answered right away but given that he is always on the move until now we haven't been able to find, a date when both of us would be available. A few months ago, he sent me a new message saying that he was writing a NSF grant, asking me to be part of his team as the counterpart in Chile. Just two weeks ago he contacted me again to find out if I was still interested in micro-diesel production because he had funds to host me at his institution for a number of months. And all this happened through the Internet."

However researchers generally agree that virtual meetings are usually not sufficient for long term collaboration. "*Communicating through the Internet is not enough, since you do not feel committed enough until you meet the people face to face. In my experience, the best way to collaborate is to travel and meet up with people in order to agree on a common project*". Nevertheless all agree that the use of Internet has greatly increased the quantity, the quality and the sustainability of their collaborations with scientists from abroad that they already knew. "*Long stays abroad are no longer needed since we are in contact with everyone in the world through the Internet. You can work in two directions: send and receive all the papers you want and need. We can write with remote partners, co-publish as well".*

Several female scientists pointed out that without the use of Internet they could not have collaborated with colleagues from other countries. "*We work as a team, but I don't have much chance myself to spend time away because I have small kids to take care of. Without the Internet I could not collaborate with people from abroad*". To some extent the use of Internet may help to alleviate family pressures in terms of international collaborations. Nevertheless, the interview continued with: *"My husband who works with us as well is attending a conference in Boston right now. Then he will go to Sweden to talk to our partner there and arrange all the new aspects of the paper we are writing together. Afterwards he will go to Spain to meet with other colleagues and arrange for a stay for one of our master's students who will do his PhD there".* As one can see, the power of Internet was not sufficient to help to change gender roles in this scientist's family.

8 – Science matters but personal trust is a prerequisite

Although science is at the heart of collaborations, shared scientific interests do not necessarily produce fruitful and longstanding partnerships. The human aspect is at least as central as science itself in these kinds of matters. All scientists interviewed agreed to varying degrees that. "*You cannot consider only the research subject. Scientific collaboration involves a social relationship and you have to consider both aspects. If you like the research subject very much and dislike the people doing it, you will not collaborate with them*". Several researchers pointed out that their stays abroad were not very easy because of difficult relationships with their thesis supervisor or because they suffered unfair behaviour of colleagues. In these cases, neither the personal relationships nor the collaborations prospered and often the scientists felt frustrated. Sometimes they expressed a kind of resignation, having the feeling that coming from less developed countries they could not be respected as fully-fledged colleagues.

Collaborate with friends

Mutual respect is the least one can expect in collaboration but more often the researchers express the need for an even higher degree of commitment. "*To know people is not enough, you have to know them well before asking them to collaborate with you. In the UK I know several groups but not well enough to suggest to them that we work together. When you have common interests, then you have to get along so that friendship and trust can grow*". This may happen very quickly like this Chilean scientist already quoted who met his most constant French partner at a meeting and who had the feeling straight away that they had known each other for a long time. Another Chilean researcher points out that friendship can be the result of collaborations. "*The work was very successful. When you do not know the people beforehand, you never know… But it turned out to be very interesting. They are very good to collaborate with, we know them, we get along very well. If we compare with the beginning of our collaboration when we were very anxious about how we could work together, we see that with time we have become close friends. When they come here they come to my place, and when I go there I go to their place". Eventually, a Mexican puts it this way: "You do science with friends and collaborate with friends".*

Nevertheless some interviewees consider that, as far as they are concerned, international collaboration is easier than local collaboration. Part of it is due to the distance existing between partners. They are not close enough to partners to experience trivial and daily problems and in addition, the plans for collaboration are better defined. "*International collaborations are very straightforward, very simple in the sense that we discuss what we want to do and divide out the work. You know that you are committed and if some of the partners are having problems they will tell you that they are not able to get the results for a particular dead line".* This criticism is sometimes made by scientists who, through working abroad, have learned working habits and methods that are not much in use by people who were never confronted to international work as discussed earlier in this paper.

The vulnerability of personal links

The fact that interpersonal links are key drivers of collaborations makes them vulnerable and may endanger their permanence. Several times the interviewed researchers pointed out that their collaborations with the institution or even with the country where they did their PhD ended with the change of post, the retirement or the death of their supervisor. "*Unfortunately, my supervisor retired, the university went through a period of restructuration and his lab faced financial problems. Consequently, collaboration with our faculty collapsed*". As already mentioned, for this reason some Latin American researchers/professors advise their students to choose relatively young supervisors from abroad. They expect that good scientists in the early stage of their careers are more likely to incorporate their students rapidly into their scientific networks and keep contact with them for longer periods. Of course, the interviews also show that a large majority of researchers having done their PhD or a Post doc abroad were already included during their stays abroad in scientific networks. They had time enough to build personal contacts with lots of colleagues and were not affected by the end of their supervisor's academic career.

The human aspects of collaboration are the most rewarding

To end with the matter of personal relationships in scientific collaboration, we reproduce below an excerpt from the interview of a talented Mexican researcher whose international scientific activity is substantial: *"The rewards of international collaboration have been tremendous in my opinion. I always tell my family that if I am asked what is the main reward I've had from my career I would say that it is the people I've met. Meeting people and getting along with them may sometimes be difficult, but very important in human, cultural and scientific terms. So to me who never had any single problem with my international partners, collaborating with them was tremendously rewarding".*

9 – The outcomes of international collaboration at the individual level.

The main outcomes of international collaborations in the online survey for Latin American scientists was in descending order "learning new techniques" (71%), "publications in high impact journals" (69%), "international scientific recognition" (62%), "greater recognition within my institution" (45.5%), "access to equipment not available in my country" (42,3%), and ultimately , "Increase funding for my lab / institution" (24.4%).

Learning new techniques and publishing in high impact journals

"Learning new techniques" was pointed out several times during the interviews "*This group was very open to collaboration, and that really helped me and the institute a lot because we were in contact with groups that have technologies that we didn't have at that time here".* Similarly, researchers who spent long stays abroad indicated that their choice of an outstanding lab was primarily based on access to facilities and techniques not available in their laboratory or country.

The researchers interviewed also clearly expressed that the numbers of publications co-authored with foreign colleagues as well as the number of papers published in high impact journals are important for them. "*Our PhD students sent abroad have to publish at least three papers in a journal with an impact factor above two. That is relatively tough. I am always a co-author as well as the supervisor in the host lab, but I may or not be the corresponding author. This is discussed between the two labs and depends on how much research has been performed at home and abroad".* The preceding excerpt came from a Costa Rican researcher's interview. The following one coming from an Argentinean is equally as explicit: *"With the German lab, we publish on average 1 to 2 papers per year. We have an agreement for when our students work together: when research is done mostly in Buenos Aires the article is written here and the Germans figure as co-authors. On the contrary when the work is done in Germany we are the co-authors. It's a fair agreement, and has worked very well, it allows us to publish in journals of a very good level"*.

International collaboration may help to get national funding and recognition

Co-publication at international level may also help to get funding "*When you are a young, not yet a known scientist at home, to publish with foreign colleagues may help to get recognized in your country. For FONDECYT the number of papers and the impact level of the journal account for 40% of the funding decision".* Despite the fact that relatively few scientists interviewed made a clear link between their career advancement and their international recognition, those who work in countries where they are evaluated on work published in high impact journals recognise the effect of international collaboration on their career. As a matter of fact, the more they collaborate with people from abroad and the more they publish in peer reviewed journals, the better and quicker are their career promotions and their success with national calls for tenders.

Their personal history as researchers also proves that international collaboration has a lot of positive effects on individual careers. In four of the five countries we met very talented and specialized technicians that changed the course of their careers while participating in international projects, collaborations or even conferences. Either their talent was noteworthy or their knowledge was very specific (because of their particular environment or their specialty) which attracted the attention of certain people in the international academic community. They were invited to do a PhD abroad and could consequently become fully fledged researchers and full members of the academic world in their respective countries once they returned home.

"*In 1977 I got a position as a medical technician at the faculty where I am now the Dean. My interest in biology was very keen and I decided to continue studying aside my job. I started a "licenciatura en Biologia". This "licenciatura" was validated as a BSc (with honours) by the Ministry of Education in Canada 6 years later (in 1983). At that time I already had several papers published given that I could already do research in Chile at the Department of Biology with important local scientists that I was working with as a technician. But the real turning point in my career, the key event, happened when in a conference in the North of Chile I met a Canadian phycologist, one of the best in the discipline. This man had read some of my published papers and decided to help me. When he returned to Santiago some time later, he invited me to do a PhD in Canada. I went there… After eight months of Master studies I was proposed to continue with a PhD. I got my M.Sc in biology in 1986, my Ph.D. in Marine Biology in 1990 and remained one more year in Canada for a Post-doc. I could have stayed in Canada where I was offered a position but I wanted to come back. At that moment the Faculty of Biology opened a professor position to which I applied. I got the post. Seven years later, in 1997 I became Head of the Department of Ecology, in 2006 Director of Research and Graduates Studies and I am now, since December 2009 the Dean of the Faculty".* This success story would probably not have been possible without study abroad which in turn would not have been feasible without international input. In this case recognition of local talent by an international expert could undermine the influence of the local academic hierarchy and allow talented people to grow scientifically.

International scientific recognition gained through collaborations generally matters.

The snowball effect of international recognition on further international collaboration is also acknowledged by the interviewed scientists. The more visible they are, the more they are asked to participate in projects. "*In 2005, I was asked to collaborate on a book. I was* *contacted by the FAO/IAEA joint programme to work for them. I went three times to Argentina as a FAO expert on vicuna to the Abrapampa Station and got recognition for that". A Uruguayan researcher in veterinary science explained that now his scientific network is worldwide. "I interact with the world's top researchers in my field. As a member of the Standing Committee of the International Congress of Animal Reproduction, I meet top level people and help to choose topics for the congresses. I participate in worldwide discussions and get the feeling that I contribute to the development of my scientific field in Uruguay. Through these associations we discover not only new scientific interests but also experiences of good veterinary practice".*

Thanks to their integration into international networks and peer recognition a substantial number of the researchers interviewed became associate members of scientific societies, members of journals' scientific boards, or scientific journal reviewers etc. *"With time, through this activity I became known abroad. I am a habitual referee of an Australian journal. I reviewed 25 articles during the last few years. I have been asked to be a referee for 14 other scientific journals. I am a member of the International Society for Applied Ethology and secretary for the Latin American board. I was invited to meetings in Mexico, Dublin and Sweden. I was invited as a keynote speaker at a Symposium in New Zeeland… A small conference but all the important researchers in the field were there. I have been asked to be the coordinator of one of the scientific sessions of the next symposium"*. This young scientist adds that the network developing from all these activities leads to other collaborations, student exchanges, co publications etc. For him the benefice of his internationalization is real, not only for himself but also for his institution and above all, for his students.

Others describe an international journey through their involvement in international organisations or NGOs *"Then came my participation with the International Foundation for Science. My association with IFS began with the awarding of four research grants in Immunology. I got also, in the framework of IFS, an international award sponsored by Belgium -Roi Baudoin. Then I became an advisor and evaluator of research projects and joined the Scientific & Grants Committee of the Foundation. Later on, I was elected to the Board of Trusties as a delegate for Latin America. Eventually, I was elected Vice President of IFS. In this context I got acquainted with a lot of scientists in and outside Europe with whom I had a very long lasting collaboration: papers, visits, exchange of students and so on"*

Amazingly, a few interviewed scientists while receiving the recognition of their peers at international level do not, apparently, care for it. *"International collaboration came by accident. This came from a project in which I was collaborating on endemic plants in the Canary Islands. Some Spanish and German people were also involved in the project. Since the publication of this first work on these plants, every paper published on the same subject is signed by all the scientists of the first publication and I am one of them. Since that first publication, I publish a lot with people I have never met. I am considered a prolific author and am invited to write articles, chapters in books. Most of the time, I refuse. My work load is too heavy"*. This scientist who publishes his own research as well as that with other international colleagues has been recently elected Vice Dean of the Faculty of Science and Engineering ("first time a Biologist has been elected and not an Engineer" he said). Heading his faculty he is very much in favour of international collaboration which he promotes by the mean of agreements with foreign institutions. He belongs to the small group of interviewed researchers (some of the entomologists, taxonomists, ornithologists) who believe that their scientific subject does not necessary need much international interaction to reach its goal apart from collaboration in the identification of samples.

Does international collaboration affect personal scientific interests and choices?

Another notable consequence of participation in international collaboration through calls for tender is how this may influence research topics. For some scientists changing their research topic is more about changing their approach rather than object of their research. "*My main interests remain the same. My scientific interest is mainly devoted to two questions. One is to understand how snake venoms affect tissues and produce tissue damage and the other is how to improve anti venom therapy. I've had these questions since the very beginning and throughout my whole career. The difference is that with the knowledge gained from international collaborations we have gone more in depth into these two questions. We can say that at the beginning our approach was more superficial, phenomenological. Now we are able to go more deeply into some of these questions using different scientific approaches. So now I understand these two issues much better than I did back in the eighties, but I wouldn't say that my interests have changed".*

Other researchers may have had to change their research focus to be able to submit to international calls for tenders. With the mastering of the same scientific technologies you can study different objects (pathogenic agents for example). *"Several times I changed the subject of my research. I worked first with Anthrax, then Tuberculosis and now I am starting to work on Escherichia Coli O157 that causes Ureamic haemolytic syndrome. The main reasons for this evolution are linked not only to the relevance of the research, even if it tackles a real health problem in Latin America. It comes from participation in international cooperation projects that may introduce changes in scientific interests, both by the need to adopt new approaches and new subjects that we learn about in meetings, exchanges. We have to be in line with the 'trendy' subjects at international level in order to be eligible. On top of that, when I change my research subject, I create new links with other colleagues*". There may be two main reasons for this: on one hand, the necessity to be among the best laboratories competing for international calls for tenders and on the other the need to secure tangible funding to conduct scientific activity of the highest quality. This aspect will be addressed below.

International exchanges broaden the mind

Anyway, it is quite unlikely that being part of the international scientific community would not cause any changes or evolution in the scientific interests of the researchers. They are quite unanimous in saying that "*International collaboration makes you change your framework for thought processes; it allows you to discover things that you never thought of before". "Cooperation makes people grow". "When my master's and PhD students go and spend time in laboratories abroad, they get inspiration, learn new techniques, and gain self-confidence*. As previously quoted, international exchange causes individuals to change their way of thinking: "*We created a new breed of students who not only can cooperate from different cultural perspectives, but also from a multidisciplinary point of view. We train people to have a broader understanding"*

Going abroad to work, collaborate with foreign colleagues require efforts but that result in payback: "*At the beginning in my host country, I was a bit shy. My spoken English was not as good as the other students. But very soon, I realized that I had nothing to lose. So I started* *to be more actively engaged in the course. As a result I met a big part of my scientific international group there and most of my best international collaborations are rooted in this time".* The mastering of a foreign language and the ability to go and team up with other people is also a big advantage when attending and participating in international conferences. As mentioned previously, the results of the online survey indicate that scientists who have worked or studied abroad show greater inclination to collaborate with new and unknown foreign colleagues. This may be due to the mastering of a foreign language and to the experience of multiculturalism acquired while abroad.

Coming from less scientifically developed countries and collaborating with people from developed countries allows partners to put things into perspective. You know that you have attained a good level of collaboration when "*you work on the same project and find that together you are building scientific knowledge",* you can then profit from the mutual benefits without putting in too much effort. "*When you go to the German base in Antarctica you see the difference with the Argentinean base. In the latter you have to carry everything, even the distilled water. In the German base, they have plants for generating liquid nitrogen. They have a solar simulator. The things we can achieve in each case are completely different but in both bases it stems from our critical perspective, and the enrichment is mutual".*

10 – The strengthening of national scientific systems through international collaboration

International collaborations may impact on the development of national scientific systems at two main levels: on one hand they contribute to the development and consolidation of the scientific institutions and on the other, they counteract the brain drain by promoting the training of high qualified scientists.

At institutional level

The mastering of sophisticated technologies acquired abroad plus the existence at national or regional levels of networks of alumni (students and post-doc) from renowned institutions abroad may lead to the creation of centres of excellence or the acquisition of this status by existing laboratories. The most convincing examples gleaned through the interviews are the founding of new labs as consequence of post-doc stays of young Latin American scientists in Europe. One lab was funded in the framework of a European joint project between Europe and Latin America, the other started thanks to a grant from a German Institute eager to establish a research partner group in Argentina. In both cases the labs were established in already existing scientific institutions and were still working at the time of the interviews. Both had a reputation for excellence and had continued fruitful collaborations with European partners.

Without collaboration between institutions at international level, many scientists in Latin America would be unable to perform sophisticated research "*International collaboration is highly important for us because we don't have access to all the technology we need to perform a certain type of research. For a small country it is not easy to get the money to buy highly sophisticated instrumentation"*. The ability to carry out these techniques is the sine qua none condition to continue to collaborate at the level of cutting edge science. *"Mainly, it allows us to interact with groups that are doing very advanced work".*

Access to funding is also an important consequence of collaboration even though national funding is now more readily available making collaboration sometimes less desirable. Most international funding for projects is through grants obtained from foreign or international institutions/organisations or from calls for tender. Many interviews confirmed the importance of such funding not only for the development of the scientists' own activities but also for the development of research within their institutions. *"From 1998 to 2002 we participated in two INCO projects. During this whole period, the support was essential for funding all our research activities. Two of the three units of our institution benefitted directly from this financing but the equipment bought through the project will be available for the general use of the institution once the project is completed".*

For laboratories engaged in advanced scientific research and benefiting from national subsidies, international funding is, as previously stated, a way to remain competitive with the best of the partner labs at international level. But for laboratories that are less at the forefront of science, international funding can constitute the means for survival. *"In universities like ours, located far away from the capital city, funding is a recurrent problem. International collaboration is a real option for obtaining additional support for our activities. Having international relationships and being included in international networks are crucial to get external funding and to conduct quality research".*

The snowball effect of funding is also an observed phenomenon. "*Since then, I do not know if it was due to international collaboration or what, but we began to have much more support, even from our country. Since that project we got two other grants for two other projects". "Thanks to this network I could participate and be successful in international and national calls for proposals and finance my research and young colleagues. This international funding went alongside my career development: IFS funding helped me to buy very little equipment, SAREC funding was not big but more sustainable than IFS funding and helped me to buy medium-priced equipment ant pay young researchers. INCO (we won 2 INCO calls for proposals) allowed us to buy more important equipment. Now, the Rockefeller Foundation and funding from Europe help us to transfer technology to industry*".

International collaboration with colleagues met while studying abroad may also be the basis for developing inter-university agreements. "*I continued collaborating with my PhD supervisor and now we exchange people for doctoral activities with different universities in Spain. In 1999, we got a fellowship from the Agencia Española de Cooperación Internacional para el Desarrollo (AECID) for the exchange of professors. I went to teach for three months at the University Miguel Hernández of Elche (Alicante) and a professor from this university came to teach in Cordoba. I had teaching activities and supervised doctoral students' research work. I co-wrote another reference book as an outcome of my collaboration at Miguel Hernández University".*

The power of networking to counteract the brain drain

Including people in internationally active networks makes them feel that they belong to the global "scientific community" and helps keep them home.

"*We started to build a very strong collaborative network, very strong with many people in many places of the world and I must say that this scenario has been essential for the development of this institute". "The network is very motivated, scientific discussions are very* *good and the prospects for continuing the collaboration are good. It was useful to build a nucleus of strong collaboration and that's the best aggregated value of the project".*

Working in an international team is not only exchanging ideas, working protocols and results. As seen previously the network of a professor/researcher benefits his or her collaborators and students. *"Scientific cooperation within my network is real. We send and receive students from other universities. We are publishing together. We meet. We write to each other. We work as a team. If I need to send a student to a particular place where I do not have contacts, I receive the help of people from my network who know the place or the people".*

Conclusion

Throughout this chapter it is apparent that the determinants of international collaboration are numerous, sometimes cumulative and based on the expectations that individuals may have in terms of possible rewards: better access to places where science is produced, access to more funding (international as well as national), better visibility, improved opportunities to publish in high impact journals, better career prospects, the chance to interact with top scientists and, not least, the widening of their personal networks of friends.

Only ten of the scientists interviewed did not spend long periods abroad. That means that the 67 who did go abroad decided to return home and do research in environments that most of the time offered fewer scientific and technical facilities than the places which hosted them in the more developed scientific countries. Nevertheless they decided to return for a number of reasons: loyalty to their country, personal reasons, refusal to be brain drained. The facilities nowadays which have enabled the scientists to maintain links and do science as members of international networks has helped to enhance the benefits of their stays abroad and allowed them to continue collaborating beyond borders in a relatively seamless way.

Before summing up the major findings of this study it is worth recalling that collaborations with foreign colleagues are easier for researchers who have spent long periods abroad especially for postgraduate study and post-docs. One reason for this could be the networking type alumni associations that can be a real support for all scientific activities. But besides the networking it is clear that those who worked in cosmopolitan groups and spoke foreign languages more or less fluently find it easier to team up with colleagues from other countries even if they have never met them before. This finding corroborates the results of the online survey.

To sum up the major findings of this study we will try to review the main initiating factors and derived consequences of international collaboration from the point of view of Latin American researchers used to collaborating and co-publishing with colleagues working in high scientifically developed countries.

The reasons to go abroad for study are mainly twofold: on one hand, the quest for excellence and on the other, a question of opportunity. The quest for excellence is linked to the fact that in a more advanced scientific environment you are more stimulated and learn more. The opportunity may be given by a professor, a visiting researcher, a representative of a foreign country, etc. It can also arise during a scientific workshop or conference. The same reasons are at work to explain the choice of the post-doc abroad. Even when occurring opportunities guide the choice, the decision still remains linked to the pursuit of excellence.

The main result of these early stays abroad is their networking effect. The majority of interviewees kept in contact with their PhD supervisors, continued to collaborate with them and/or other colleagues from the same institution while they still share common scientific interests. The relationship is not only longstanding and fruitful but it may also open up new avenues and give rise to other collaborations. It is not uncommon for international collaborations started with colleagues met when studying abroad to develop into inter-university agreements. This is even more accentuated when related to the outcomes of post-docs abroad: the feeling of belonging to a group which operates as a network of excellence, the mutual recognition of the members, the perpetuation of the links through generations (by the students) reinforce the rewarding effects of networking. On the top of this, feeling trained to compete at international level the members of these selective networks want to be as visible globally as their colleagues from the more scientifically developed countries.

Other stays abroad for sabbaticals and training are more oriented towards responding to specific research issues such as: training workshops in the framework of cooperation projects, analysis of endogenous samples, learning new techniques not available locally etc. These stays do not apparently generate the same expectations from the researchers. They usually happen once careers are in progress and are perceived more as pleasant and stimulating ways to tackle research problems, learn new techniques and advance in their scientific endeavour. Nevertheless, they may be great “sources of inspiration” but do not have the same networking effect.

International collaboration is not the exclusive privilege of scientists trained abroad. The interviews were able to throw light on various determinants of the collaborations of this other group of Latin American scientists. Developing scientific activism is one of them. Among the biologists interviewed those who worked with a deep-rooted commitment (environment preservation for example) belonged to active international scientific networks. The same occurred with researchers working in topics of strong commercial interest like salmon diseases. Other scientists happened to be at the right place at the right moment (working in Marine biology in the Strait of Magellan at the moment of the oil pollution for example). A few others worked on research topics relevant to a highly specific environment (effects of altitude, endogenous fauna for example). The last way to get involved in international collaboration without spending long stays abroad is to be noticed during international conferences.

All interviewed researchers agree that participating in conferences is a very important and stimulating scientific activity. It is even an acute necessity for some to compensate for the narrowness of their scientific discipline locally. Many collaborations start between the participants, even with people who have not met previously. The networking power of conferences has to be acknowledged here since the collaborations initiated or enhanced in these settings are, for the interviewed researchers, mainly long lasting.

The researchers who answer international calls for tenders (and sometimes succeed) have their own systems for finding out about them; they are often informed by foreign colleagues or learn of them during international conferences. These labs compete at international level not only for funding but also to be visible in the international scientific community. The availability of national funding programmes for science in the five countries where the interviews were conducted lessens their interest in participating in big calls for tenders (too much time invested for too little reward). For several interviewees, the scientific interest in such programmes is far from being tangible. The majority of the researchers give priority to small scale bilateral collaboration based on personal relationships (the inter-university agreements springing from lasting relationships nurtured by networking). They also emphasize the fact that often their international collaborations take place outside official frameworks.

Unanimously they acknowledge that the human factor is of paramount importance in collaborations. *"To collaborate you have to like the people", "we became friends", "we get along very well"* is the most recurring type of phrase on this subject. When they talk of the visits of their partners they say that they invite them to their homes and vice versa. *"The rewards of international collaboration have been tremendous in my opinion... If I am asked what is the main reward I've had from my career I would say that it is the people I've met."*

Nevertheless, the main outcomes of international collaboration are not of an interpersonal nature, they are, at the individual, institutional and national levels, above all scientific in character. On a personal level these are: learning new techniques, publishing in high impact journals, learning to compete at international level, enhanced networking activities, better access to funding, international recognition (as well as national). At the country level, the benefits are also key. Some reference labs have been funded in Latin America by young expatriates who returned home with foreign funding to enhance research and international partnership in their disciplines. The international collaboration gave rise to many inter-institutional partnerships, which developed an extensive social networking system eventually giving the less developed partner countries the possibility to become visible in the scenario of the international scientific community.

As a way of concluding this chapter, the following excerpt from the interview with the Dean of the Faculty of Science of a big national university stresses the urgent challenge of strengthening international collaboration: *"Our country has an obligation to make efforts to be part of the international scientific community. A way to reach this goal is to re-enforce international collaboration. In all my activities at the University, on scientific panels and committees, I definitely push and will continue to push the idea of international collaboration and will promote it as part of our institutional strategy. I think that our country has not yet understood the potential importance of collaboration. We are still going out to search for money, but what we have to do now is to invest in international collaboration and provide the necessary financial means to promote it."*

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Research Collaboration between Europe and Latin America

Mapping and Understanding partnership

Scientific editors: **Jacques Gaillard and Rigas Arvanitis**

International collaboration has become increasingly important in carrying out research activities. This book, written by a large group of scholars from Europe and Latin America, maps, analyses and discusses research collaboration between the two continents during the last twenty years. The empirical material underlines the richness and the variety of the links that bind the two continents, well beyond the simplified views of science, either as the brainchild of global networking or as a result of dependence. The book also develops an innovative methodological approach, combining bibliometric analysis, social surveying, in-depth interviews, and a careful analysis of research programmes and policies. While arguing that the asymmetry of relations that once existed in cooperation has turned into a more equal partnership between the two continents, it deciphers some of the reasons behind this more balanced cooperation. It also challenges the view of science as a global self-organising system through collective action at the level of researchers themselves. On the contrary, the importance of policy, institutions, and previously developed research is highlighted and recognised.

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