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.

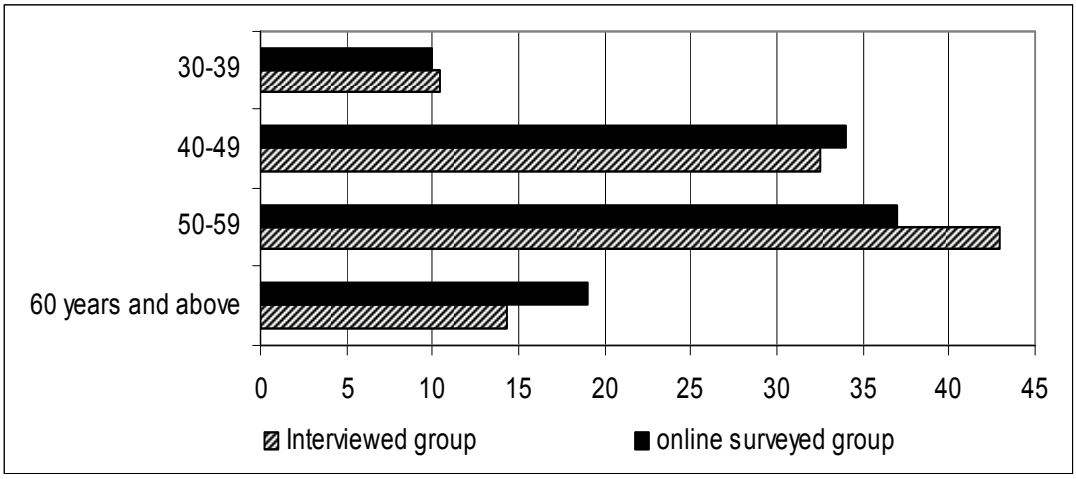
Age, gender and academic profiles

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.

[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

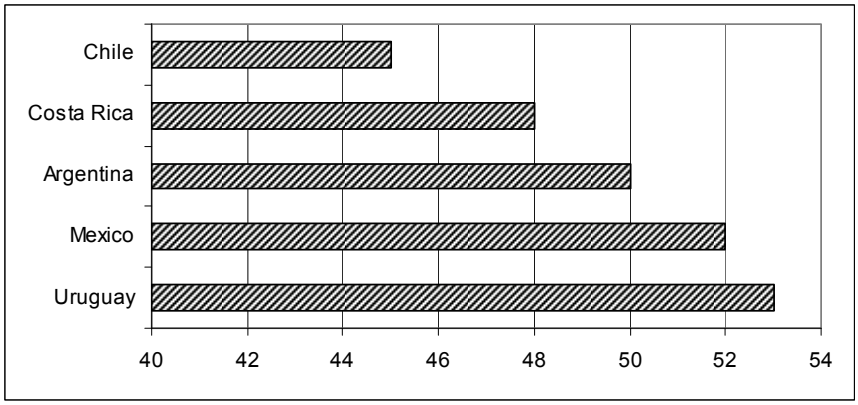


Figure 3 Age at highest degree

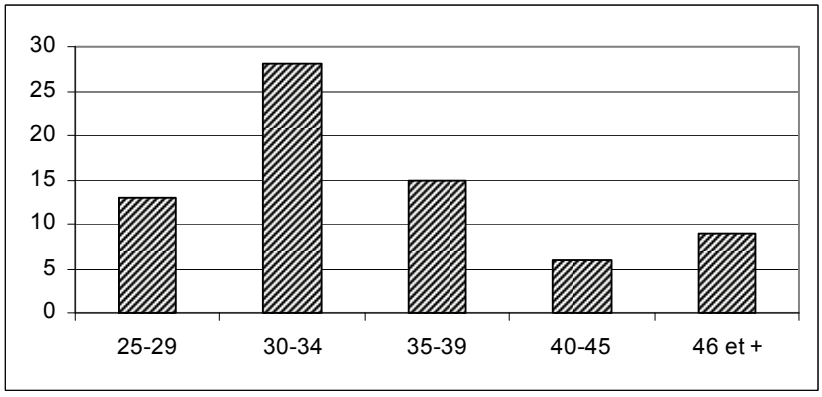
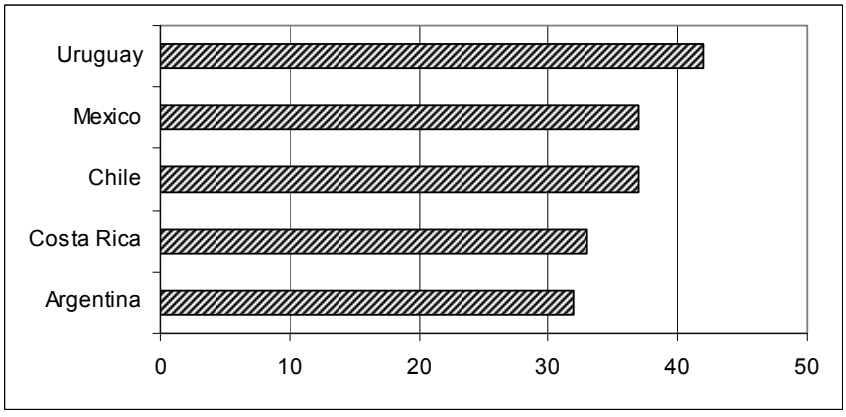


Figure 4 Age average at highest degree



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*

[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

[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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