Patterns of Collaboration of Scientists at the National University of Mexico (UNAM)

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Introduction

Collaboration in science has been shown to be an effective mechanism to advance research, as well as a means to increase productivity and visibility (Pao, 1992). The fact that international scientific collaboration has become a political objective as shown by the establishment of government initiatives for the enhancement of this activity, suggests that collaboration which transcends national boundaries is seen as a particularly good thing (Luukkonen, Persson and Sivertsen, 1992).

In the developing country situation, establishing contact with colleagues from countries with a high scientific research profile is believed to compensate to some extent for the isolation and shortcomings of the emerging scientific communities in these regions. The integration of scientists from countries on the periphery and especially those from the developing world, into the global scientific community is considered an important requisite for improving national research performance. Levels of international coauthorships are inversely related to the scientific size of a country (as expressed through the number of publications in the mainstream scientific literature). Developing and small industrialised countries with only small shares of international publication counts, make more significant contributions to the volume of internationally coauthored papers (Luukkonen et al., 1992)

The degree of international contacts and its effect on research performance of scientists in a small industrialised country has shown a relatively strong correlation with respect to contact frequency, conference participation and publishing in all fields of learning (Kyvik and Larsen, 1994). However, Carlson and Martin-Rovet (1995) suggest that only through contacts and collaboration, more than through conferences and seminars, can recognition be gained for work internationally. Mobility can reduce barriers of both distance and language between scientists and the best outlets for their most important publications. They see mobility too as a career device, as a way round some of the constraints faced by scientists in different environments.

In the present paper we look at the relative importance in terms of research performance of the links established with national and international colleagues for scientists in a developing country. We used as subjects for our analysis 15 of the most productive researchers working in five different scientific fields at the National University of Mexico (UNAM), institution responsible for approximately 42 % of Mexican research papers published in the international scientific literature. A case study is presented of the collaboration and citation patterns of one of the physicists (Physicist 1) who showed a particularly high level of international mobility. This analysis forms part of a broader research project on the relationship between collaboration and research performance of Mexican scientists.

Methodology

Patterns of collaboration

Three UNAM scientists from each of the five following research areas were selected for an in-depth study of their activities : Biomedical Research, Chemistry, Physics, Astronomy and Astrophysics, and Geosciences. Areas were selected on the basis of the following criteria : the need for representation of a wide range of scientific disciplines, and the desire to give special importance to those subject areas where UNAM scientific research makes an important contribution at international level.

The criteria for selection of the individual scientists were based on their 1985-1989 publication counts in the Science Citation Index (SCI) CD-ROMs. Scientists chosen had published at least five documents as first author, and a total of between 10 and 35 documents as first or coauthors. This strategy was chosen after a preliminary analysis of the publication levels of UNAM scientists in the SCI database, and the need to have a sample of 15 scientists with comparable levels of publication. In addition, researchers had to be affiliated to the UNAM from 1980 to 1994, and be willing to cooperate with the research project. When two authors commonly published together, only one was chosen in order to avoid analysis of basically the same publication set.

The 15 scientists chosen were asked to provide their CVs updated to the end of 1994. Analysis of papers was based on the publications reported in the individual CVs and corroborated with records in the SCI files. Details of institutional affiliations were taken from the SCI records or checked with the original papers. Analysis of coauthorships was determined for four types of publications only : articles, notes, reviews and letters (referred to as papers in this study), in accordance with recommendations made by Schubert, Glanzel and Braun [1989]. These authors consider that these four types of documents are the only ones which receive a significant number of citations in subsequent publications, and are therefore relevant in impact orientated analyses.

Distinctions were made with regard to the different levels of coauthorships in accordance with the following classification : 1) UNAM, coauthorship with member(s) of his/her own UNAM faculty, research centre or institute, or with member(s) of other UNAM faculties, centres, or institutes, 2) national, where coauthorship is with colleagues from other national institutes, and 3) international, in the case of coauthorships with foreign institutions. The frequency of institutional collaborations at different levels was calculated for each paper according to the number of times the UNAM scientist appeared as coauthor with author(s) from different institutes, regardless of the number of coauthors involved. For instance, a paper involving six coauthors from two foreign institutes, was assigned two foreign institutional collaborations. Papers where the UNAM scientist was the sole author were assigned the institutional level corresponding to the affiliation reported in the paper.

Relationship between coauthorship and citation patterns

In addition to the coauthor analysis mentioned above, citation analysis was carried out on the 1985-1989 papers of Physicist 1 using the SCI CD-ROMs. The 1985-1993 citations to these papers were downloaded onto diskettes and converted into MICRO-ISIS version 2.32 database format. Additional fields were coded corresponding to the countries of the citing institutions. Records were manipulated using FOXPRO version 2.0 software to relate data on citing articles with that of the cited articles (authors, institutions, countries, and years).

Results

Patterns of collaboration of the 15 scientists.

The 15 scientists produced a total of 797 papers from 1980-1994, with individual production ranging from 34 to 68 (from 2.3 to 4.5 papers per year). Of these, 232 papers (29.1 %) were published in collaboration with authors from overseas (Figure 1). The physicists showed the highest level of international coauthorship (41.1 %), followed by the astronomers (33.9 %), and the geoscientists (30.6 %). The biochemical researchers and the chemists showed lower levels (25.4 % and 17.0 %, respectively).

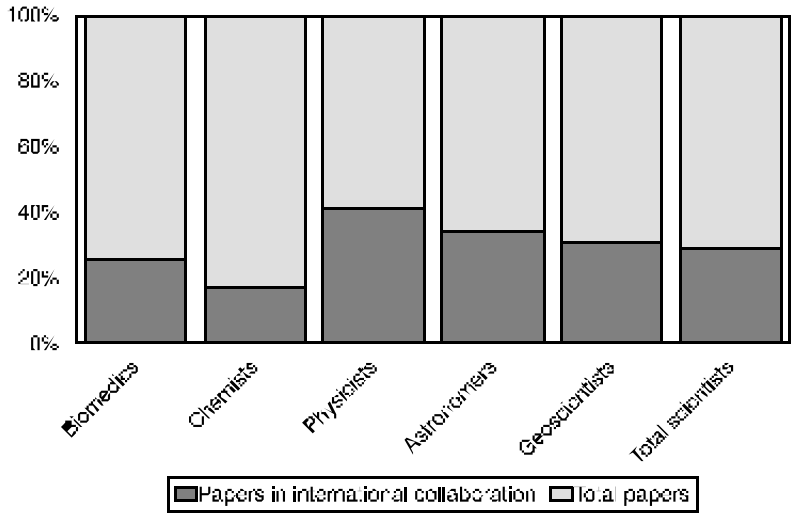


Figure 1. 1980-1994 papers in international collaboration of the 15 scientists in different disciplines

While the number of papers written either as the sole author or in collaboration with national colleagues fell from 1988 onwards, the number of papers coauthored with colleagues from foreign institutions showed a definite upward trend (Figure 2). In 1980 25.6 % of papers were international, a percentage which reached 35.8 % in 1994. Figures peaked in 1986, and again in 1993, year in which the number of international papers surpassed those published alone or with national counterparts.

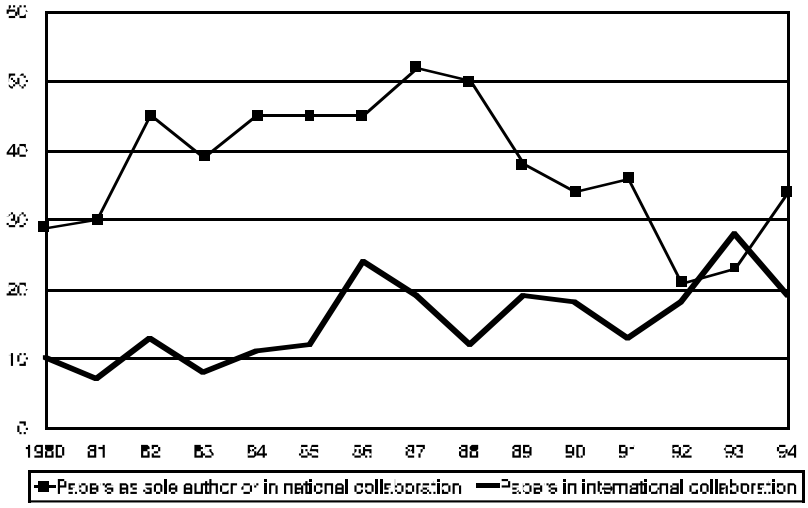


Figure 2. Annual production of papers in national and international institutional collaboration of the 15 scientists

Institutional coauthorships at UNAM level followed closely the annual production of papers indicating the important role of colleagues from the same institution in the research task (Figure 3). Collaboration with foreign institutes took on increasing importance during the 15 years studied. The peak in production seen during the mid 80's was associated with a peak in the number of international institutional collaborations. However, while the production of papers began to drop thereafter (picking up again from 1992), coauthorships with institutions abroad continued to rise. Collaboration with other national institutes was less significant and show no well-defined pattern.

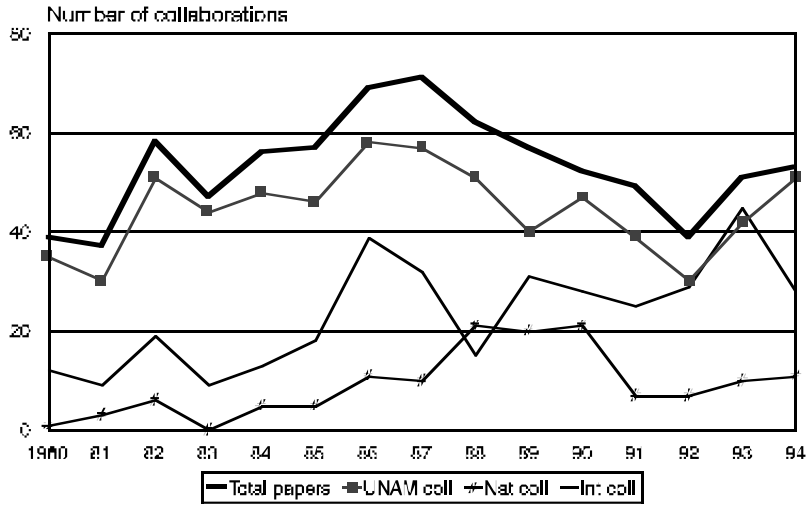
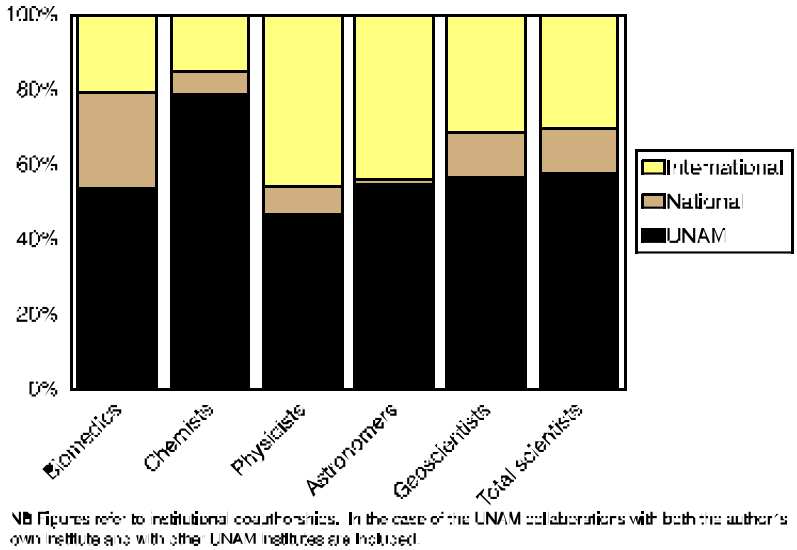


Figure 3. Different levels of institutional collaboration and annual production of papers of the 15 scientists

However, collaborations at different institutional levels varied between disciplines. In general, collaboration within the UNAM represented 57.7 % of the total number of collaborations, with other national institutions, 11.9 %, and with institutions abroad, 30.4 % (Figure 4). However, approximately one quarter of the institutional collaborations of the biomedical researchers were with other national institutions, a figure noticeably higher than in other disciplinary groups. Almost 80 % of the chemists' institutional collaborations were with colleagues from their own institution while the physicists and the astronomers showed high collaboration rates with institutions abroad (approx. 45 % in both cases).



NB Figures refer to institutional coauthorships. In the case of the UNAM collaborations with both the author's own institute and with other UNAM institutes are included.

Figure 4. 1980-1994 institutional collaborations of the 15 scientists in different disciplines

Taking the biomedical researchers as an example of a group with a high collaboration profile at national level, Figure 5 shows the annual tendency of all levels of their institutional collaborations from 1980 to 1994. Coauthorship with other national institutions showed a sharp rise from 1980 to 1989, after which period it showed a definite decline. However, both collaboration with colleagues from the UNAM and that with other national counterparts followed fairly closely the production of papers. The exception was from 1987 to 1989 when collaboration with the UNAM dropped with a simultaneous rise in coauthorships with other national institutes. International collaborations also showed a notable increase up to 1990 after when they declined.

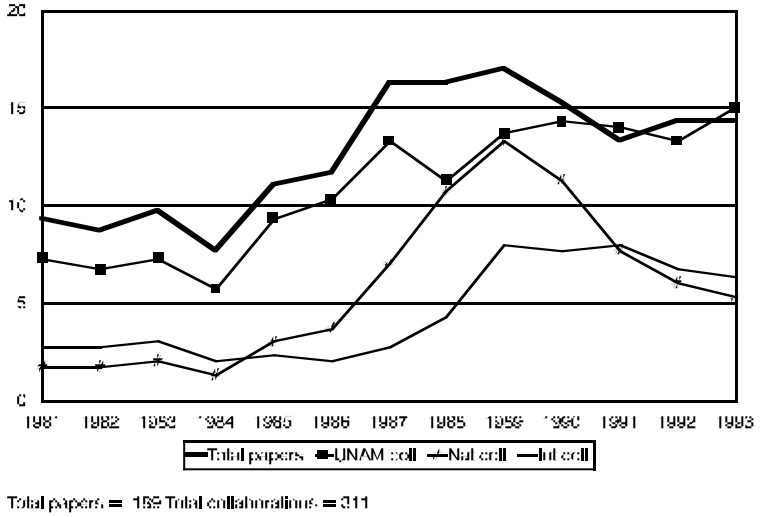


Figure 5. Different levels of institutional collaboration and annual production of papers (3yr moving averages) of the biomedical researchers

In the case of the institutional coauthorships of the physicists and astronomers which show an important international component, collaboration with colleagues from the UNAM showed a decline from 1983 through to 1992, while international collaboration was on the increase (Figure 6). From 1986 onwards the number of international institutional coauthorships followed closely the levels of production of papers, suggesting a direct relationship between these two variables. The peaks in the production of papers found in 1987, 1989, 1991, and 1993 coincided with peaks in the number of coauthorships at international level. Increases in the number of UNAM collaborations also followed this pattern suggesting an association between this parameter and international coauthorship.

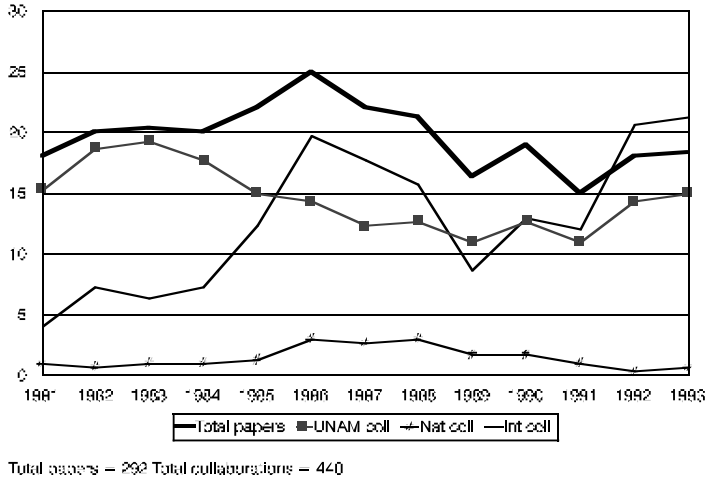


Figure 6. Different levels of institutional collaboration and annual production of papers (3yr moving averages) of the physicists and the astronomers

The addresses reported by the different groups of UNAM scientists in papers coauthored with foreign institutions are analysed in Figure 7. In 76.3 % of the total of 232 international papers, the Mexican scientists gave a UNAM affiliation. While the biomedical researchers, the astronomers and the geoscientists showed low frequencies of reporting foreign institutional affiliations (< 17 % of international papers), the chemists and the physicists were much more likely to do so (in 54.8 % and 35.7 % of cases, respectively).

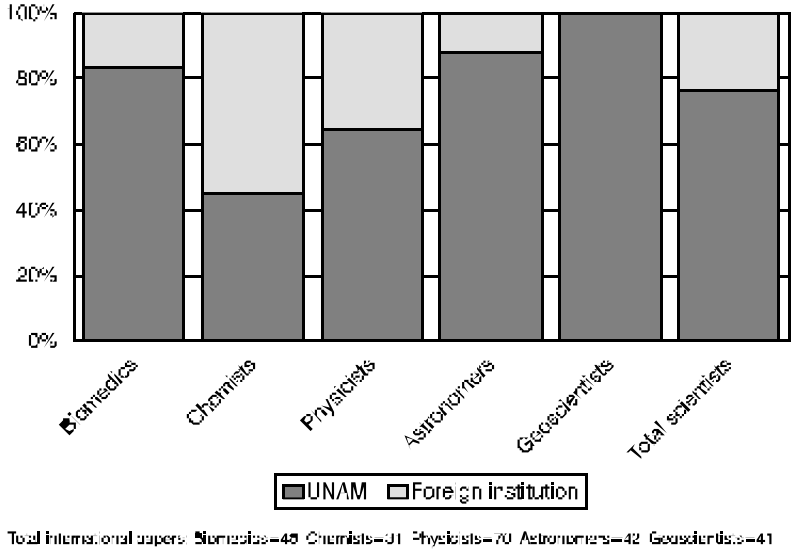


Figure 7. Institutional affiliations of the 15 scientists in 1980-1994 papers published in international collaboration

Papers coauthored internationally had a larger number of authors per paper than those published with no foreign collaboration (Figure 8). The international papers published by the astronomers and the physicists had the highest and the lowest number of authors per paper (5.2 and 3.4, respectively) while the chemists and the biomedical scientists showed the highest level of coauthorships with respect to papers written with national colleagues (4.4 and 3.8, respectively).

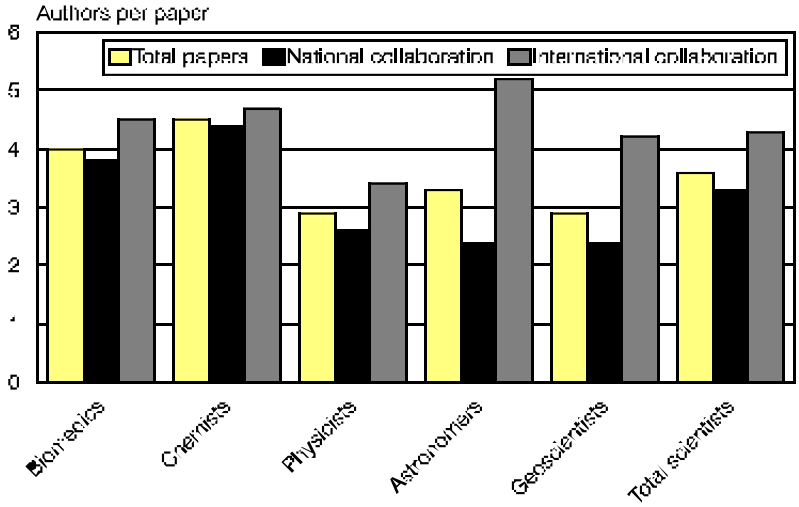


Figure 8. Number of authors per paper in national and international collaboration 1980-1994

Relationship between coauthorship and citation patterns of Physicist 1

Figure 9 shows the 1985 to 1993 citation pattern of Physicist's 1 papers published between 1985 and 1989. Self citations are not included. The number of citations showed a steep increase up to 1990 when they began to fall. Average citations per paper during this time was 3.8 The most cited paper received 25 citations with 7 papers receiving no citations during the nine-year window, three of which were articles published in a Mexican journal.

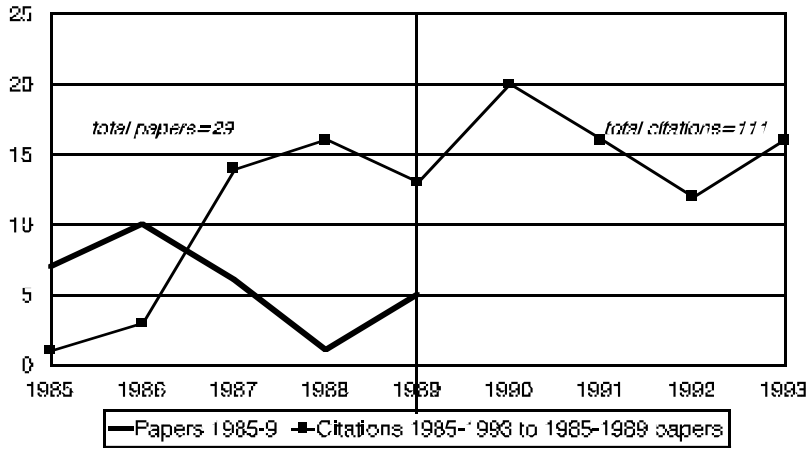


Figure 9. Production of papers and citations of Physicist 1

The country of most coauthorships with Physicist 1, the USA, was also the country giving the most citations to his papers during this time (Figure 10). Important levels of impact were seen in three European countries, Germany, the UK and Belgium, where institutional collaborations had also taken place. However, institutions in seven other countries also cited this physicist's work more than five times, although no collaborations between these and the UNAM scientist were apparent from the coauthorship patterns.

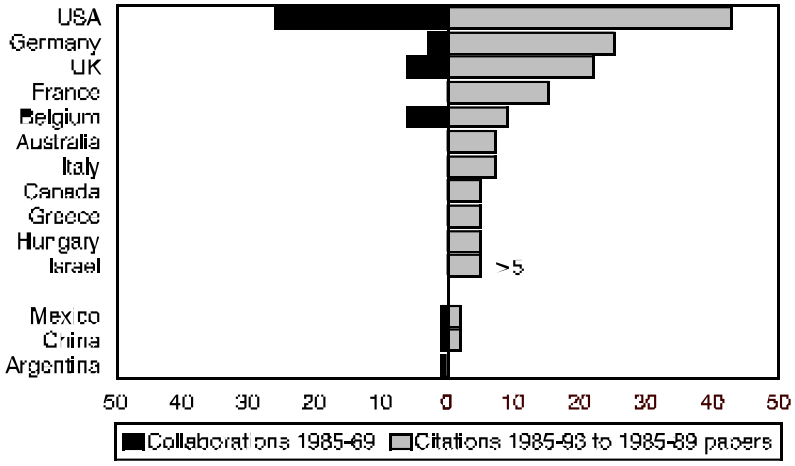


Figure 10. Institutional collaborations and citations of Physicist 1 according to country.

When looking at the relationship between collaborating and citing institutions, the dominant role played by one institution in particular, Yale University, is apparent (Figure 11). Physicist 1 spent two months as visiting researcher at Brookhaven National Laboratory towards the end of 1985, and eight months as a visiting professor at Yale in 1985-6. Coauthorships with the

Technische Universitât Mûnchen in Germany, the Science and Engineering Research Council in the UK, and the Instituut voor Nucleaire Wetenschappen in Belgium, also related to important citation rates by scientists at these institutions.

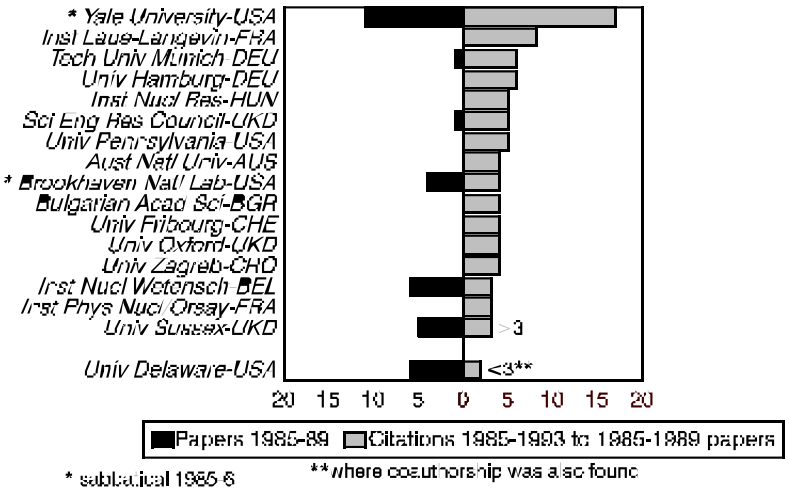
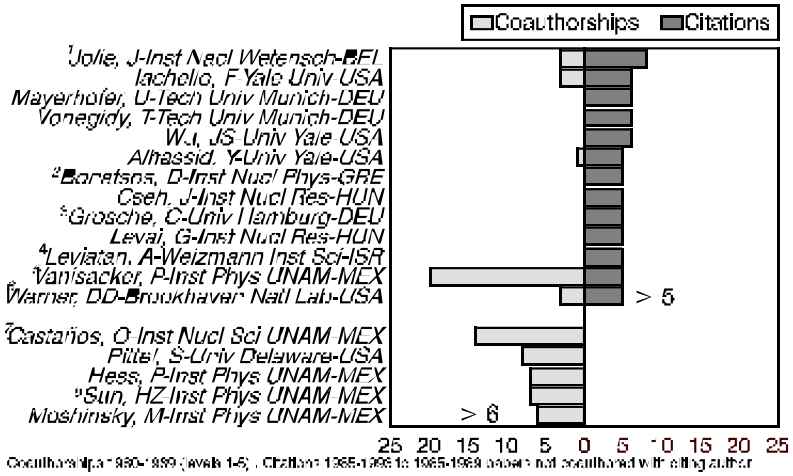


Figure 11. Institutional co-authorships and citations of Physicist 1 according to institution

At the level of individual researchers, Physicist 1's most frequent coauthor during this period was a colleague from his own university, but not from the same institute (Figure 12). This colleague cited other papers by Physicist 1 five times during this period. High levels of coauthorship with other colleagues from the UNAM was seen in the absence of citations (other than citations to the coauthored papers) from these coworkers to other papers by Physicist 1. Coauthors from Yale and Brookhaven, as well as scientists from institutes in several other countries, cited Physicist's 1 papers indicating a widespread influence of his research work. A high level of mobility was found in this group of scientists with eight of the coauthors reporting changes in institutional affiliations during this time, all of which also involved moves between countries and, in most cases, between regions.



Afterwards:

[1] Inst. Laue-Langevin-FRA [2] Univ Oxford-UKD [3] Imp Coll Sci Tech-UKD
[4]Yale Univ-USA [5] Univ Sussex-UKD/SERC-UKD/Univ Surrey-UKD
[6] SERC-UKD [7] Louisiana State-USA [8] Univ Drexel-USA/Univ Beijing-PRC

Figure 12. Collaborations and citations of Physicist 1 according to author

Discussion

The frequency of international collaboration in the papers by our sample of highly visible Mexican scientists, is comparable with that reported for Mexican science as a whole (Russell, 1995). In both cases, approximately 30 % of all papers (articles, notes, reviews, and letters) had at least one coauthor reporting foreign institutional affiliation. Also the number of papers in international collaboration showed a marked annual increase from 1980 onwards. In the particular case of the three physicists analysed in the present study, a higher level of international papers was found than that reported for physics research in Mexico as a whole (41 % for 1980-1994 as compared to 32 % for Mexico from 1980-1990). These results suggest a particularly high international profile for this group of UNAM physicists.

Results for the 15 scientists indicate that important collaborations are established with colleagues from the UNAM, suggesting that these highly visible scientists form part of established groups of scientists within their own institution. Pao (1992) found that global collaborators (those who in addition to collaborating within their own group, also coauthor with members of other groups) are more productive than those scientists who restrict their collaboration to their own local groups.

Collaboration patterns and scientific mobility are known to vary between fields. Mobility is typically less frequent in applied research than in basic fields (Carlson and Martin-Rovet, 1995). Scientists in basic fields achieve recognition from the international research community suggesting higher levels of international collaboration in these areas (Luukonen, et al., 1992) More applied fields can be expected to show higher levels of national collaboration, as is the case of biomedical research in the present study, although scientists in all five fields showed varying levels of international coauthorship.

Our results for the exact scientists suggests a direct relationship between number of papers published and the levels of international institutional collaboration. The evidence found in the particular case of Physicist 1 suggests that sabbaticals spent in institutions abroad not only boost levels of international coauthorship but also increase productivity. However, it is dangerous to generalise at this point on the evidence of one individual scientist. Preliminary analysis on the research trajectory of Physicist 2 indicate that a first sabbatical produced only one paper coauthored with the sabbatical institution, while a second period spent abroad produced much higher levels of coauthorships involving the UNAM scientist and colleagues from the foreign institution.

The technique of tracing author mobility by analysing the occurrence of institutional affiliations in published papers requires further study. It is possible to speculate from the present results that research disciplines where laboratory work is the norm, such as chemistry and physics, show higher incidences of foreign addresses because of time physically spent in foreign laboratories. In contrast, in disciplines where field studies are often carried out, such as in astronomy, and in the geosciences, the scientists tend to report the address of their home institution. Although there is an unwritten rule that scientists are expected to give as their institutional affiliation in the published report the address of the institute where the work was carried out, this is not always heeded (Day, 1988). It could also be that the accredited institution is where the work was written up which could well be the home institution. In some cases two institutional affiliations are noted, suggesting that both institutions were involved in the experimental procedure.

The fact that international papers have a greater number of authors suggests a variety of scenarios. The first concerns the involvement of both national and international colleagues in the work. This might be the case of the UNAM as coauthorships patterns suggest the presence of

important local collaborators. The second relates to the greater critical mass of scientists in industrialised countries in any one field, implying the availability of a greater number of collaborators for any one project. A third explanation could be the incorporation of the developing country scientists into big science projects, more characteristic of the scientifically advanced countries.

The case study of Physicist 1 suggests that international coauthorship can lead to increased international impact as measured by citations, as well as indicating the important role that sabbatical leaves of absence play in this process. The fact that this UNAM scientist forms part of a highly mobile group of scientists is most likely having a positive effect on his own visibility and opportunities for collaboration and mobility. In their study on scientific research in the Netherlands, Moed, de Bruin and van Leeuwen (1995) found that the highest values for three impact indicators referred to papers resulting from international collaboration, and the lowest for articles with no collaboration, once again suggesting that for peripheral countries, international collaboration is an important variable in performance evaluation.

These preliminary results from a small group of productive Mexican researchers suggest certain tendencies which merit further consideration. The next stage of this study is to measure the specific effect of prolonged stays abroad on the performance of these 15 scientists and to determine the effect of coauthorship on the citation patterns of all fifteen.

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