**The effect of team consolidation on research collaboration and performance of scientists.
Case study of Spanish University researchers in Geology.**

M.J. Martín-Sempere, J. Rey-Rocha, B. Garzón-García

Centre for Scientific Information and Documentation (CINDOC)

Spanish Council for Scientific Research (CSIC)

Joaquín Costa, 22. 28002 Madrid. Spain

Tel.34- 915635482. Fax 34-915642644

sempere@cindoc.csic.es

**This is an author post-print (ie final draft post-refereeing) of the paper published in
Scientometrics, 55, 3 (2002): 377-394**

Abstract

We analyse to what extent research collaboration and performance of individual scientists is influenced by the level of consolidation of the team they belong to. A case study of Spanish Senior University researchers in Geology is performed. Methodology is based on the combination of a mail survey carried out among a defined set of researchers, and a bibliometric study of their scientific output. Results provide support for the hypothesis that consolidation of research teams would result in a greater facility to establish contacts and collaborations with colleagues, that could benefit all members of the team, fostering their participation in funded projects and favouring their potential to publish in international mainstream journals.

Introduction

Research performance of scientists is influenced by a wide range of both individual and contextual factors. Over the last few years scientific research has been increasingly carried out within groups or teams of scientists. Bearing that in mind, the study of factors as team size and composition, team stability and consolidation, and scientific collaboration among researchers and teams, is of great importance to understand research patterns and performance of scientists.

In a previous work¹, we studied a sample of Spanish Senior University Geologists, with the aim of determining to what extent productivity of researchers is influenced by the level of consolidation of the team they belong to. In that study, productivity, measured in terms of scientific publications, was analysed, as one of the multiple dimensions that constitute the criteria of effectiveness and performance of researchers and research units.

Earth Sciences, and particularly Geology, are scientific disciplines where teamwork and collaboration have a special importance. This characteristic can be considered as an indicator of maturity of research teams². In Spain, Geology is a scientific discipline with a great tradition that counts with numerous well-established, internationally recognised teams. International collaboration of these groups has been favoured by the great diversity and geological complexity of Spanish territory that has aroused the interest of many foreign scientists, mainly French, Dutch, German and British³.

The present paper is an extension of the above mentioned by the same authors. Here we analyse, together with research output of scientists, their patterns of scientific collaboration. It is intended to respond some relevant questions proposed in that previous study. Does team consolidation favour research collaboration? Does it favour participation of scientists in funded research projects? Does it improve research performance, measured in terms of scientific output and research collaboration? Our goal is to contribute to understand to what extent team consolidation level affects research performance and habits of scientists.

Methods

Methodology is based on the combination of a survey carried out among a defined set of Spanish researchers, and a bibliometric study of their scientific output. The sample analysed consist of 93 scientists doing research in Geology at University faculties. The basic structural unit for analysis are individual scientists, not research teams.

Survey data were collected in some of the seven thematic blocks of the broader, specially created, 27-point questionnaire, which surveys different aspects of respondents' research activity, including publishing and collaboration patterns. Selected questions from the original questionnaire are shown in Appendix. As in our previous paper¹, researchers were assigned to one of the following categories: a) C researchers, i.e. those working within Consolidated, well-established teams; b) NC researchers, i.e. those belonging to Non-Consolidated, not well-established teams; and c) NT (No Team) researchers, i.e. those that are not members of any research team, who either work with different teams in different projects or usually work alone.

Bibliometric analysis was carried out starting from bibliographic information retrieved from the CD-ROM version of a multidisciplinary domestic database (Spanish Index on Science and Technology, ICYT), a multidisciplinary international database (Science Citation Index, SCI), and an international database specialised in Earth Sciences (Geological Reference File, GeoRef).

Same methodological aspects as in our previous paper¹ are valid here, with the following remarks.

Differences among researchers have been investigated with regard to productivity, number and rate of national/international collaborations, and participations in national/international R&D programmes and/or projects.

We refer to collaboration in terms of inter-departmental and inter-institutional collaboration. Firstly, scientific collaboration has been studied through co-authorship indicators. Indicators based on counts of co-authored papers are often used to study the collaboration between scientists. The evaluation of collaboration through co-authorship presents numerous advantages^{4,5}, although the obtained indicators

must be managed and interpreted with caution. In this respect, it must be taken into account that numerous collaborations do not result in a published paper signed by several institutions, thus they cannot be detected by co-authorship based indicators. On the contrary, there are cases in which very peripheral or indirect interactions between scientists result in publications signed by various authors

Furthermore, collaboration has been studied, through the number of collaborations maintained with Spanish and foreign teams, (see appendix, survey's question 22), as well as through its participation in R&D programs and/or projects (see survey's question 23). In this respect, it is necessary to consider that the participation in national projects not always constitutes an indicator of inter-institutional collaboration, since this type of projects do not necessarily entails the participation of researchers from two or more different institutions. Not therefore the participation in the rest of programs and projects specified in the survey, since all require the participation, in addition to Spanish researchers or teams, of foreigners. Querying experts for opinion through methods like surveying or personal interviewing provides another way of obtaining data that allows analysing the phenomenon of scientific collaboration from a wider perspective. Collaboration can then be considered as two or more teams working together, sharing resources and efforts, either intellectual or physical ⁴. It is also true that this method displays other disadvantages, opposed to the co-authorship based, such as difficulty in obtaining large and representative samples of researchers' population, or the subjectivity inherent to any study carried out through the survey of the parties concerned. In this respect, combination of scientist's surveying and the bibliometric analysis of their co-authored papers, provides a wider perspective of the scientific collaboration process.

Statistical analyses were carried out with SPSS 10.0 for Windows statistical package. Figures are shown as 'average $\pm$ standard deviation (range)'. Differences were considered as significant with a $\alpha < 0.05$. Non-parametric tests for sample comparisons were used (the Kruskal-Wallis H test and the Mann-Whitney U test). When relationship between quantitative variables exists, K-Means cluster analysis has been carried out, standardising the variables and not including the 'team consolidation level' variable on the analysis. The 'cluster membership' variable is saved as a new qualitative variable. The correspondent Chi-square test and, if appropriate, a correspondence analysis, were performed with variables 'cluster membership' and 'team consolidation level'.

Results

Research collaboration

Data on collaboration obtained from collaborative articles (those signed by two or more authors with different institutional affiliation, i.e. pertaining to different departments and/or institutions) are displayed in Table 1. The degree of (national, international) collaboration is the percentage of (national, international) collaborative articles out of the total number of articles.

In general, C authors show higher figures of collaboration than NC, and the latter higher than NT, both in absolute as in relative values. The only exceptions are the number of national collaborative articles and the degree of national collaboration, both in SCI journals, where NC authors show higher values than C and NT ones.

Statistically significant differences, indicated in Table 1, refer to a) the number of co-authored articles per author: C researchers appear to be significantly more productive than NT ones, both in SCI and in the rest of journals, without finding differences between the output of these type of articles from authors belonging to consolidated teams and non-consolidated teams; b) the total number of international collaborative papers: Same differences as in previous case have been found when analysing the whole set of journals, being differences mainly due to bilateral collaboration with teams from other European Union (EU) member countries. In SCI journals, however, C researchers published a significantly higher number of articles co-signed with foreign scientists, than their NC and NT colleagues; and c) the rate of international to total co-authored papers and the degree of international collaboration (both in the whole set of journals; articles published in SCI journals do not reveal differences in these indicators).

Table 1: Collaborative articles per author in journals covered by SCI, GeoRef and ICYT

	<i>C</i>	<i>NC</i>	<i>NT</i>	<i>Total</i>
<i>All journals</i>				
- Collaborative articles **	2.9±2.7 (0-11)	1.9±2.3 (0-7)	1.2±1.4 (0-4)	2.5±2.5
-- National collaboration	1.9±2.3 (0-11)	1.7±2.1 (0-6)	1.1±1.4 (0-4)	1.7±2.1
-- International collaboration **	1.2±1.6 (0-8)	0.5±0.9 (0-3)	0.1±0.3 (0-1)	0.9±1.45
-- Bilateral (with EU-teams)**	0.8±1.3(0-7)	0.4±0.7(0-2)	0.1±0.3(0-1)	0.6±1.2
-- Bilateral (with non-EU teams)	0.2±0.5(0-2)	0.1±0.3(0-1)	0	0.2±0.4
-- Multinational	0.2±0.6(0-3)	0.1±0.3(0-1)	0	0.1±0.5
- International / Total **	0.38±0.36	0.28±0.36	0.12±0.32	0.33±0.36
- Degree collaboration	0.56±0.36	0.49±0.40	0.37±0.34	0.52±0.36
- Degree national collaboration	0.33±0.31	0.31±0.32	0.29±0.28	0.32±0.31
- Degree international collaboration *	0.23±0.30	0.17±0.30	0.08±0.27	0.19±0.30
<i>SCI journals</i>				
- Collaborative articles **	1.3±1.4 (0-6)	1.2±2.2 (0-7)	0.4±0.7 (0-2)	1.1±1.5
-- National collaboration	0.7±1.0 (0-5)	1.2±1.8 (0-5)	0.4±0.7 (0-2)	0.7±1.2
-- International collaboration *	0.8±1.3 (0-7)	0.2±0.8 (0-3)	0.1±0.2 (0-1)	0.6±1.3
-- Bilateral (with EU-teams)	0.5±1.2(0-6)	0.1±0.5(0-2)	0.1±0.2(0-1)	0.4±1.0
-- Bilateral (with non-EU teams)	0.1±0.4(0-1)	0	0	0.1±0.3
-- Multinational	0.1±0.4(0-2)	0.1±0.3(0-1)	0	0.05±0.3
- International / Total	0.42±0.42	0.20±0.32	0.20±0.45	0.37±0.41
- Degree collaboration	0.62±0.37	0.60±0.42	0.55±0.53	0.61±0.40
- Degree national collaboration	0.33±0.35	0.48±0.40	0.44±0.53	0.37±0.38
- Degree international collaboration	0.29±0.38	0.11±0.21	0.11±0.33	0.24±0.36

Significant differences: * C>(NC=NT); ** C>NT

Table 2 shows the average number of collaborations per author within the different groups, according to survey's data. In accordance with bibliometrics analysis, survey likewise shows that, in general, C researchers collaborate more than the rest, both in national and international collaboration. In this respect, stability and consolidation of teams seem to have a favourable effect over collaboration, particularly over international collaboration. Spanish University Geologists belonging to consolidated, well-established teams, performed a significantly higher average number of international collaborations during the period studied, than those belonging to non-consolidated teams and those not belonging to a team. Besides these absolute figures, the rate of international collaboration with regard to the total (more than 50%), is also higher. Differences are mainly due to bilateral collaborations with teams from other EU member countries. On the other hand, NT researchers show some figures slightly higher than the corresponding to scientists in non-consolidated teams. This is particularly noticeable in the case of domestic and multinational collaborations.

Table 2: Average number of collaborations of researchers surveyed (Source: survey's question 22)

Collaboration type	C	NC	NT	Total
- National (with other Spanish teams)	3.0±2.6 (0-10)	2.3±2.0 (0-7)	2.9±1.6 (0-6)	2.9±2.4
- International *	3.6±3.4 (0-15)	1.4±1.4 (0-5)	1.7±2.0 (0-8)	2.9±3.1
-- Bilateral (with EU-teams) *	2.0±2.1 (0-10)	0.8±1.0 (0-4)	0.7±1.1 (0-3)	1.6±1.9
-- Bilateral (with non-EU teams)	0.8±1.3 (0-6)	0.5±0.6 (0-2)	0.5±0.9 (0-3)	0.7±1.1
-- Multinational	0.9±1.3 (0-4)	0.1±0.3 (0-1)	0.4±0.6 (0-2)	0.7±1.1
- International/ Total **	0.53±0.30	0.37±0.29	0.35±0.29	0.47±0.30
- Total	5.6±3.5 (0-15)	3.7±3.0 (0-10)	4.6±2.8 (2-13)	5.1±3.4

Significant differences: * C>(NC=NT); ** C>NT

Participation in research projects and/or programmes

As indicated in Table 3, significant differences have been found in the total number of participations in research projects and/or programmes, as well as in the number of international bilateral projects with EU-based teams and in the number of participation in EU-funded projects. C scientists participated in a significantly higher number of projects than NC ones. NT researchers occupied an intermediate position, showing a higher number of participation in projects than NC ones. NT researchers overcome their NC colleagues in the number of both national and international projects.

Most outstanding differences have been identified in the participation in international projects, which constitute another indicator of international collaboration. C researchers overcome their NC and NT colleagues, both on the amount of projects in which they participate and on the percentage of international projects with regard to the total number of projects they participate in. This difference is mainly focused on bilateral projects in collaboration with EU teams.

Table 3 Average number of participations in projects and/or programmes (Source: survey question 23)

Type of project/programme	C	NC	NT	Total
- National	3.1±1.69 (0-8)	2.5±2.3 (0-7)	3.4±2.4 (0-8)	3.1±1.9
- International *	2.6±2.5 (0-10)	0.5±0.8 (0-2)	1.1±1.5 (0-5)	2.0±2.3
-- International bilateral (with a EU-team) *	1.0±1.3 (0-5)	0.4±0.7 (0-2)	0.5±0.9 (0-3)	0.8±1.2
-- International bilateral (with a non-EU team)	0.3±0.7 (0-3)	0	0.4±0.9 (0-3)	0.3±0.7
-- EU **	0.8±1.4 (0-7)	0	0.3±0.4 (0-1)	0.5±1.2
-- Multinational	0.5±1.0 (0-4)	0.1±0.5 (0-2)	0.1±0.3 (0-1)	0.4±0.9
- International/Total *	0.39±0.26	0.19±0.32	0.22±0.24	0.33±0.28
- Total **	5.6±2.9 (1-13)	3.1±2.3 (0-7)	4.5±2.8 (0-9)	5.0±2.9

Significant differences: * C>(NC=NT); ** C>NC

Characterising researchers by its scientific output and collaboration figures

In this chapter, results of cluster analysis carried out with the analysed variables are shown. The aim is to determine whether is possible to create homogeneous clusters of individuals (researchers) characterised by a similar performance of the concerned variables, and to what extent these groups correlate to the ones defined according to the level of consolidation of research teams (C, NC, NT). For this purpose, we select those variables where significant differences have been found, along with data of scientific output from our previous study¹.

The different international collaboration figures and patterns revealed by the survey allow us to establish a first division between researchers belonging to consolidated research teams and the rest of their colleagues (see Figure 1). A cluster analysis has been performed with four survey variables that shows this collaboration, both in absolute or relative values. Significant differences have been found on the belonging of scientists to clusters according to these variables (Chi-square=11.6 $\alpha=0.02$). Results of the correspondence analysis performed with variables 'cluster membership' and 'team consolidation level' is shown in Figure 1. The corresponding plot shows that the horizontal dimension, i.e. that accounting for the largest part of the association between rows and columns, seems to be largely determined by C versus NC and NT researchers. NC and NT researchers are shown ascribed to lower cluster score in all variables (cluster 3), opposite to authors belonging to consolidated teams, associated to clusters 1 and 2. Differences among groups seems to be mainly produced by the number of international collaborations and projects (the variables that differ the most across the three clusters), rather than by the percentage they represents with respect to the total number of collaborations and projects.

Figure 1: Correspondence analysis row and column plot for cluster membership according to international collaborations and participation on international projects.

Source: survey's questions 22 and 23. Table shows final cluster centres. Cluster 3 shows the lowest values for all variables, being the differences more relevant for the number of international collaborations (ANOVA $F=106.7$) and the number of participations in international projects ($F=72.2$), than for the corresponding relative values of participations in projects ($F=56.0$) and collaborations ($F=37.2$). In cluster 3, values of variables are among 0.5 and 0.8 standard deviation units below the mean for all researchers. Both dimensions of the correspondence analysis plot explain 45.3% of total variation, dimension 1 accounting for 94.5% of it.

Cluster analysis of the number of collaborations and the percentage of international collaborations, measured through co-authored articles, has also been carried out. Although the correspondence analysis performed with variables 'cluster membership' and 'team consolidation level' is on the limit of statistical significance ($\alpha=0.051$), it shows a picture (Figure 2) similar to that of the previous case (Figure 1). The horizontal dimension seems to be likewise determined by C versus NC and NT researchers, being the latter associated to lower values in all variables (cluster 3). Differences among groups seem to be mainly produced, in this case, by the percentage of international collaborative articles.

Figure 2: Correspondence analysis row and column plot for cluster membership according to the number of co-authored articles and the percentage of international co-authored articles.

Source: bibliographic databases. ANOVA: rate of international to total co-authored articles $F=107.0$; number of co-authored articles $F=67.2$. Both dimensions of the correspondence analysis plot explain 40% of total variation, dimension 1 accounting for 90.2% of it.

A similar division of researchers is obtained when trying to characterise them not only according to their collaboration figures but also by their scientific output (Figure 3). The analysis carried out starting from the data obtained from bibliographic databases, coincide in distinguishing C researchers from the rest. Significant differences have been found on the belonging of scientists to clusters according to these variables ($\text{Chi-square}=10.8$; $\alpha=0.03$). As in previous figures, the horizontal dimension seems to be largely determined by C versus NC and NT researchers, being the latter associated to lower values in all variables. Differences among groups seems to be mainly produced by the number of articles in both domestic and foreign journals, rather than by the number of collaborative papers.

Figure 3: Correspondence analysis row and column plot for cluster membership according to scientific output in domestic and foreign journals together with national and international collaborative articles. Source: bibliographic databases. ANOVA: number of articles in foreign journals $F=63.3$; number of articles in domestic journals $F=47.7$; number of national collaborative articles $F=41.5$; number of international collaborative articles $F=14.2$. Both dimensions of the correspondence analysis plot explain 36.6% of total variation, dimension 1 accounting for 99.7% of it.

Similar result is obtained if analysis is only reduced to the variables that represent the scientific output in foreign journals and the number of articles on international collaboration (see Figure 4).

Figure 4: Correspondence analysis row and column plot for cluster membership according to scientific output in foreign journals and international collaboration.

Source: bibliographic databases. Cluster 3 shows the lowest values for both variables, being the differences relevant for both variables (ANOVA $F=98.89$ and 109.64 , respectively). Both dimensions of the correspondence analysis plot explain 47.7% of total variation, dimension 1 accounting for 91.8% of it.

Equivalent analysis carried out with the variables obtained throughout the survey shows a more acute differentiation, dividing three groups (Figure 5). NT researchers appear associated to cluster with lower values on scientific output and intermediate values on international collaboration (cluster 2). NC researchers, with a higher value on output in foreign journals, show however the lowest values on international collaboration. Finally, researchers in consolidated teams are shown associated to cluster 1, with the higher values on international collaboration and intermediate values on publishing articles in foreign journals. Significant differences have been found on the belonging of scientists to clusters according to these variables (Chi-square=19.8, $\alpha=0.00$). The significance of the correspondence analysis is noticeable higher than in previous cases, as both dimensions of the correspondence analysis plot explain 70.8% of total variation.

Figure 5: Correspondence analysis row and column plot for cluster membership according to scientific output in foreign journals and international collaboration.

Source: survey's questions 13 and 22. ANOVA: number of articles in foreign journals $F=71.7$; international collaborations $F=60.7$. Both dimensions of the correspondence analysis plot explain 70.8% of total variation, dimension 1 accounting for 66.3% of it.

Analysis shown in figures 6 and 7 add a new variable to both previous cases, to differentiate authors according to their scientific output in foreign journals and their international collaboration, inserting the 'participations in foreign projects' as an additional indicator of international collaboration.

In what respect absolute figures of these variables, a four-cluster analysis was necessary to find significant differences on the belonging of scientists to clusters (Chi-square=16.1 $\alpha=0.014$). Figure 6 shows correspondence analysis plot for cluster membership according to said variables. Dimension 1, accounting for 84.4% of variability, is mainly determined by C versus NT researchers, with NC scientists in a intermediate position, contributing almost nothing to the inertia of this dimension. Researchers not belonging to any research team appear associated to lower cluster scores in all variables (cluster 3). C and NC are lying along dimension 2, being NC researchers associated to intermediate values (cluster 1) and C scientists near both clusters with highest values in all variables (cluster 2 and 4). Differences among cluster seems to be mainly produced by the number of articles

published in foreign journals and the number of international collaborations, rather than by the number of participations in international projects.

Figure 6: Correspondence analysis row and column plot for cluster membership according to scientific output in foreign journals and international collaboration.

Source: survey's questions 13, 22 and 23. ANOVA: number of articles in foreign journals $F=126.9$; international collaborations $F=90.6$; number of participations in international projects $F=26.0$. Both dimensions of the correspondence analysis plot explain 56.3% of total variation, dimension 1 accounting for 84.4% of it.

With regard to relative values of these parameters (proportion of articles in foreign journals, of international collaborations and of international projects) has not allowed characterising three clusters that significantly correspond to the three teams defined according to consolidation level. No significant differences have been found on the belonging of scientists to clusters according to these variables, being the analysis on the limit of statistical significance (Chi-square=9.4; $\alpha=0.051$). Nevertheless, the correspondence analysis plot shows a picture (Figure 7) similar to that of the previous case (Figure 6).

The horizontal dimension, accounting for 91.5% of the variability, seems to be likewise determined by C and NC versus NT researchers, being the last associated to lower cluster scores in all variables (cluster 3), while NC and C ones appear associated to highest values in all variables (clusters 1 and 2). Differences among clusters seem to be mainly produced by the percentage of participation in international projects and the percentage of articles in foreign journals.

Figure 7: Correspondence analysis row and column plot for cluster membership according to scientific output in foreign journals and international collaboration.

Source: survey's questions 13, 22 and 23. ANOVA: percentage of articles in foreign journals $F=42.1$; percentage of international collaborations $F=32.6$; percentage of participations in international projects $F= 55.9$. Both dimensions of the correspondence analysis plot explain 41.5% of total variation, dimension 1 accounting for 91.5% of it.

Discussion and conclusions

Same regards as in our previous paper¹ concerning a) multidimensionality of research effectiveness and performance, b) aspects to bear in mind when comparing with other studies' results, and c) the specific characteristics of the population under study, should be considered here.

International collaboration seems to be intimately linked to, or favoured by, the degree of team consolidation, so that the belonging to a consolidated, well-established team, entail an substantial improvement of scientists' capacity of facility for establishing collaborations and participating in international projects. On the other hand, it should be emphasised that, although differences are not always statistically significant, survey's results suggest that researchers not belonging to teams collaborate more than their colleagues in non-consolidated teams, both at the national and international level, and participate in more international projects. Nevertheless, as inferred from bibliometric data, this does not result in a higher number of co-authored papers. This could be interpreted as NT researchers having a larger movement freedom to join research teams (consolidated or not), together with a greater necessity of joining these teams to participate in funded research projects. The exception seem to be bilateral collaborations with foreign teams, where a more direct and narrower contact between two research teams might be the norm, while in multilateral collaborations the incorporation of an isolated researcher is more feasible. Scientists in non-consolidated teams could have more difficulties to establish international collaborations than NT ones, and of course, than researchers belonging to consolidated, well-established teams. In some way, it could be said that NC researchers are “own team's prisoners”, in a way that if the team is not able to get funded projects, all researchers of the team remain without project. In this respect, not belonging to a team would suppose some kind of advantage over the belonging to non-consolidated teams.

Considering jointly the results of our previous paper on research productivity¹ and those of the present study, the most significant finding is the greater scientific activity, measured in terms of productivity, international collaboration and participation in international projects, of scientists that belongs to a consolidated, well-established research team, opposite to those who do not. Most of the multivariate statistical analyses performed allow us to establish a distinction between the former and the latter

Nevertheless, the joint analysis of the productivity in foreign journals, international collaborations, and participation in international projects, indicate that a further differentiation could be established among NC and NT researchers.

The lower performance of NT scientists can be due to the need to assume in solitaire all tasks inherent to scientific research and collateral activities (manuscript writing, fund raising, administrative work, relationship with colleagues and so forth). In this sense, the capacities of scientists who belong to a team are harnessed, resulting in a better personal performance.

On the other hand, the labour situation of scientists is another factor important that affects their activity and performance. In fact, our previous study showed that team size does not appear to be as important as the number of scientist of the permanent staff within the team, that is to say the number of team's components who have a permanent or stable job position. In this sense, the results show the positive influence exerted on the activity and performance of scientists, by the labour stability and the fact of carrying out their research activity within a team, preferably if this is a consolidated, well-established one, where scientists have common objectives and interests, and where a more effective task sharing is likely to result in an improvement of both individual and team performance.

In conclusion, the present results provide support for the hypothesis that consolidation of research teams would result in a greater facility to establish contacts and collaborations with colleagues, that could benefit all members of the team, fostering their participation in funded projects and favouring their potential to publish in international mainstream journals.

Appendix

Selected questions of the survey '*Research activities in the R&D system in Earth Sciences in Spain: 1990-1994*'.

Q6. Are you member of a consolidated, well-established research team?

- Yes, I belong to a consolidated, well-established team.
- No, my research team cannot be considered as a consolidated, well-established one.
- I am not member of any research team. Depending on the project, I work with different teams.
- I usually work alone.

Q13. Please give the number of the following documents you produced (signed) during the reference period (1990-1994)

- Journal articles (in Spanish journals).
- Journal articles (in US journals).
- Journal articles (in EU journals).
- Journal articles (in Latin-American journals).
- Journal articles (in other foreign journals).
- Scientific and technical reports.
- Conference papers (national).
- Conference papers (international).
- National patents.
- International patents.
- Maps.
- Books.
- Book chapters.
- Other (please specify).

Q.22. Please give the number of collaborations you maintained during the mentioned period (1990-1994), with...

- Other Spanish teams.
- EU teams.
- Non-EU teams.
- Multinational teams (teams including researchers from more than one foreign country).

Q.23. Please give the number of participations, during the mentioned period, in ...

- National Programs/Projects.
- Bilateral Programs/Projects in collaboration with a EU country.
- Bilateral Programs/Projects in collaboration with a non-EU country.
- EU Programs/Projects.
- Multinational Programs/Projects.

Acknowledgements

Authors express their thanks to all the survey's respondents. We acknowledge *Laura Barrios*, at the CSIC Department of Operational Research and Applied Statistics, for her valuable statistical advice. *Mercedes Planas* is thanked for her help in writing the English manuscript.

POST-PRINT

References

1. J. Rey-Rocha, M.J. Martín-Sempere and B. Garzón. Research productivity of scientists in consolidated vs. non-consolidated teams: the case of Spanish University Geologists. *Scientometrics* (forthcoming)
2. D. Beaver and R. Rosen. Studies in scientific collaboration. Part I. The professional origins of scientific coauthorship. *Scientometrics*, 1 (1978) No 1, 65-84.
3. J.A. Vera Torres. Análisis crítico sobre las Ciencias de la Tierra en España. In: *Prospectiva en Ciencias de la Tierra. Encuentro sobre prospectiva en Ciencias de la Tierra*. Universidad Internacional Menéndez Pelayo, 1986, 30 June-2 July, Santander. Madrid, Gabinete de Estudios de la Presidencia, Consejo Superior de Investigaciones Científicas (CSIC), 1987, p. 7-15.
4. J.S. Katz and B.R. Martin. What is research collaboration?. *Research Policy*, 26 (1997) No. 26, 1-18.
5. K. Subramanyam. Bibliometric studies of research collaboration: A review. *Journal of Information Science*, 6 (1983), No. 6, 33-38.