

IMPACT OF NATIONAL SIZE ON RESEARCH COLLABORATION

A COMPARISON BETWEEN NORTHERN EUROPEAN AND AMERICAN UNIVERSITIES

G. MELIN

*The Swedish Foundation for International Cooperation in Research and Higher Education (STINT),
Skeppargatan 8, SE-114 52 Stockholm (Sweden)*

(Received June 14, 1999)

It is generally assumed that there is a negative correlation between national scientific size and amount of international research collaboration: The larger the size is of the national scientific arena, the lesser the amount of international research collaboration. In this study, the collaboration pattern of 49 universities is analysed and a comparison is made between the Northern European and American universities in our sample. It was found that the American universities have more national and less international collaboration than the European ones. However, for the European universities there are no impact of national size although the countries differ much in scientific size. This deviation from the general trend indicates that the above-mentioned explanation is too simple and that national scientific size does not correlate negatively with the amount of international research collaboration without exceptions.

Introduction

As the study of research collaboration continues among bibliometricians and others, the complexity of the phenomenon is revealed step by step. The relation between national and international collaboration, or local and external collaboration, is one area of high interest, not the least from a policy perspective.¹ In this study a comparison is made between a number of Northern European universities and a number of American universities, regarding their collaboration pattern. A discussion about the impact of national size is also held.

The collaboration pattern of the Northern European universities has been investigated in an earlier article by *Melin and Persson*,² why it is the American universities which are in particular focus here. *Melin and Persson* showed that small universities in somewhat peripheral locations have almost exactly the same relative amount of external and international collaboration as large well-known and centrally

located universities within the same country. According to this result, it does not seem to be a disadvantage for a university to be small and even in the geographical outskirts when it comes to external collaboration. Although the earlier study did not focus on the national level, but on the university-level, it revealed some national differences among the 33 investigated universities. For instance, the percentage of the collaboration defined as 'national' varied from 4% (University of Iceland) to 37% (Kuopio University, Finland). One interpretation of this study is that national borders and geographical distance have quite small effect on research collaboration.

However, there are studies indicating that this may not at all be the case. The quite considerable importance of distance that *Katz*³ found when looking at collaborating universities in the U.K., Canada and Australia suggests that geographical distance still has an impact on patterns of research collaboration. *Narin et al.*⁴ studied the EU-countries and their results have two key points when it comes to transnational collaboration:

"[...] first, international co-authorship is increasing steadily, and second, it is higher for scientifically smaller countries. The second point is, of course, a direct consequence of scientific size. Scientists in countries such as Italy have far more scientists outside of their country to cooperate with, and far fewer inside, than scientists of much larger scientific countries as the United States or the United Kingdom."(Ref. 4, p. 317)

*Melin and Persson*² make precisely the same conclusion when discussing impact of national size on research collaboration. Moreover, in the paper of *Schubert and Braun*,⁵ data is presented for all countries' scientific output and their amount of co-authored papers, according to SCI for 1981–1985. The percentage of foreign co-authorship vs. paper productivity for all countries is shown, and it is clear that the general tendency is that scientifically small countries have more foreign co-authorships than scientifically large countries. Like in the quotation above, *Schubert and Braun* mean that scientists in larger countries more easily can find partners within their country than scientists from smaller countries.

The partly conflicting results can be explained by the fact that the study by *Melin and Persson*² does not consider with whom the collaboration occurred, while this is highlighted by *Katz*.³ Further, *Narin et al.*⁴ study scientific performance on a national level, not on a university-level, and consequently, their results need not to be in conflict with *Melin and Persson*.² Universities in different countries may very well have similar collaboration patterns, although the countries' amounts of collaboration differ. Last, on a national level of analysis *Melin and Persson*² agree with *Schubert and Braun*,⁵ who show the general trend of all countries, but there are deviations from the general trend (which *Schubert & Braun* investigate further) showing that the trend is not without

exceptions. This indicates a complexity of the impact of national scientific size on research collaboration which is not well captured in the simplified conclusion that scientists from large countries more easily can find their partners within their own national borders, while scientists from smaller countries need to cross borders more often to find partners. We ought to conclude that national size seems to matter, but the picture is somewhat blurred and further studies are needed in order to clarify the circumstances in general and the causality between national size and international collaboration in particular.

According to the general trend, we would expect American universities to have more national collaboration than the European universities since the national scientific arena is larger in the United States than in the European countries. Furthermore, we would expect universities from a scientifically large country like the United Kingdom to have more national collaboration than universities from a small country like Denmark. Below, data are presented for the American universities, but since data for the European universities are published earlier they will not be repeated. Also, the amount of collaboration at a given university is pictured along with the size of the particular national scientific arena. This method will allow us to see how the size of the nations respectively effect the universities' research collaboration pattern, with the purpose to clarify some of the structures which are only briefly touched upon in the above-mentioned studies. The specific questions raised in this study are:

- How does the collaboration pattern of the American universities differ from the collaboration pattern of the Northern European universities?
- How does national scientific size effect the amount of international collaboration that the universities have?

Method and sample

In this study institutional co-authorships are used as an indicator of research collaboration. Both critical and supportive voices have been raised regarding this way of measuring collaboration. The supportive arguments seem to dominate, and since *Price* and *Beaver*⁶ first used co-authorships as an indicator of research collaboration it has become an established method. More recently, *Logan* and *Shaw*⁷ have recommended the bibliometric method for studies of collaborative activity, and in an overview of the use of co-authorships as an indicator of research collaboration, *Melin* and *Persson*⁸ suggest further evaluation of the method. They conclude that if used together with editing or standardization processes and an overall scrutiny, the potential errors of the data can be brought to a level of minor influence on the results.

Of course, the issue of research collaboration can not be understood only by measuring the co-authorships; it is a sociological phenomenon that indeed can be quantified and measured but also needs to be studied and described through qualitative investigations. So far such studies are rare but *Russell*⁹ has recently made a comprehensive study where fifteen scientists are investigated. Bibliometric and scientometric data are used along with questionnaire and interview data, in order to determine the importance of links established with colleagues abroad, especially during sabbaticals. *Melin*¹⁰ has also made attempts to describe the collaborative event on the individual level through interviews. An understanding of the statistical structures together with an understanding of the underlying social and psychological structures is necessary for a thorough knowledge of research collaboration.

All bibliometric data were retrieved from the 1993 CD-ROM version of *Science Citation Index* (SCI), and only genuine articles were used. Other types of documents do also indicate collaboration, but differently, and should therefore not be put together with genuine articles. Articles were retrieved from 49 universities from the following countries: USA, U.K., the Netherlands, Denmark, Norway, Finland, Iceland and Sweden. These countries cover a good part of the spectrum regarding the size of national research systems indicated by the article production, but they were also chosen due to a particular interest in the Northern European countries. There is reason to believe that a major part of the total article production from the universities is retrieved when entering the search string for each one; for example 'harvard univ', 'univ calif berkeley', or 'univ hawaii'. However, the standardization of the university-name in the database is not perfect and some ten to fifteen percent could be missing. There is no reason to believe that the collaboration pattern of the missing articles with variants of the 'correct' address would differ, but we have to keep the reservation in mind.

For all countries but the United States the same data as in the earlier article by *Melin* and *Persson*² were used, and in addition sixteen universities in the United States were chosen. More specifically, for Norway, Sweden, Finland, Denmark and Iceland, data were retrieved from all their universities. Four universities with different amount of article production were chosen in the Netherlands as well as in the United Kingdom and these universities were chosen with no other purpose than to form a representation as trustworthy as possible. Still, an important reservation is that the overall collaborative pattern in the Netherlands and the United Kingdom might be different from this small sample. For the United States mainly large well-known universities were chosen, simply because it seemed most interesting to investigate those universities, but a handful of smaller and less known universities were also chosen with the purpose of covering a reasonable size spectrum and even get a geographical diversity.

For each one of the universities a matrix was formed with combinations of internal, national, international or mixed institutional co-authorships. *Internal collaboration* is defined as collaboration within the particular university; *external collaboration* is defined as collaboration involving at least one institution from another university (in the country or abroad). Of the external collaboration, *national collaboration* is collaboration with institutions within the country while *international collaboration* is collaboration between the particular university and institutions from at least one other country, and the *mixed* variant is collaboration involving both national and international collaborators.

A fractional ratio was calculated, which shows the universities' share in the co-authorships, respectively. The ratio is the fractional sum of authorships divided by the number of externally co-authored articles. (As an example, in one article there are three authors of whom one comes from the university at hand, giving that university one third of an authorship. In next article there are four authors of whom two come from the university at hand, giving the university two fourths or one half authorship. The third part is added to the half part and so on resulting in a fractional sum of authorships.) It can vary from 0 to 1, where 0 means a hypothetical extreme with only external collaboration without the given 'home' university involved, and 1 means no participation in external collaboration at all. This ratio shows how strongly the universities participate in their collaborations. In total the sample contains 30494 journal articles.

Results

A matrix was produced where every single university's particular collaboration pattern is shown as several columns of data. In Table 1, the sixteen American universities are listed.

The fractional ratio is rather constant. It varies from 0.35 to 0.44, which means that the proportion of external collaboration does not differ much between the large and well-known places and the small or peripheral universities. This finding goes hand in hand with the result from the European universities where the ratio varies between 0.38 and 0.48. The proportions of external collaboration at the American universities are also similar to the ones found in Europe; here the variation is from 47% to 72% and the mean is 58%. At the European universities the variation is between 44% and 68%, the mean is 56%. So far the results seem to be quite in accordance.

What is different though, is how the external collaboration is scattered over the national and international scientific arena. The proportion of national collaboration is significantly higher at the American universities than at the European universities. The mean value for the European universities is 25% national collaboration while it is 37% for the United States. It is difficult to see any pattern among the American universities. The largest one and the smallest one have the two highest proportions of national collaboration (George Mason and Harvard): over 50% of their co-authored articles. No co-variation between collaboration and size and/or location could be found for the other American universities. Princeton and Berkeley have the lowest degrees of national collaboration, 28%.

Consequently, the proportion of international collaboration is significantly lower than at the European universities. The mean value is 11 percent international collaboration, to be compared to 23 percent at the European universities. The mixed variant also contains international collaboration but there is no dramatic difference between the American and the European universities (11 and 8 percent, respectively) which could explain the lower mean value.

Table 1
The pattern of institutional co-authorships at 16 American universities, 1993

	Articles	% internal	% external	% mixed	% national	% internat	Frac. sum	Frac. ratio
George Mason Univ	88	30	71	14	51	6	22	0.35
Oakland Univ, MI	89	34	66	9	43	15	23	0.39
Univ Alaska	166	46	54	12	32	10	37	0.42
Univ Arkansas	323	53	47	8	33	7	63	0.41
Univ New Mexico	571	41	59	9	39	11	139	0.41
Univ Hawaii	623	42	58	11	32	14	138	0.38
Princeton Univ	986	45	55	12	28	14	217	0.40
Columbia Univ	1014	38	62	10	39	13	255	0.41
Yale Univ	1838	49	51	9	33	10	387	0.41
UC San Diego	2115	37	63	11	40	11	550	0.42
MIT	2132	44	56	11	34	12	486	0.41
UCLA	2152	42	58	9	38	11	513	0.41
UC Berkeley	2230	49	51	8	28	14	502	0.44
Stanford Univ	2320	44	56	11	35	10	520	0.40
Cornell Univ	2739	47	53	7	33	12	597	0.41
Harvard Univ	4619	28	72	11	55	7	1311	0.40
Total/Mean	7813	42	58	11	37	11	—	0.40

A graphic comparison between all of the universities is presented in Fig. 1. On the y-axis is the relative share of international collaboration for each university shown, and on the x-axis we see the size of the countries as producers of scientific journal articles according to SCI, as share of the world production. In order to get any visibility at all the x-axis scale is logarithmized.

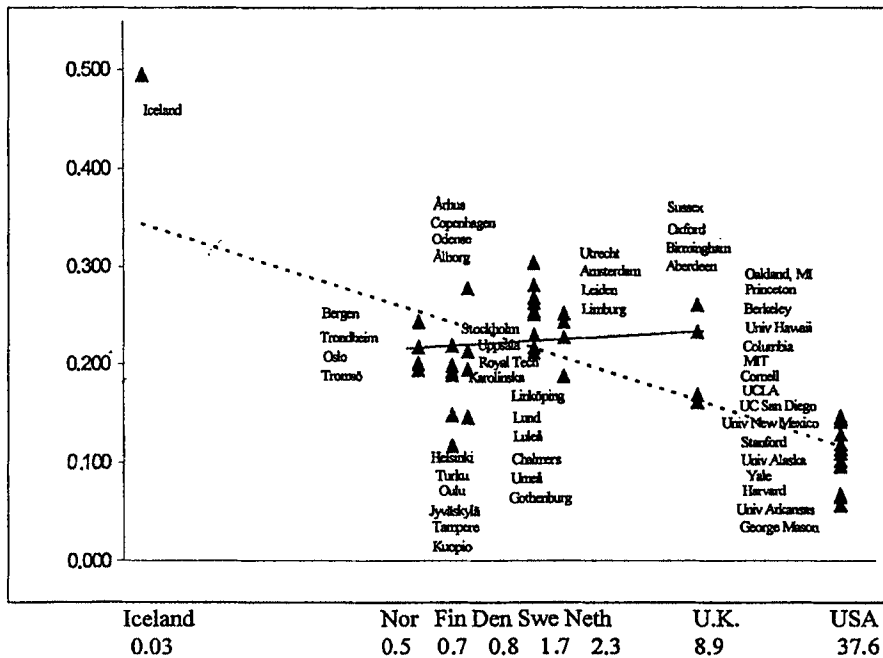


Fig. 1. International co-authorships per university (relative share) and by size of country (as science-producers; no. of articles/world production: %) 1993. $N=49$ universities, 30494 genuine articles

Two trend-lines are shown in the figure: The dotted line ($y=-0,032x+0,232$) shows the trend of the whole serie, and according to this line the amount of international research collaboration obviously decreases with increasing size of the national scientific arena, as predicted and expected.

Indeed, the United States makes a rare case with its significantly larger national scientific arena than any other country (roughly four times the size of the U.K.), as makes Iceland which scientifically is about as small as any country can get; 101 SCI-listed journal articles in total for 1993. Most countries have a scientific size somewhere in between, like the other ones in our sample. The solid line ($y=0,0077x+0,2162$) shows the trend of a serie where Iceland and the United States are excluded, and according to this trend-line, there is no indication that international collaboration decreases with increasing national scientific size; the trend-line is nearly horizontal and even peaks slightly with decreasing size.

Conclusions

Two main questions were raised in this study. First, how does the research collaboration pattern differ between the American and the Northern European universities in our sample? We can conclude that the American universities have a higher proportion of national collaboration and a lower proportion of international collaboration than the European universities have. The fractional ratio in the United States is 0.40, to be compared to 0.44 for the European sample, indicating a slightly weaker degree of participation in the external collaborations at the American universities. In most other aspects there are few differences. In America, as in Northern Europe, there are negligible differences between the universities according to their size as article producers or their geographical location.

Second, how does national scientific size effect the amount of international research collaboration that a particular university has? If we look at a scientifically small country like Iceland it is clear that it is involved in a very high proportion of international collaboration, while the world's scientifically largest nation, the U.S., has a relatively low proportion of international collaboration. For these two countries their national size obviously affects the universities' research collaboration pattern in a way which is in accordance with the general trend described in earlier literature. This is however not the case for universities in the other countries even though there are significant differences between those countries as science producers. *Schubert* and *Braun*⁵ pointed at some deviation from the general trend and here we have an example of such deviation, if the picture would remain with the whole of the U.K. and the Netherlands taken into account.

We should not draw too far-reaching conclusions from this finding but the result indicates that the situation is much more complex than that large countries collaborate less internationally than small countries, as their scientists more easily can find their partners within the national borders than in smaller countries. Other factors than size, like language and culture, most likely play a significant role as well.

There are also differences within each one of the countries in the sample. There seems to be a difference in international collaboration rate of around ten percent between the most and the least internationally oriented universities. Again, it is clear that size or location of the university hardly effects the pattern of research collaboration. The causes of the variation should be sought among other factors.

Finally, the author of this study has already made the remark that if we wish to dig deeper into the phenomenon of research collaboration and reach beyond the bibliometric structures, we must look at other factors than the bibliometric ones. Often other studies in this sub-field have made the same remark. Future research should use the frame that quantitative studies have revealed and try to go beyond the bibliometric findings and investigate the structures from a more qualitative methodological point of view. Which role does languages play? Does international collaboration and international exchange lead to globalization? How about different scientific cultures, or scientific traditions? As informal networks become more and more important for communication and for getting access to crucial information, are certain groups of researchers excluded on a non-formal basis? How do we become socialized into the academic system in general and the specialized networks in particular? These are all questions that it seems urgent to start dealing with. A similar qualitative approach could also help clarify what impact national size has on research collaboration.

*

Thanks to Monika *Ericson* and Ann-Zofie E *Duvander* for comments and corrections.

References

1. J. S. KATZ, D. HICKS, How much is a collaboration worth? A calibrated bibliometric model, *Scientometrics*, 40(3) (1997) 541–554.
2. G. MELIN, O. PERSSON, A bibliometric study of collaboration at some European universities, *Journal of the American Society for Information Science, JASIS*, 49 (1998) 43–48.
3. J. S. KATZ, Geographical proximity and scientific collaboration, *Scientometrics*, 31 (1994) 31–34.
4. F. NARIN, K. STEVENS, E. S. WITHLOW, Scientific co-operation in Europe and the citation of multinationally authored papers, *Scientometrics*, 21 (1991) 313–323.

G. MELIN: NATIONAL SIZE AND RESEARCH COLLABORATION

5. A. SCHUBERT, T. BRAUN, International collaboration in the sciences, 1981-1985, *Scientometrics*, 19 (1990) 3-10.
6. D. J. DE SOLLA PRICE, D. BEAVER, Collaboration in an invisible college, *American Psychologist*, (1966) 1011-1018.
7. E. L. LOGAN, W. M. SHAW, A bibliometric analysis of collaboration in a medical specialty, *Scientometrics*, 20 (1991) 417-426.
8. G. MELIN, O. PERSSON, Studying research collaboration using co-authorships, *Scientometrics*, 36 (1996) 363-377.
9. J. M. RUSSELL DE GALINA, *Collaboration and Research Performance in Science: A Study of Scientists at the National University of Mexico (UNAM)*. PhD Thesis, Department of Information Science, City University, London, UK., 1998.
10. G. MELIN, Pragmatism and self-organization. Research collaboration on the individual level, *Research Policy*, in press, 1999.