# The organization of international collaboration in research production

David Hsieh, G. Kerr Whitfield
College of Medicine, The University of Arizona, Phoenix, AZ

## ABSTRACT

The purpose of this study was to assess global trends in the composition and function of multinational research teams. By examining 3.7 million primary research articles published from 1975 to 2005, we show that the frequency and scale of international collaborations is increasing over time and that the publications of countries associated with lower research output are more often affiliated with other nations. By analyzing article citations, we discovered that multinational research studies have a greater research impact than research without an international presence although the number of affiliated nations does not strictly correlate with citations.

## METHODS

Bibliometric records of primary research articles published from 1975 to 2005 were downloaded from the Thomson Reuters Web of Science (WOS) database between March 2012 and December 2012. WOS publication results were refined with Boolean operators to include only English language entries coded as article document types without anonymous authors. Publications coded in the WOS as article document types are distinguished from non-primary research articles if they include more than 100 references and contain the words “review” or “overview” within the title. Records with missing or unreliable data in any record field were excluded from this study. Unique text strings corresponding to a country’s name were identified within the author address and reprint address field tags. Data from countries which have changed names or their constitution since 1970 were incorporated into the publication counts of modern sovereign states which are politically and geographically representative of the previous entity or succeeded the previous state identity.

## CONCLUSIONS

This study demonstrates that over the last four decades multinational teams have an increasing role in the production of knowledge and are evolving into larger scale structures of three or more nationalities. It was also discovered that collaborative publications constitute a considerable portion of the total research output of developing countries rather than that of developed nations. This demonstrates how collaboration may be a key resource for knowledge production to allow certain countries to serve as critical nodes linking other countries in scientific research. This study also provides evidence that is contrary to the widely held assumption that collaborative research efforts lead to higher impact publications. In fact, our findings indicate that there may be a citation disadvantage with collaborations involving more than three nations.

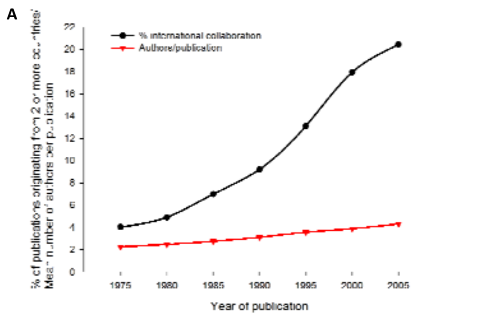
## INTRODUCTION

Scientific discoveries are conventionally recognized as the feat of individuals or small teams. For example, internationally renowned science prizes such as the Nobel and Lasker awards are bestowed to no more than three persons per achievement under current provisions. However, since the second half of the 19th century, the number of one-author manuscripts has declined exponentially (1, 2). Beginning in the 1950s, multi-author and multi-institute research papers have emerged as the primary products of scientific research in both the natural and social sciences (3).

Elements of recent grant initiatives, including the United States National institute of Health’s Clinical and Translational Science Award program and the European Union’s Seventh Framework Programme, specifically promote research collaboration between countries. However, it is unclear if political and financial policies are meaningful research strategies in advancing scientific knowledge. Further studies are warranted to define conditions and contexts where a collective effort is beneficial, efficient, and synergistic rather than additive in impact. Such findings would be crucial because the risks of collaborations, including opportunity costs, diminishing marginal returns and increasing management and administrative expenses, have not been well elucidated and may not be anticipated. The goal of this study is to define networking trends within authorship structures of primary research articles with a focus on country-level relationships. The citation impact of international collaborations over time is also investigated. By elucidating how international collaboration in research and its impact has changed over the last few decades, the evolving behavior and utility of scientific international relationships may be revealed.

## THE RISE OF INTERNATIONAL COLLABORATION

A

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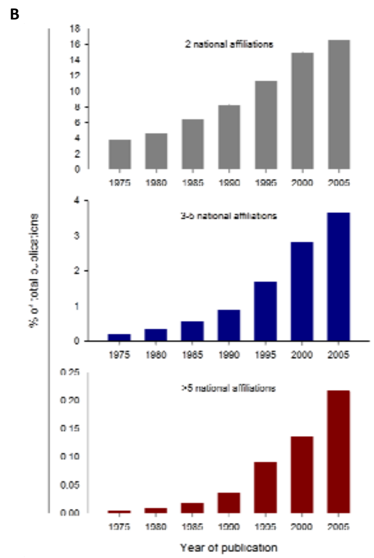
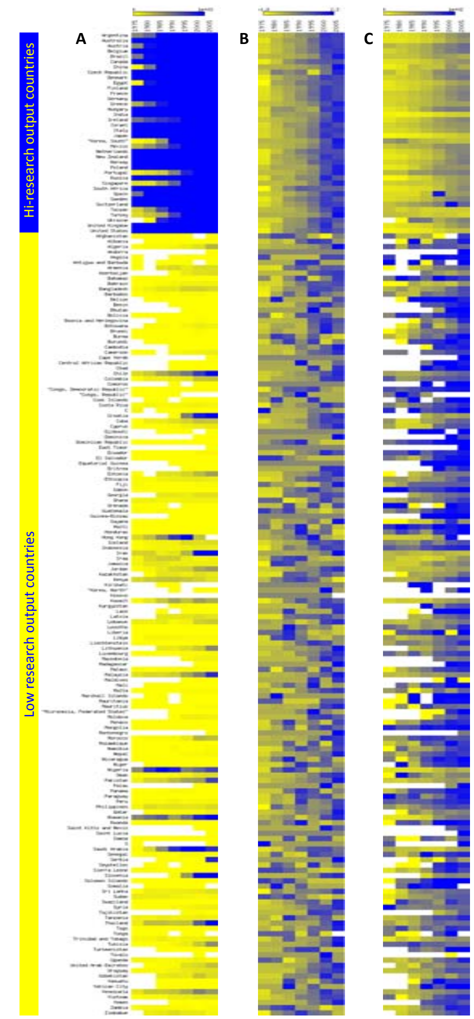



By examining 3,730,067 primary research articles published across 7 years from 1975-2005, it was determined that the number of publications with authors associated with two or more countries has increased rapidly especially between 1990 and 2000 (Fig. A). The rate of increase in the mean number of authors per publication is subtle and is therefore not likely to contribute significantly to the surge in international collaborations.

The scale of multinational collaboratives was assessed by classifying publications according to the number of nationalities represented. As seen in Figure B, the number of publications composed of 2, 3-5, and 6 or more national affiliations has increased from 1975 to 2005 nearly 4, 16, and 24 fold respectively. Interestingly, the rate of increase in the number of publications with greater than 5 national affiliations is greater than that of publications with 3-5 national affiliations which in turn is greater than that of publications with 2 affiliated countries.

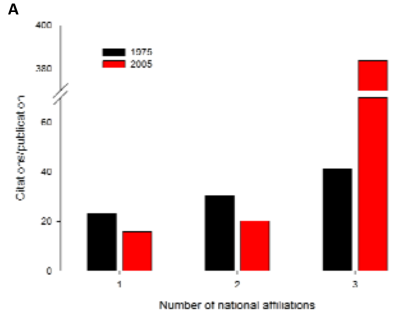
## COLLABORATIVE RESEARCH BY COUNTRY




To examine individual collaborative behaviors, the number of publications with multiple national affiliations was quantified for each country and portrayed in a heat map (Fig. A). By setting the maximal value for scaling at 1000 publications, it becomes apparent that only a few countries chiefly consisting of developed states, including the US, Canada, UK, and France (red), contribute substantially to the total number of collaborative papers. By normalizing data within each country, it is possible to discern how individual collaborative behaviors have changed over time (Fig. B). When the fractional collaborative research output was determined for each country, the greatest percentage of multinational efforts was seen among developing countries and nations with relatively lower research output (Fig. C).

## CITATION IMPACT OF MULTINATIONAL AFFILIATES

A

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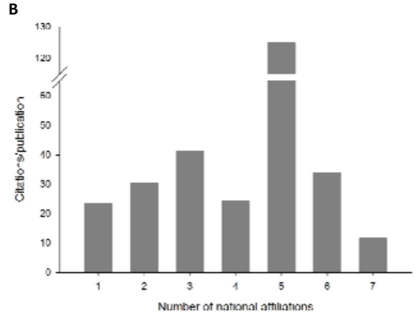


The relative impact of international collaboration in research over the span of the present study was determined by quantitating citations in 1975 and 2005. As seen in Figure A, there is a correlation between the citation impact of publications and the number of international affiliations. Interestingly, there was a significant citation advantage ($p<0.001$) of papers with one or two national affiliates published in 1975. However, papers with three national associations had a dramatic citation advantage ($p<0.001$) if they were published in 2005 as opposed to 1975(Fig. A). The mechanism behind this phenomenon is unclear, although it may be influenced by temporal changes in the nature and efficiency of joint research ventures.

Anecdotally, collaboration may foster creativity, increase utilization of resources, and thus yield high-impact research studies. However, when we computed the mean citation of publications in 1975 with more than three national affiliates, the positive correlation between citation count and the scale of international collaboration appears tenuous (Fig. B). Similar results were seen in analyzing articles published in 2005.

1. Greene, M., The demise of the lone author. Nature 450 (7173), 1165 (2007).
2. Abt, H., The future of single-authored papers. Scientometrics 73 (3), 353-358 (2007).
3. Jones, B.F., Wuchty, S., & Uzzi, B., Multi-university research teams: shifting impact, geography, and stratification in science. Science 322 (5905), 1259-1262 (2008).