

# What does International Co-authorship Measure?

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**Abstract**— We argue that while researchers note that co-authorship is an insufficient metric for international research collaboration there is little understanding about what else international co-authorship represents. Rather than focus on co-authorship solely as an output of research, we focus on the interaction between researchers involved in a co-authored paper. We therefore interview a range of researchers who had co-authored papers in a specific field – bio-fuels. From our interviews we find several factors driving collaboration such as different types of motivations, differences between researchers from the Global North and South, and differences between research rank among others. We then integrate these various factors together to postulate new models for the emergence of international research collaboration.

**Index Terms**— *international research collaboration; co-authorship; bio-fuels*

## I. CO-AUTHORED PAPERS AND INTERNATIONAL RESEARCH COLLABORATION

Collaboration, as with any human endeavor, is crucial to scientific progress. While this is an old concept, the actual study of scientific collaboration is somewhat more recent. de Solla Price [1] showed a noticeable increase of scientific collaboration since the beginning of the 20th century, a phenomenon that has attracted further study [2-6]. One common finding is that international research collaboration has grown very significantly [7-13].

In spite of this wealth of research, there is no clear definition of research collaboration itself. Some approaches focus on the actors involved [5] and others focus on the set of related activities. Indeed the lack of specificity around the concept of collaboration is not only reflected in theoretical definitions, but also in scientists' own perceptions [14]. One working definition that we employ in this paper is that of [15] who state that research collaboration can be broadly understood as

two or more scientists working together on a joint research project, sharing intellectual, economic and/or physical resources.

Even if we can agree on a definition, part of the challenge in studying international research collaboration lies in its measurement. Based upon the belief that collaboration usually results in a published paper, co-authorship is widely used as a measurement for research collaboration [16-19]. There are several practical advantages to using co-authorship in this way: (1) invariant and verifiable; (2) inexpensive; (3) large amount of data are available, and (4) un-intrusive and non-reactive [5].

However, the validity of co-authorship as an indicator for collaboration relies on two assumptions: firstly all coauthors actually participated in the collaboration, and secondly most collaborations result in coauthored publications [14], [20]. The first assumption is challenged by the phenomenon of honorary authorship [5]. The second assumption is also often criticized since not all collaboration results in co-authorships [5], [21], [22]. For example, collaborators may choose to publish collaborative work separately; and valuable suggestions and comments are not reflected in co-authorship.

There are also several empirical studies to investigate systematically the relationship between collaboration and co-authorships. In a small scale study in a university context, Melin and Persson [23] found that only 5% of the authors experienced situations where collaboration did not result in coauthored papers.

Another challenge to the co-authorship measurement is that it does not indicate what kind of contributions are made by each coauthor, and therefore cannot reflect the complex human interaction process underlying collaboration [15]. This lack of understanding of the interactive process behind the collaborative research enterprise is what we seek address in this paper. Specifically, we argue that although an imperfect measure of collaboration, co-authorship can provide further insight into the process of collaboration by looking at the authors themselves rather than just the resulting publication.

There has of course been significant work in understanding the process of research collaboration and the factors that contribute to its emergence. At a macro level there are, in general, three major types of factors driving research collaboration: intellectual, economic, and social. Collaboration is driven by intellectual needs to accomplish a project in the

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research environment characterized by specialization and interdisciplinary research [5], [24-26].

de Solla Price [1] emphasizes the importance of economic factors driving collaboration as well. He argues that one important motivation to collaborate is to squeeze “full papers out of people who only have fractional papers in them at that particular time” (pg. 160). Also, “big science” requires expensive facilities, large personnel, and therefore massive funding, which in turn drives collaboration. Several other authors list many economic concerns as important driving factors, e.g., sharing resources, data, equipment, etc. [5], [8], [27-30].

Science is also a social institution where social interaction plays a crucial role. Kuhn [31] depicts scientists as a community governed by paradigms. Beaver and Rosen [16] view collaboration as a response to the increasing professionalization of science: it helps both professional advancement and increasing knowledge. Collaboration not only provides intellectual and material resources, but also includes factors related to the social stratification of science as a profession, e.g. young professionals gain not only resources and equipment access from seniors, but also visibility because of the association with elites in their field.

The difference in social status between collaborators also shapes the type and dynamic of collaboration. Some scientists understand collaboration must be a partnership of equals, and therefore exclude student-teacher collaborations [5]. Research also found that extramural collaboration is characterized by similarity of the social status [32], highly productive authors prefer to collaborate with highly productive peers, rather than low status fellows [20].

On the other hand, junior researchers are motivated to collaborate with seniors to access to their resources and help professional development [16], [21], [33]. Also, Crane [34] argues that a few highly productive scientists set priorities for research and recruit and train students who become their collaborators.

At a micro level, collaborative projects are driven by different motivations depending on the specific contexts. Beaver & Rosen [16] highlight 18 motives ranging from access to special equipment and facilities, access to special skills, to accident or serendipity. The authors provided a conceptual analysis, but no data about motives or their impacts. Also, personal characteristics also influence collaboration actions. Personal beliefs about whether collaboration will (1) bring access to valuable expertise, apparatus, data, or other resources, and (2) help personal reputation and career development, are important factors for collaboration [35].

Finally, another set of factors that we look at include the country of origin of the researcher. First, country characteristics impact the tendency of collaboration: small countries and developing countries are more likely to seek international collaboration because of limited domestic resources [8], [36], [37]. Country characteristics also impacts

on what kind of collaboration to participate and outcomes. Hwang [27] found that Koreans collaborate with UK is not primarily for knowledge co-production, but for knowledge transfer, career building, model application to local conditions, or fund-raising. Duque et al. [38] found that collaboration has negligible and even negative effects on productivity in Ghana, Kenya, and the State of Kerala, India, because of underdeveloped local research conditions, and the difficulties that accompany poverty, red-tape, and corruption. Culture, language, and geographical proximity are also important [5], [8], [39].

Studies have also found that North-South collaboration often follows patterns based on historically colonial relationships [15]. More specifically, Edejer [40] notes that funding in these types of collaborations often comes from countries in the North and such research is often designed in those countries as well. Another issue is who actually initiates the collaboration. Few institutions in the South enjoy the variety of international contacts that would enable them to initiate bilateral collaborations with institutions in the North [41].

One way of improving our understanding of the various factors driving international research collaboration is to see how they interact together. In particular we want to combine intrinsic factors such as motivation with other explicit characteristics such as research rank and nationality as key factors of interest. As we have noted, it is widely acknowledged that co-authorship is only a partial measurement for collaboration. Thus rather than use it exclusively, we want to instead begin with the authors themselves to see what are the different models of collaboration that were used.

## II. INTERNATIONAL RESEARCH COLLABORATION MODELS

We analyzed the interview data using several different dimensions, some of which became more relevant as the analysis progressed. For example, we realized that there were differences between researchers from the Global North and those of the Global South. That is, there were differences in the co-authored papers where both authors were from the North (NN) and those where the one was from the North and the other from the South (NS)<sup>1</sup>. In addition, these differences sometimes overlapped with researchers who are at junior stage and those who were senior at the time of the publication. We assigned a junior or senior status to an interviewee by comparing the academic ranks of the authors involved in a given publication. A junior rank often referred to someone with a postdoctoral or similar position.

While these dimensions ostensibly pointed to differences in perceived benefits/costs and motivations behind international co-authored papers, we found that they partly illustrated the patterns in collaboration that we were seeing. Co-authored papers, while often viewed as the output of a research project, also indicate different types of factors driving international research collaboration. Based on the interview data, we

<sup>1</sup> None of the co-authored papers used in our samples had South-South co-authorship, an important area for further investigation.

postulate three models of how international research collaboration emerges. These models combine many of the discrete factors that previous research has pointed to whether at a micro or macro level as described above. Thus, for example, we look at how researcher rank combines with North-South dynamics and individual motivations.

#### A. Career Oriented Collaboration

One of the trends we observed was the way in which collaborations were initiated. In several cases, researchers were at a junior stage in their career such as a graduate student or postdoctoral scholar. Junior researchers did not run their own lab nor did they supervise graduate students. These researchers would instead visit the lab of the senior partner. A co-authored paper would often follow from this visit either based on the actual work done during the visit or from subsequent work. It is this junior-senior relationship between the eventual co-authors that is important to the collaboration overall.

In one case, an interviewee from Germany, reported that one of her main motivations for engaging in work with her collaborator was his status in the field and the opportunities that working with someone of his stature would represent. She reported that, at the time, this senior professor was looking for someone with her skill set to join his lab in a temporary position. She also reported that the collaboration led to a major publication which was very important in the subsequent development of her career. These results are congruent with other studies that recognize collaboration is important for building an individual reputation and establishing a viable career path, whether nationally [42] or internationally [27]. However, these previous studies did not make explicit reference to junior scholars in this way.

Indeed other junior researchers in our study pointed out that they sought specific collaborations based on a motivation to further their careers. In another case, a Brazilian interviewee visited and worked at a university in the United States as a postdoctoral researcher. He also reported that the professor he worked with was well known in the field and that this collaboration had a positive impact on his career in terms of international exposure to academia outside Brazil, his personal academic development and of course a publication.

The example of one researcher visiting the lab of a more senior collaborator as a postdoc occurred several times in our sample. However in a few cases the collaboration did not come in the form of a postdoc but still included a long-term stay at the senior partner's lab. For example, one interviewee from India reported that he was a professor in India and went to work with a more senior professor in the United States. As in the other cases, he also reported that the resulting publications were beneficial to his career back in India. In one case from China, there was no actual visit involved. Rather collaboration took place online and via telephone with work going on in two different labs. This kind of division of labor was however difficult and rare in our sample.

Of note, is the fact that of the five female interviewees in

our sample, three were identified as junior. There was however, little difference between the reports of the female junior researchers themselves. While two were based in Germany (one of whom did not state her nationality) and the other in China, they all expressed similar motivations in engaging in a collaboration that could augment their careers. This is again consistent with junior researchers in general.

As mentioned earlier, one dimension of interest is the differences between researchers from the North and those from the South. In this case, there was ostensibly an overlap between collaborations that included researchers from both the North and South and junior/senior researchers. For example, we observed that there were more junior researchers who were from the South and thus initially thought this was indicative of a larger trend. However, our results also indicate that there was no statistical significant relationship between researcher rank and region of origin. Thus although, as indicated in Table 1, there are more junior researchers from the South, in general such researchers are not more likely to come from region or another.

TABLE I. SUMMARY OF INTERVIEWEES BY RANK AND REGION.

	<i>North</i>	<i>South</i>	<i>Unassigned</i>	<i>Total</i>
Senior	8	14	3	25
Junior	2	5	2	9
Total	10	19	5	34

While researchers of a junior and senior rank were found from both regions, junior researchers from the South were more likely to emphasize the opportunities that such a collaboration might provide in terms of access to lab resources, funding, etc. Another benefit reported by junior researchers from the South is the positive perception that their peers would have of them after collaborating internationally. Thus they attached a higher premium to international research collaboration than their colleagues from the North. In two instances, senior researchers from the North felt that their partners from the South had benefited more. Alternatively, junior researchers from the North often reported benefits in terms of career development more than access to resources. Regardless of origin however, both senior and junior researchers often viewed such collaborations as an opportunity to improve the latter's career and this is was the basis for instigating the partnership.

#### B. Research Project Oriented Collaboration

In contrast to the career oriented collaboration, we note that many of the collaborations in our sample, were research project oriented. That is, their primary focus was on producing research and this goal was shared by the main researchers involved. This would be the case even where one researcher would stay at another's lab/university. One interviewee from Germany noted that although he had been collaborating with a colleague in the US in the past, when given the funding and the

time (he was on sabbatical), they were able to arrange an actual research visit. Through this visit they produce two important papers. As in this case, several other interviewees reported meeting their partner at a conference or in other instances they had been working together for some time. In both scenarios, they were able to identify common broad research agendas and pool complementary resources.

In this German/American example, the two researchers still maintain contact a few times a year and are open to future collaboration. This continued desire to collaborate stemmed from both researchers already having an established path in their research careers and relatively stable interests. This is in contrast to several of the junior-senior partnerships where subsequent contact after the initial collaboration is seldom. This is most likely the case as by definition, a junior researcher is still defining his or her career.

As with the career oriented model, there were again several noticeable differences between researchers based in the North and those in the South. In most cases, both sets of researchers felt that their projects were successful. There were several commonly stated reasons for this success such as good timing, availability of funding and a recent general interest in that particular field. There were however, two instances where the researcher from the South would attribute much of that success to the partner from the North even if they were of similar rank.

Several researchers mentioned language as being one of several potential challenges to engaging in international research collaboration. For the most part, the interviewees did not mention differences in culture as a challenge to collaboration. However, at least one researcher (a German) noted how the dynamics between North and South might influence perceptions. For example, he reported that on his first visit to Brazil he had to convince the staff that the Germans were not just there to take Brazilian resources or access cheaper human resources. Thus he felt that to overcome such fears/issues, one needs to build up a relationship with the potential partner prior to working with them.

Interviewees also suggested that the collaboration in question had motivated them to engage in other collaborations. This comment was in fact very common among interviewees. In general this would support the positive perception that interviewees had of international research collaboration as a whole. Thus unlike the works of Gaillard [41] or Edejer [40:440], researchers from the South, for example, did not comment that “sometimes we are like poor prostitutes,” nor did they feel disadvantaged by engaging in research collaboration with colleagues in the North.

### *C. Sponsor Initiated Collaboration*

The final model that we observe relates to the nature of funding for these research projects. While this can occur in different ways, of significance is in several different ways including funding from academic institutions, government programs and industry groups. There were again differences depending on the region of origin of the researchers. That is, North-South collaborations were more likely to get funding

from industrial/corporate sources, or international donors. While North-North collaborations were more likely to be funded by their universities or governments. This led to different types of partners in each group. In the NS cases it was sometimes university-industry and in NN it was university-university partnerships. We characterize these sponsor initiated collaborations as a third model because while they might support both career oriented research and of course research projects their modus operandi were different.

In one example from India, the interviewee noted that the company General Motors provided the funding for joint work between their institution in India and their colleagues in the US. In this way GM acted as a funding agency for the project and regularly monitored activities and outputs. In another example from China, Shell was the industry sponsor and played a key role in supporting the research project. In contrast, several interviewees from Germany and the US pointed to their governments or universities as main sponsors for their research. This pattern was not viewed negatively by any of the interviewees themselves, indeed funding is always a good thing as they noted. The point here is somewhat more subtle and refers to that fact that in some collaborations companies can play a bigger role in setting the research agenda while funding a project.

Another issue that was not brought up in many cases but is of interest was that of intellectual property rights. In two cases researchers from the South mentioned intellectual property as an issue. For example, when dealing with foreign firms they noted that part of the research arrangement was that intellectual property generated in the course of the research would accrue to the sponsoring company. Although a common arrangement, they noted that this was one of the challenges of international research collaboration in general. This perhaps points to one of the consequences of the limited funding and options that are available to some researchers.

## III. CONCLUSION

This paper presented the results from a series of interviews that sought to understand the ways in which many of the established factors influencing international research collaboration interact. Our analysis outlined three different models of collaboration. Though not necessarily mutually exclusive, these models show how researchers at different times and different points in their careers can emphasize some interests over others to collaborate in different ways. Of note is the fact that across the three models, there were no significant differences in the two time periods used. Interviewees reporting on their collaborations between 2004-2006 or those reporting on the 2007-2009 period had similar experiences.

This work contributes to the understanding of international research collaboration by highlighting the connection between key variables of interest such as researcher rank, region, gender, and funding source. The resulting models are an attempt to articulate other functions of collaboration beyond the singular notion of project oriented research. This paper is therefore presented as a step towards better understanding the

complex interactions that underscore collaboration. This research also could form the basis on a larger investigation on international research collaboration that would go beyond the small sample used here. Indeed it could be applied to other fields as well enabling a better understanding of science as a whole.

#### APPENDIX A - WEB OF SCIENCE SEARCH STRATEGY FOR PUBLICATIONS IN BIO-FUELS (2004-2006 AND 2007-2009)

- 1 TS=(hemicellulos\* OR lignocellulos\* OR biomass OR "forest residue\*" OR "forest waste" OR "agricultur\* waste" OR "agro waste" OR "crop residue\*" OR "crop waste" OR bagasse OR "corn stover" OR "corn stalk\*" OR switchgrass OR miscanthus OR poplar
- 2 TS= (sugarcane OR "sugar cane" OR energycane OR "energy cane" OR beet OR beets OR "sugar beets" OR sorghum OR corn OR maize OR cassava OR wheat)
- 3 TS= (ethanol OR bioethanol OR bio ethanol OR biobutanol OR biofuel\* OR bio fuel\* OR bio refinery OR biorefinery OR bio refineries OR biorefineries)
- 4 #2 OR #1
- 5 #4 AND #3
- 6 TS=(biodiesel OR bio diesel OR biofuel\* OR bio-fuel\* OR bio-gasoline) OR TS=(renewable SAME fuel\*) OR TS=(synthetic SAME fuel\*) OR TS=(energy SAME crop\*) OR TS=((fischer - tropch OR fischer tropch) AND (biomass OR feedstock\*))
- 7 #5 OR #6
- 8 TS=(medicin\* OR medication OR medical OR pharmac\* OR rat OR rats OR liver OR drug\* OR blood OR plasma OR embryo OR cereal OR fruit OR fruits OR nutrition\* OR wine\* OR polymer OR membrane OR biopolymer\* OR biomaterial\* OR biofilm\* OR film OR bioremediation OR coating OR extrusion OR extruder OR crustaceous OR crustacea)
- 9 #7 NOT 8

#### APPENDIX B - INTERVIEW QUESTIONS AND DISCUSSION POINTS

- 1 Tell me a little about your research and how it relates to biofuels.
  - 1.1 What were the main motivations to initiate collaboration with your international partner? Have you collaborated before?
  - 1.2 Who initiated/invited the collaborative activity
  - 1.3 How was the topic of your research selected? Does the choice of research topic precede or follow the decision to collaborate internationally
  - 1.4 What is your role in the project? Who takes the lead role in the research?

- 1.5 How long did your project take (for a project that has already been finished); or how long the current collaborative project will take?
- 1.6 How do you communicate and how often do you communicate? How often do you visit your research partner in her/his home country, if ever?
- 1.7 (Depending on the level of responsibility of interviewee) How is the research funded, how are the funds allocated, and who manages the finances of the project?
- 1.8 Overall, do you consider your project successful? If so, what factors contribute the most to the success of your project? If not, what factors prevent it from being successful?
- 1.9 What would you do differently, if anything?
- 2 Structure of the team
  - 2.1 How many people were involved all together?
  - 2.2 How many were junior researchers? What roles did they have?
  - 2.3 How many were students? What roles did they have?
- 3 Benefits of IRC for the researcher being interviewed
  - 3.1 Can you list the most important benefits of this IRC to you? To your team?
  - 3.2 Can you list the most important costs of this IRC to you? To your team?
  - 3.3 To what extent did this collaboration brings benefits in
    - 3.3.1 Gains in knowledge
    - 3.3.2 Learning about new instruments and methodologies
    - 3.3.3 Stimulating scientific network/interaction
    - 3.3.4 Building capacity for problem solving
  - 3.4 Do you think that you and your international research partner benefited equally?
  - 3.5 Did the junior researchers benefit from the collaborative research? How?
  - 3.6 Did the students benefit from the collaborative research? How?
  - 3.7 Did your collaborative research generate any publication, patents, conference presentations, or books? If so, could you please provide a list of them?
  - 3.8 Do you plan to collaborate with your international research partner in the future? Why or why not?
- 4 Challenges in the international collaboration

- 4.1 Did the collaborative research with your international partner(s) involve any challenges? If so, which are/were they, and why do/did they exist?
- 4.2 Did you experience the challenge(s) for the first time in this collaboration, or did you have the same challenge(s) before in other international collaborations?
- 4.3 Do you think that there are either incentives or barriers to international research collaboration in general? Political, contractual, cultural?
- 5 Other international collaboration
  - 5.1 Have you collaborated internationally with other teams or researchers?
  - 5.2 Do you have plans for more international collaboration?
  - 5.3 Does your department have collaborative relationships with other universities? Can you give 2-3 examples?
  - 5.4 Does your university/research institution have collaborative relationships with other universities? Can you give 2-3 examples?
  - 5.5 Does your team, department, or university/institute have an international collaboration strategy? If so, what is it?
- 6 Additional information
  - 6.1 Interviewer asks for list of junior researchers and students that were involved, as well as contact information if available.

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