
INTERNATIONAL RESEARCH COLLABORATIONS: ANTICIPATING CHALLENGES INSTEAD OF BEING SURPRISED

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Research has always been, in large measure, a global enterprise. The search for new knowledge is undertaken everywhere in the world, and researchers are typically among the best-travelled members of any community. Participation in international networks is a signature activity of top researchers, and most scientists take advantage of education, conferences and exchanges outside their own countries. Indeed, the walls of academic offices are often miniature museums, exhibiting collections of artefacts from far-flung adventures.

At present, there is considerable interest in expanding a particular form of global interaction: international research collaboration, that is, research pursued jointly by scientists whose primary institutional affiliations are in different countries. The emphasis here is not on researchers merely learning from each others' ongoing work, but rather on cross-national teams jointly initiating, pursuing and owning research projects. These ventures range from projects involving two people from different countries, to mid-sized international groups pursuing a line of research, to major ventures involving cooperation among international teams and substantial investment from participating countries (as in the case of the Large Hadron Collider). It is not the size or degree of formality that distinguishes these collaborative projects; it is instead the joint nature of the research process across national boundaries.

Research institutions and funding agencies, like researchers themselves, are increasingly interested in the benefits of international collaboration. Funders' enthusiasm for joint efforts is matched by scientists' eagerness to take advantage of the broader research agendas and opportunities in the international arena. At both levels, however, eagerness to 'go global' often outpaces awareness of the attendant complications. A recent volume on international research collaborations (Anderson and Steneck, 2010) calls attention to a wide variety of challenges embedded in international research. This essay's framework and examples derive largely from that volume.

EXPANSION OF INTERNATIONAL RESEARCH COLLABORATIONS

Authorship is one way of tracking the development of cross-national collaboration. Lists of co-authors from different countries indicate successful, productive collaborations, but, as such, they significantly underestimate the extent of international work, as many collaborations are delayed or unsuccessful in yielding publications, even if they generate useful outcomes of other kinds. Still, trends in international authorship provide evidence of significant growth in cross-national collaboration.

Bruce Alberts (2010), the editor of *Science*, one of the most prestigious international scientific journals, noted recently that over half of the papers published in the journal in 2009 were co-authored by international teams. Data from the US National Science Board (2010) provide relevant trend analysis. Between 1988 and 2007 the percentage of science and engineering articles worldwide that involved international authorship rose from 8% to 22%. The effects of Europe's promotion of international projects are evident in this measure: European international co-authorship rose from 22.4% to 49.9% in the same period. By contrast, the comparable increase in the People's Republic of China was from 22.4% to 24.8%.

Other measures of international collaboration are less reliable. Funding mechanisms that encourage or require international cooperation provide only a partial estimation of collaborative activity. Most research funding is allocated intranationally, and international collaborators often pool funding from their own sources to support their joint research, adding substantially to overall investment in international ventures. Migration of graduate students and postdoctoral fellows is another rather unsatisfactory measure, as advanced training has always involved significant numbers of international students, and their numbers fluctuate in part on the basis of political conditions in the relevant countries, which may have little to do with changes in research intensiveness. Suffice it to say that participation by trainees in research outside their home countries always accounts for a significant portion of international collaboration.

REASONS FOR INTERNATIONAL COLLABORATION

To some, cross-national research might seem self-evidently valuable or even necessary, as international collaboration becomes the norm in many fields, particularly the sciences. Motivations for international work are not always transparent, however, and sometimes they stem from questionable aims.

Of course, most researchers initiate collaborations because of their desire to work with particular people whose work they have admired or who are pursuing similar lines of inquiry. Specialization of research fields often means that one's closest peers in an area of study are few in number and dispersed around the globe. Connections are made by e-mail or by sharing the stage at a conference symposium. Scientists get in touch through mutual collaborators or service on committees. In any case, researchers inhabit small worlds of research expertise (Clark, 1987) in which they are familiar with most of the other potentially collaborative (or competitive) teams.

The imperatives of specific research problems can also promote international collaboration. The objects of scientific study (e.g., glaciers, malarial swamps, inbred populations) are not evenly distributed around the globe. Research at distant sites increasingly involves participation of local or regional collaborators. Equipment or materials can also prompt collaborative work. At times, incoming researchers need to rely on local access to proper equipment, and in other cases local researchers benefit from equipment manufactured in other countries and brought in by collaborators.

Some ventures require infrastructure far beyond equipment. Major scientific initiatives may require a decade's worth of construction and preparation that no country would be willing or able to fund alone. Worldwide clinical trials are often beyond the scope of any individual nation's capacity to fund and manage. Such 'big-science' projects depend on multi-national investment and shared risk. Funding agencies, partly in recognition of these benefits, are now more frequently recommending or insisting upon cross-national components in the work that they support. They thereby provide strong incentives for researchers to find partners outside their home countries.

There are also times when potential collaborators are motivated more by a desire for affiliation with top researchers than by any substantive connection with them. Researchers in the developing world have less ready access to publication outlets, funding and peer networks. Their stature in their own countries and globally can be enhanced by affiliation with well-known researchers in research-intensive nations, who

sometimes contribute in only cursory ways. For example, when Hwang Woo-suk of the Republic of Korea (South Korea) was charged with fraudulent research and other offences, his US collaborator, Gerald Shatten, was implicated. Shatten had agreed to serve as senior author on one of the initially most acclaimed but ultimately fraudulent publications, though his actual contribution was limited to revising the manuscript. Hwang was found guilty of embezzlement and ethics violations (Akst, 2009); Shatten was cleared of misconduct but declared guilty of misbehaviour through irresponsibility (Holden, 2006). In another case, Pattium Chiranjeevi, a researcher in India, added dozens of researchers to papers that reported fictitious experiments, in an effort to increase the likelihood of success in publication (Schulz, 2008).

Even less acceptable motives drive some international collaborations. Researchers have been known to focus data-collection efforts in countries that have under-developed or non-existent regulations on the use of human subjects. Doing so can significantly ease the burdens of paperwork and compliance, but it can also put research subjects at risk, without access to mechanisms of redress. One hears stories of researchers who have followed the examples of multi-national corporations and have sited their research where costs will be low, usually because of cheap labour or access to large numbers of subjects whose participation can be bought at a low price. Corruption can be a major deterrent to international collaboration, but some researchers find it easier to work where payments to officials will hasten approvals.

On balance, however, most researchers conduct their international research with integrity and in a spirit of adventure. Scientists get caught up in the excitement of travel, as they become more familiar with other cultures and extend their work's impact to other countries. Collaborations are far easier to manage since the advent of the internet, other electronic networks, inexpensive telephone connections and expanded international air travel. Indeed, young scientists have grown up in a globally connected world. Their experience leads them to be not only open to international research but often dismissive of research that is constrained by national borders.

TRIPPING OVER DIFFERENCES

Driven by the momentum of expanding collaborations and a variety of motivations, many researchers are eager to begin or extend their international work. They may focus on particular objectives in working internationally, or they may have only a general sense of the attractiveness of international projects. They often do not pay much attention to how the international nature of the work will complicate their efforts.

These complications are part of most collaborations, but they come particularly to light when something goes wrong. If improprieties derail a project, the parties often initially blame language differences or cultural misunderstanding. Language is an obvious potential source of miscommunication. Culture represents differences in assumptions, expectations, roles, work styles and so on, which researchers encounter among their international colleagues but often do not fully understand. In blaming either of these factors, researchers seem to suggest that if only all parties could 'be on the same page' in approaching the work to be done, problems in international research would be no worse than those in domestic projects.

The problem with this thinking is that researchers from different countries often *cannot* be on the same page. There are significant differences in national research systems that pose challenges in international collaborations. These differences are largely invisible to or ignored by many researchers who embark on cross-national work, precisely because they are accustomed to taking their own national research systems for granted. This essay and the book on which it draws (Anderson and Steneck, 2010) focus on the influence of these systems on international collaboration, not denying the role that culture plays, but suggesting that vague cultural factors have too often been blamed for problems that may stem from fundamental national differences in the organization, support and conduct of research.

CHALLENGES DUE TO DIFFERENCES IN NATIONAL RESEARCH SYSTEMS

National research systems encompass all the institutions and activities involved in the conduct and support of research. Many differences in national research systems can affect the course of an international collaborative effort. Some differences are quite obvious. If a researcher is accustomed to good facilities and readily available supplies, working with a collaborator who has neither can require considerable adjustment in budgets, schedules, conceptualization of the project and personal expectations. If a researcher has been working in a country where personal connections and influence are the keys to access in research, it can be quite a challenge to work within an elaborate system of regulation and oversight.

Four dimensions of national research systems are of particular relevance to research collaborations: the organization of the research system (including funding mechanisms), legal and regulatory systems, oversight related to research integrity, and the training of graduate students and postdoctoral fellows. Each is considered here, with illustrations largely from Anderson and Steneck (2010).

ORGANIZATION OF THE RESEARCH SYSTEM

Perhaps the most basic systemic feature relevant to research collaborations is how the actual work of research is organized and funded. Institutional structures shape each nation's distinctive research enterprise, including where the work is done (Chapman et al., 2010). In some countries, notably in Central Asia, much of the work is done in research institutes. In others, such as the USA, non-commercial research is done largely in research universities, with a complementary sector of government research facilities in specific locations. In China, the Chinese Academy of Science has laboratories spread across many universities. Emerging pan-European research facilities, such as the European Spallation Source, will play increasingly important roles.

The distribution of research across sectors can be illustrated by research profiles in three Asian contexts (LaRocque, 2007). In Hong Kong 64% of research and development is done in the academic sector, with 33% in the business sector and 3% in the government sector. By contrast, in Japan the academic sector accounts for only 14% of research and development, with business and the government doing 75% and 9%, respectively. Indonesia represents a third distinctive profile, with a mere 5% of research and development in the academic sector and only 14% in the business sector, but 81% in the government sector.

Governments also vary in the extent to which they control research agendas. Some exert a great deal of central control over the direction and scope of research done, to the extent that the priorities of the research system become largely indistinguishable from national priorities. In such cases, national funding usually flows through ministries of science and technology directly to universities, in support of national goals for science. By such means, China has promoted expansive, rapid increases in production of applied research. The USA has taken a more investigator-driven approach to funding and has focused far more attention and investment in basic science. Priorities set by the US Congress and the federal funding agencies do play important roles in shaping research through funding mechanisms, but to a lesser extent than in many other countries. The European Union Framework Programmes have played a role in both altering the organization of research across Europe and in influencing the direction of research by channelling investment to promising areas of inquiry.

Cross-sector collaborative initiatives are supported in some countries and difficult to navigate in others. The US Bayh-Dole Act, for example, has encouraged substantial collaboration between universities and industry by providing mandates and incentives for such cooperation (Bohnhorst et al., 2010). By this Act, the commercial potential of research that is funded by the federal government and conducted at universities must be considered; if such research leads to commercialized products, universities are able to capture some of the revenues through patents and licensing, despite the project's original funding from government sources.

Organizational differences in research systems need to be considered at the local as well as national level. Research systems differ in terms of authority structures, communication networks and decision making. Most scientific research is done in teams, but norms of authority within teams are not universal. In open systems, members of a research group are encouraged and expected to contribute ideas related to the direction of research projects, quite beyond the scope of their assigned work, even if their ideas challenge the project leader. In other systems, project direction is considered the responsibility of the principal investigator, who is not to be openly challenged. Communication patterns are likewise affected by varying norms. In some contexts, researchers are accustomed to interacting only with those in collaborating groups at the same hierarchical level, while in other national systems it is common for communication to cross hierarchical levels, both within and across teams.

Researchers who are interested in establishing international collaborations may not be aware of organizational and funding differences that can complicate their work. There is no reason to assume that the structural and funding properties of a potential collaborator's institutional home will necessarily impinge on the work to be done, but awareness of organizational differences can help one anticipate problems.

For example, most researchers setting out to initiate an international project do not consider the role of the diplomatic corps. There are times, however, when diplomatic knowledge of a country's institutional structures and research-related norms can deflect problems. Handley (2010) recounts one such situation. A US researcher working in sub-Saharan Africa set out to study the nursing care given by traditional midwives and by nurses in government hospitals. The research team acquired consent from the patients, the institutions involved and the midwives, and they videotaped the caregivers in interaction with patients. When the findings, including the videotaped interactions, were presented at a seminar, it was clear that the care provided by the nurses fell far short of the care given by traditional midwives. The problem was that the seminar was attended by senior government health officials and college administrators. The seminar erupted into a volley of pointed questions and the administrators confiscated the videotapes. Handley's point in providing this illustration is that US diplomats could have provided valuable information concerning the government's wariness about criticism of government officials and traditional versus medical models of care, as well as the role of family members in providing consent to participate in research projects in that country.

In most cross-national collaborations, even those free of sensitive issues, differences in organizational structures lead to complex management protocols. If there is little match or even harmonization between systems for managing budgets, purchasing, payments, materials and oversight, projects can be difficult to administer (Nebeker, 2010). These challenges are particularly pressing when the participating countries have significantly different laws pertaining to research.

LEGAL AND REGULATORY REQUIREMENTS

Countries have different laws and different legal systems, a fact overlooked by many researchers who are eager to collaborate internationally. When working domestically, researchers may have little need to monitor legal requirements or consider the legal implications of their project decisions, largely because they can count on their institutions' staff to handle the legal side of things. In international collaborations, legal staff may themselves be challenged by very different legal requirements and ways of reconciling legal mandates.

Perhaps the most fundamental challenge in the case of mismatched laws is deciding whose laws apply in a given situation. Cross-national research may involve researchers from several nations, all of which may have different requirements. In some cases, contracts can be drawn up at the initiation of a collaboration, specifying whose laws will take precedence in the event of problems (Nebeker, 2010). In the absence of such contracts, legal issues can be a project's greatest headache and the easiest way for researchers to get in trouble.

Bohnhorst et al. (2010) describe a variety of legal challenges relevant to international collaborations. They describe, for example, the difference between European Union and US approaches to intellectual property. The former assumes from the start that intellectual property will be shared by all parties to the collaboration. The USA, through the Bayh-Dole Act, specifies that the parties to a collaboration have a right to intellectual property that they have created, but they are not expected to share that right with others who have not been involved in that creation. Indeed, as Bohnhorst et al. (2010) note, certain parties to collaboration may simply not be the right people to move a project's output from basic research to commercialization.

Other legal constraints on international collaboration involve the payment of foreign taxes and dealing with passports. Tourist visas are generally easier and quicker to obtain, but collaborators who will be working in another country may not be able to use them; those who try to get by on tourist visas are sometimes detained abroad.

Each country has its own legal requirements, some of which are specific to another nation. Three such requirements in the USA are important worldwide, because of the extent of US participation in international collaborations (including clinical trials) and the serious consequences of violations of these laws. The first derives from US export control law, specifically the International Traffic in Arms Regulations (ITAR), and the Export Administration Regulations (EAR). The first addresses the export of items that have military purposes, and the second covers 'dual use' materials—that is, materials that have both military and non-military uses. Bohnhorst et al. (2010) describe a situation involving these regulations in a collaboration related to climate-change research. The scientists involved wished to transport an instrument to Iceland. The instrument had been used in the USA to map lake beds by sonar. It included, however, an 'inertia motion unit' that was designed to control for the motions of the boat during underwater mapping. This unit had a potential use in missile guidance systems, and it was reclassified from EAR to ITAR, necessitating an ITAR licence before the researchers could take the equipment to Iceland. Such complications can lead to considerable delays, which researchers must accommodate.

A second legal requirement specific to the USA is 'deemed export'. This derives from export control laws that refer to 'items' that may be exported. Under US law such items include information (Bohnhorst et al., 2010), with the consequence that information shared with someone from another country is deemed to have been exported to that country. In combination with restrictions on exports to certain countries, this provision substantially complicates access to information by people from these countries. Consider, for example, the situation of graduate students who work in a laboratory, some of whom are from countries covered by deemed export provisions. These students must not receive information that could have military use, and anyone who provides such information is subject to prosecution. There is, however, a 'Fundamental Research Exclusion' that exempts some basic research from deemed export requirements, but it is extremely important for US researchers and their collaborators to adhere strictly to deemed export rules, which apply even when the US researcher is working in another country.

A third US legal requirement is based on the Foreign Corrupt Practices Act, which addresses corruption, the payment of bribes, and questionable accounting practices. It prohibits any payment of a bribe by a US citizen to a foreign official or to someone who will forward it to a foreign official (Bohnhorst et al., 2010). Corruption has, unfortunately, been a part of the conduct of some collaborative research, as in some countries bureaucratic tangles can essentially stymie a project until a bribe is paid to clear the way. It is important for collaborative agreements with US participation to address the provisions of the Foreign Corrupt Practices Act at the beginning, to be sure that all parties are aware of the law and the consequences of violations.

INTEGRITY OVERSIGHT

As legal issues can have serious consequences for international collaborations, so can matters of regulatory oversight. Of particular interest is compliance with policies and regulations that, unlike export control, are

specific to research. Included here are policies related to the use of human and animal subjects in research and other policies intended to maintain the integrity of research.

Issues such as research misconduct can be very difficult to deal with in the international context. Boesz and Fischer (2010) present a case that is not, strictly speaking, related to international collaboration, but suggests the kinds of problems that arise when misconduct occurs internationally. A researcher from one country submitted a proposal to a funding agency in another country. The proposal was rejected, in part because of a highly negative review by one particular reviewer. Some time later the researcher was asked to review a proposal. Upon reading it, the researcher discovered that it included part of the text of the original proposal. It was found to have been submitted by the over-critical reviewer. This case of plagiarism was difficult to handle, particularly because it involved grant proposals, which are supposed to remain confidential during the review process. What made it even more difficult, of course, was that the researcher and the reviewer were from different countries.

This case highlights one of the most troubling aspects of international research: there is no body with authority to investigate and adjudicate cases of misconduct internationally (Steneck, 2010). Indeed, there is no shared, global definition of misconduct or approach to investigating it. Researchers who collaborate cross-nationally may find that they need to adhere to different standards than their domestic policies would require, and the project overall must satisfy the strictest provisions of all relevant regulations.

Recent initiatives have addressed the need for harmonization of policies related to research misconduct and oversight. The Global Science Forum of the Organisation for Economic Co-operation and Development (OECD) consulted widely among international officials and experts in the field and, after a workshop in Tokyo in 2007, issued a statement on best practices for ensuring scientific integrity and preventing misconduct (OECD, 2007). The statement identifies core research misconduct as fabrication, falsification and plagiarism, as in the US federal definition of misconduct. It also, however, identifies a range of other types of misconduct, including research practice misconduct (e.g., poor research design, inappropriate treatment of human and animal subjects), data-related misconduct (e.g., inappropriate data management, withholding data), publication-related misconduct (e.g., inappropriate authorship practices, failing to correct errors in the record), personal misconduct (e.g., inadequate mentoring, harassment), and financial/other misconduct (e.g., misuse of research funds, inappropriate peer review) (OECD, 2007). After release of the best-practices statement, a Coordinating Committee for Facilitating International Research Misconduct Investigations (2009) was appointed, which issued a final report along with a Practical Guide to investigating allegations in the context of international collaborative research. These efforts and others (Stainthorpe, 2010) may prove influential in moving countries toward harmonized approaches to defining and addressing ethical challenges in research.

Two conferences on research integrity represent another approach to fostering harmonized—if not common—approaches. The First World Conference on Research Integrity, held in Lisbon in 2007 (www.esf.org/index.php?id=4479), was an opportunity for officials, policymakers and researchers to discuss their varying conceptions of research integrity and to suggest ways of handling integrity issues in the cross-national context. The Second World Conference in Singapore during the summer of 2010 (www.wcri2010.org) was to focus on moving toward consensus on some fundamental aspects of integrity, notably in four areas: publication ethics, official responses to misconduct, codes of ethics and instruction in the responsible conduct of research. To the extent that some degree of consensus can be reached in these critical areas, it will support the development of cross-national or even global approaches for handling misbehaviour in research.

In the absence of global mechanisms for integrity oversight, US standards and policies often serve as the framework for ensuring ethical behaviour in research. US influence in this area is bolstered by the large US investment in international research projects and by the highly articulated US system of integrity oversight through the Office of Research Integrity in the Department of Health and Human Services, the Office of the Inspector General of the National Science Foundation, and the Office of Human Research Protections, among

others. Capron (2010) argues that US dominance in this area is both unfortunate and inappropriate, but concludes that until a system of global governance of research ethics is established, the US system will continue to exert undue influence. De Vries et al. (2010) likewise discuss the challenges of reconciling Western conceptions of bioethics and the norms of research with non-Western approaches to ethical dilemmas.

TRAINING OF GRADUATE STUDENTS AND POSTDOCTORAL FELLOWS

Most research teams involve young researchers as well as senior investigators. Students and postdoctoral fellows are critical to the success of most research projects, because they are often the ones who collect the data, run the experiments and do the actual analyses under the supervision of the principal investigators. Trainees often participate fully in cross-national research projects as well.

Of course, these young scientists themselves represent an international component, if their training is outside their home countries. They account for a substantial proportion of cross-national scholarly migration, and the work they do with foreign supervisors is perhaps the most common form of international research collaboration. As such, this form of collaboration is subject to all the complications discussed above but also involves problems specific to training.

For example, countries differ in terms of the extent of independent or individual doctoral study (Anderson et al., 2010). In the USA doctoral students typically take courses and most doctoral programmes are run by academic departments with oversight by an institution-level graduate school. By contrast, in some European and Asian countries doctoral study is significantly more individually oriented, with very little coursework, if any, and with supervision largely at the level of the academic adviser (Shaw in Anderson et al., 2010; Jie in Anderson et al., 2010). In Japan, students are trained in the *koza* system, which emphasizes hierarchical structure and harmonious relationships among the members of the research team (Kamata in Anderson et al., 2010).

Young researchers also have differential access to and motivation for internationally collaborative work. Most doctoral students in China are not able to defend their dissertations until they have published in the core journals, and usually the publications must be in nationally or internationally recognized journals (Jie in Anderson et al., 2010). In Brazil also, students are encouraged to submit manuscripts to English-language, internationally recognized journals before completion of their doctoral work (Vasconcelos and Sorenson in Anderson et al., 2010). In Kazakhstan, as in other former members of the USSR (Union of Soviet Socialist Republics), successive waves of educational reform have led to instabilities in graduate education and great interest in partnering with researchers in other countries, despite challenges of access to information and equipment (Kuzhabekova in Anderson et al., 2010). Such challenges are far greater in the Democratic Republic of Congo, where access to information, facilities, technology and researchers with advanced training are all compromised by inadequate institutional infrastructure and political and economic instability (Chiteng Kot in Anderson et al., 2010).

Researchers who themselves have been trained under different systems should be aware that the young investigators on an international project may have different assumptions and expectations about how work and interactions should be conducted. Given the critical contributions that students and postdoctoral fellows make to research projects, it is important for all senior researchers to know how the young investigators have been trained, what they know about regulatory and legal compliance, what kind of supervision they receive, and what they hope to gain professionally from the collaborative experience.

CONCLUSION

International research collaborations will continue to expand as the world becomes more globally connected. Problems that know no national boundaries attract international research teams who find it progressively

easier to communicate, travel and co-ordinate their joint activities. They take on the practical challenges of working across different time zones, trying to get materials shipped despite uncertain carriers and customs practices, and dealing with the strains of travel and living abroad. The annoyances that plague any traveller are often magnified under the pressures of trying to complete research projects with collaborators on the other side of the globe. As first-time collaborators figure out how to cope with these practical difficulties, they would do well also to pay attention to the kinds of national differences discussed here.

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