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Geoffrey Oldham

Before considering the types of mechanisms which might facilitate international collaboration in science, engineering or medicine it might be useful to establish a framework for the categories of collaboration. The following is a suggested framework of analysis

Informal Collaboration

The increasing collaboration between scientists as a part of their way of doing research is demonstrated by bibliometric evidence which shows that an increasing proportion of all published papers are co-authored. Frequently, the co-authorship involves scientists from other institutions and these are often in other countries. Some bibliometric studies have shown the pattern of collaboration between countries and demonstrated how that pattern changes over time. For example, the United States appears to be almost everyone's favorite partner, although collaboration between institutions within Europe has increased substantially in recent years.

The pattern of international collaboration involving developing countries is also of interest. There is a tendency for former colonies to collaborate more with their former colonial powers. In addition, there is a clear pattern which suggests that the smaller the scientific community in any given country the greater the propensity to collaborate with other countries. The exceptions to this rule are Japan and Russia.

Most of these bibliometric patterns follow expected trends and reflect old and new political affiliations. They also reflect the increasing specialization of science whereby it is increasingly likely that one's peers will be found in other countries. Other factors such as relative ease and cheapness of

Geoffrey Oldham is Science and Technology Advisor to the President at the International Development Research Center in Ontario, Canada. Since joining IDRC, he has participated in a review of S&T policy in South Africa and is currently involved in a study of the S&T decision-making process in Canada as well as in China. Prior to joining IDRC, Professor Oldham was a member of the Standing Committee on international scientific collaboration of the U.K. Prime Minister's Advisory Council on Science and Technology from 1989 to 1992, and was chairman of the United Nations Advisory Committee on Science and Technology for Development from 1991 to 1992. He is currently the U.K. delegate to the UN Commission on Science and Technology for Development. Professor Oldham obtained his Ph.D. in geophysics at the University of Toronto.

international travel are also contributing factors. Use of the Internet is also likely to facilitate informal international collaboration in science, engineering and medicine.

Formal Collaboration

Formal scientific collaboration occurs within schemes which usually involve contractual commitments. These may involve governments, scientific societies, business enterprises and research institutions which agree for various reasons to work together. These reasons determine the nature and organization of the collaboration, and hence need to be identified and specified:

(a) geographic reasons;
(b) cost reasons;
(c) political reasons;
(d) commercial reasons; and
(e) global problem reasons;

(a) Geographic Reasons

(i) When the research problem spans several geographic regions and crosses national boundaries, for example, climate change and geophysical studies of the Earth's crust the motivations for collaboration are clear. The problem cannot be solved unless similar observations are made across several countries usually at the same time.
(ii) Some research topics are of international interest, but the issue is unique to a particular geographic location. High altitude physics, or studies of tropical rain forests are obvious examples. Collaboration may be required if scientists in one country, lacking the necessary environmental features, are to carry out their research in the field.

Collaboration on these topics are frequently implemented by institution to institution collaborative agreements and such agreements may be facilitated by an international scientific organization. There may be organizational difficulties, however, when the scientific problem requires an interdisciplinary approach for its solution.

(b) Cost Reasons

Big science, or megascience, projects are, by definition, very expensive. The costs are frequently beyond the abilities of any single country to pay alone. Large telescopes and particle accelerators fall into this category, but so too do projects such as the human genome project. In these circumstances, agreement on cost sharing for the building of a scientific facility are common. CERN is one of the best examples of such collaboration.

(c) Political Reasons

Visiting heads of state sometimes want to cement good relations with their hosts by signing an agreement on something. Not infrequently, these are scientific agreements. Sometimes such agreements lead to extra budget allocations by governments, but often they do not. There is a general consensus that these political agreements, while sometimes necessary for some countries, rarely produce worthwhile scientific results.

(d) Commercial Reasons

Scientific and technical collaborations occur between firms for a variety of commercial reasons. Sometimes they involve research collaboration for a specific expensive product, such as the Concorde or the Airbus. Military research collaboration also often occurs for cost-sharing objectives.

Another form of collaboration which ultimately is carried out for commercial reasons is pre-competitive research collaboration, that research which competitive firms are prepared to collaborate on together. The ultimate objective to strengthen the competitive strength of a region. Much of the framework program of the European Union falls into this category.

(e) Global Problem Reasons

Many collaborative scientific projects are pursued for the advancement of science. But others are pursued because by doing so they contribute to the solution of problems of global significance. Such problems may be environmental, health, or poverty related. It is this category of collaboration which seems to be most lacking in effective facilitating mechanisms.

Some type of classification scheme of this nature is important for structuring an analysis of current experience and options for future institutional needs. Each category has its own, often different, management needs. I suspect some mechanisms for facilitating collaboration work well; others could be improved. But given the diversity of collaboration objectives it is unlikely that a single mechanism for facilitating international collaboration in science will be effective.