# Reflections on Indicators of International Cooperation in S&T

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## What is International Cooperation in the Context of S&T?

International cooperation in S&T can be defined as any sharing of S&T knowledge[1] between two (or more) citizens of different nations within the context of mutually acceptable conventions for the exchange of that knowledge. . It can take many forms:

[1] S&T as used here is based on the UNESCO definition. Within this definition lie the various fields of science, the best description of which was developed by the Australian Bureau of Statistics. The OECD has prepared manuals (Frascati and Oslo) that provide standard definitions of R&D and innovation. This paper is based on the premise (and the hope) that all measurements of cooperation would follow these standard definitions. It should be emphasized that S&T is much more than high technology, although there is a tendency for the media to exclude the social sciences and artisanal technology from its portrayal of science.

exchanges of students and research personnel or the exchange of knowledge embedded in products and services. These exchanges take place in both the public sector and the private sector. They include exchanges that are specifically sanctioned by explicit agreements and informal transfers of information between individuals. The use of the term "knowledge" in this sense implies that it is a commodity that can be bought and sold. This may be true of some types of knowledge (as for example "intellectual property") but it is not necessarily true of all types of knowledge. In the context of international cooperation, knowledge includes those understandings that arise in the course of the relationships of the people involved. This type of knowledge can neither be bought nor sold, so that while it may not have a market value, it certainly falls into an accountant's balance sheet as "good-will". Throughout this paper we will use the term "knowledge" in the latter sense, in that knowledge can be increased and redistributed through international cooperation.

The sharing of knowledge is like international trade. Both parties benefit, so that the total amount of knowledge after the exchange is greater than the sum of the knowledge actually exchanged. In referring to private investment in knowledge (such as R&D) within a single economy, some economists refer to this effect as knowledge "spillover". Again language fails us; in international cooperation overall gains in knowledge to all parties through a transfer of that knowledge from one nation to another exceeds the net "profit" to the nation that initiates the knowledge transfer. The process is similar to the benefits that accrue to a nation when individuals or corporations invest in R&D: the knowledge they produce from their investment inevitably escapes beyond their ability to profit from it and becomes a free good, a benefit to the national economy as a whole. This is the premise on which governments subsidize private R&D investment, secure in the knowledge that the private sector R&D performer will benefit society as well as the performer himself (or herself) by that investment. The same applies to international cooperation in S&T: even if the original exchange were based on purely profit-oriented motives, knowledge will inevitably spin over within the recipient country to its collective benefit. However in the international sphere, there is an added benefit: this redistribution of knowledge is not unilateral; the transfer of knowledge is bilateral and moves among all of the parties to the agreement. Therefore, S&T exchanges are rarely one-way; indeed, in most international cooperation activities, there is a return flow of knowledge and experience that benefits the donor, knowledge that would often be unobtainable in the donor country.

International exchanges of knowledge are also synergistic. Because S&T knowledge builds on the experiences of all S&T work that has gone before, the transfer of knowledge from one country to another will always build upon the existing experience of the recipient country. For the most part, this transfer will increase the total stock of knowledge in the recipient country, but also increase the stock of knowledge in the donor country; knowledge from the recipient country often complements existing national capacities in the donor economy. (For further discussion the reader should see the paper by Dr. Jesus Sebastian in this volume).

One is left to wonder then, if international cooperation in S&T can be truly altruistic. In transferring knowledge to a less developed nation, the donor nation stands to gain as well. International cooperation in S&T can be viewed as "good business", a "win-win" situation in which both parties benefit. Thus while governments may promote international exchanges for foreign policy reasons, they also promote international cooperation for the same reason as they subsidize investments in R&D: the spillovers

from the program are captured by the nation as a whole.

One can take this mercantilist argument one stage further: while governments may wish to promote international cooperation to support projects that address sustainable development, social progress, biodiversity and health, commercial interest is probably the driver. The main thrust of governmental programs for international cooperation in S&T is to enhance the prospects of the productive sector of the cooperating economies to do business with each other. The policy objective is to make commercial deals that make sense in the context of the national economy, against the backdrop of national policies and in the face of international circumstances.

However international cooperation need not be institutionalized by government agencies. International cooperation also happens in the market place (such as trade, or the hiring of highly qualified staff). Other exchanges happen even in spite of government controls such as the emigration of highly trained workers and students.

Multinational corporations have an important role in international cooperation. They have the ability to move money, technology and people from country to country within their corporate structure. Usually this is done for profit, not through altruism. But as with any international exchange there is spillover, and the recipient economy gains more than just the transfer of resources by the corporation. In that respect, such transfers should be encouraged by governments, since they represent acquisition of knowledge at little or no cost to the tax base.

## Why Measure International Cooperation?

In the most general sense, indicators enable us to take stock - to see where we are in relation to where we would like to be. They enable this to be done in relation to ourselves, to other institutions in our own community and to others in other communities. They also allow us to determine whether we are meeting our cultural and legal obligations - nationally and internationally. Thus, in the S&T context, indicators are tools by which we can measure how we are performing with and for S&T programs. At the institutional level, indicators are used to develop, analyze, and track policies and actions and to measure the consequences of policies and programs. In this context we must also be aware that the choice of a particular indicator may well influence the further development of a 'policy or program: if a government is focusing on R&D/gross domestic product, it may invest too heavily in R&D activities to the detriment of other S&T activities.

International cooperation is difficult to quantify and still more difficult to measure, yet indicators of the level of cooperation are needed. Governments agree that actions associated with international cooperation in S&T are important and that it is important to have national policies regarding international cooperation in S&T.

Knowledge is an intangible asset, and an elusive one at that. One cannot quantify knowledge in units. For the most part, to date, S&T commentators and policy analysts have used the monetary cost of investment in knowledge as a proxy for the quantity of knowledge actually produced by the investment. This assumes that all investments are equally productive. Clearly this cannot be the case, but lacking a common metric, money (and person-years) invested in knowledge are viewed as an acceptable proxy. To convert these into indicators, they are usually normalized as a ratio with population,

GDP, or some other macroeconomic variable as the denominator, to enable comparisons from nation to another.

Based on a presentation to the 4th International Conference on S&T Indicators in Antwerp, October 1995, by Ian van Steen of the Dutch Ministry of Education, Culture and Science, S&T indicators have the following purposes for governments:

- signaling or monitoring: giving insight and calling attention to trends in the S&T system and it environment
- accountability, evaluation and resource allocation: giving insight into the performance of the S&T system against goals and budgets set by policymakers and managers
- legitimization: support for existing policies
- awareness: providing information to set aside prejudices of the performance of the S&T system

These objectives apply equally well to indicators of international S&T cooperation. The political importance of indicators of S&T investment and performance cannot be underestimated. In 1990 the Select Committee of the House of Lords in the United Kingdom stated:

" *In the public sector, overall policy on R&D spending is settled to a large degree by comparisons...1he goals of science policy can rarely be assessed in absolute terms...1he most useful indicator of all is international comparisons, even with its admitted imperfections".*

While the authors were commenting on the use of S&T indicators for internal programs, the same can be said of international programs.

If one accepts the hypothesis that much international cooperation is driven, ultimately, by commercial interest, this establishes the design parameter for indicators of international S&T cooperation.

As a concrete example, the Canadian ASEAN Centre in Singapore exists "to forge the kind of S&T partnerships that will increase the research capabilities of each country and contribute to their economic competitiveness". It accomplishes this by:

- identifying and introducing potential S&T partners in Canada and ASEAN countries
- facilitating cooperation on R&D projects, and,
- encouraging the commercialization of results

What benchmarks does the director use? According the current director, Ian Robertson, the purpose of the Centre is to make deals. The deals can range from "soft" to "hard" The former refers to the establishment of networks of contacts and friendships. "Hard" deals refer to commercial contracts and similar arrangements where specific actions take place. Thus as a measure of his performance the director counts and classifies the

deals made through the Centre.

We believe that counting and classifying deals to measure international cooperation in S&T is a good start. Most of the APEC/PECC countries did not do even this. But a "deal" in the end is designed to facilitate investment in new knowledge by someone, and perhaps the transfer of knowledge from someone else.

International programs, particularly if they are funded by multilateral agencies require program evaluation. Rank and Williams of ARA Consultants, a Vancouver-based firm of international policy and program consultants have offered the following insights in relation to programs of cooperation in S&T:

Program evaluations are conducted to:

- explain what the program is for and what it does
- justify the program's ongoing existence
- improve the program
- meet a requirement for periodic program evaluation

These policy or program evaluations therefore address the following questions:

- what is the program for and how does it accomplish it?
- does the program make sense?
- is it organized in a way that allows it to meet its objectives?
- has it met its objectives?
- what positive, negative, and unexpected impacts have resulted from the program activities?
- is the delivery mechanism effective, and are there alternatives?
- how much did it cost, and is it cost effective?
- can recommendations be made to improve it, replace it, or terminate it?
- are there any other special issues?

The reason for cataloguing these questions is to show the range for which indicators of international S&T cooperation must be found.

## A Quick Survey of APEC/PECC International Cooperation

Governments place a priority on international cooperation in S&T. As an example consider the data contained in the 1995 edition of the Pacific S&T Profile prepared by the Asia Pacific Economic Cooperation (APEC) group of nations and the Pacific

Economic Cooperation Council (PECC). In it, 15 out of 22 economies reported some official international S&T cooperation activities. Virtually all reported that they participated in multilateral activities, and most also had bilateral S&T agreements. Figure 1 shows a quick analysis of this publication. Gaps in the table do not mean that there was no cooperation at all, simply that it was not reported to APEC/PECC for the 1995 Pacific S&T Profile.

***Figure 1: Comparison of International Collaboration (based on 1995 APEC/PECC S&T Profile)***

| Country | International Collaboration Statement | Type of Collaboration | Quantitative Measures (if any) | Remarks |
|---|---|---|---|---|
| Australia | yes | Mulilateral Bilateral | exchanges collab. R&D | See annual S&T budget |
| Brunei | no | | | |
| Canada | yes | multilateral bilateral | exchanges collab. R&D FDI in R&D | US major partner |
| Chile | no | multilateral bilateral | | CONICYT is responsible agency |
| Columbia | no | multilateral | | COLCIENCIAS is responsible agency |
| China | yes | bilateral | co-op and exchanges (134 nations) govt bilateral (86 nations) | multilateral initiatives to be launched |
| Hong Kong | no | | | |
| Indonesia | yes | multilateral bilateral | major bilateral agreements with Japan and Australia | other bilaterall and multilateral mainly related to aid projects |
| Japan | yes | multilateral bilateral | bilateral (20 nations) | multilateral projects include megascience projects - Space Stations, ITER, Human frontiers |
| Korea | yes | bilateral | government and corprate bilateral agreements | primarily throught the HAN project, with major trading partners |
| Malaysia | no | bilateral | | mainly non-governmental |
| Mexico | yes | bilateral multilateral | primarily bilateral with major trading partners | CONACYT is primary institution |
| New Zealand | yes | multilateral some bilateral | | mainly through Int'l S&T linkages fund |
| Pacific Island Nations | yes | multilateral | | primarily through UN affiliated programs |
| Peru | yes | multilateral | | Iberoamerican program (CYTED) |
| Philippines | yes | multilateral bilateral | exchanges of students and experts | |
| Russia | yes | multilateral bilateral | bilateral (100 nations) counterpart agreements with institutes ( 500 projects, 30 nations ) | multilateral includes Soros Foundation and Int'l S&T Center 9 for conversion of military and nuclear R&D) |
| Singapore | no | | | |
| Taiwan | yes | bilateral | 20 nations 80 agreements | Natioanls Science Council (NSC) is coordinating agency |

| | | | | |
|---|---|---|---|---|
| Thailand | yes | bilateral multilateral | | |
| United States | yes | bilateral multilateral | primarily based on institutional agreements | megascience projects; EU and OECD projects NATO projects |
| Vietnam | no | | | |

What was noticeable by its absence was any formal recognition of S&T exchanges in the private sector. As we shall later, it is probably easier to measure private sector exchanges through trade data that it is to measure exchanges by public sector institutions. Student and professorial exchanges were also not mentioned. In Canada's experience, the bringing to Canada of students through the Canadian International Development Agency and the International Development Research Centre programs (to name the two major programs) has been a most effective tool for bringing together Canadian scientists and students and scientists from other nations. The vast majority of such exchanges are successful and tighten links between Canada and other nations for a relatively small investment. One of the challenges facing APEC/PECC is to document the full volume of the flow of human capital among the member economies.

## A Systematic Paradigm for Indication of International Cooperation

Most of the APEC/PECC economies probably did not carry out a formal evaluation of their S&T cooperation activities as outlined above. In the end, like the director of the ASEAN Centre, policy analysts are reduced to looking at "deals", where these deals are designed to facilitate investment in new knowledge by some person or institution and perhaps to transfer that knowledge to someone else.

Cooperation agreements can take many forms and have many dimensions such as the following:

- expressions of good intentions - with details yet to come
- detailed agreements to buy/sell or work jointly on something, including:
    - how the parties to the agreement will act
    - how disputes will be resolved
- types of agreements
    - bilateral agreements - country to country
    - multilateral agreements, including trading blocks such as NAFT A
- parties to the agreements
    - government organizations (usually enablers rather than performers)
    - business enterprises

A matrix can be constructed reflecting the different dimensions of the agreements.

Typically the dimensions include the degree of formality and the sector of performance. Within these dimensions, the characteristics of each agreement can be catalogued and indicators appropriate to each cell can be developed (e.g. size and number of projects, number of people involved, impact of each project, risk [uncertainty of success]), etc. Figure 2 shows such a matrix.

***Figure 2***

| **Instruments for international co-operation in S&T** | | **What they do** | **Indicator** |
|---|---|---|---|
| **Formal Instruments** | | | |
| Framework agreements | bilateral<br>multilateral | Set out principles, intentions and boundaries for mutual projects and activities. Establish a space of possibilities. Allows for buying and selling | Numbers of, and areas covered by such agreements. |
| Bilateral project agreements | how funded<br>how carried out<br>how disputes are settled<br>other terms and conditions | Define specific results, actors, and funding arrangements.<br>Establish action and commerce. Involves buying and selling. | Numbers of, and areas covered by such agreements.<br>Size of projects. |
| Multilateral project agreements | how funded<br>how carried out<br>how disputes are settled<br>other terms and conditions | Define specific results, actors, and funding arrangements.<br>Establish action and commerce. Involves buying and selling. | Numbers of, and areas covered by such agreements.<br>Size of projects. |
| **Informal country arrangements** | | | |
| Unofficial arrangements | Bilateral<br>multilateral | respect cultural practices<br>expedient solutions to complex problems | Case studies<br>Historical accounts of trading practices |
| smuggling | Bilateral<br>multilateral | maintenance of informal economies | Difficult to track and measure |
| **Arrangements within and across business enterprises** | | | |
| multinational or transnational enterprises | supply agreement<br>sales agreements<br>labour agreements<br>tax agreements | maximize market share<br>minimize costs<br>capitalize on local advantages | Case studies<br>Historical accounts of trading practices<br>surveys |
| Small and medium size enterprises | sales agreements<br>purchase agreements | international sales<br>international purchases<br>employment | Firm-level data on products/services, employment, location of markets, fields of science and technology, and supplier/vendor relationships<br>surveys<br>taxation statistics<br>national statistics |

## The Neoclassical Paradigm: Investment in Knowledge

Another approach is to view international collaboration on a transactional basis, as a bilateral investment in knowledge. Investments in S&T knowledge comes in three ways, in both the public and private sectors;

- investment in R&D ( or perhaps more correctly in innovation through the development of new products, processes and services)
- acquisition of intangible intellectual property, through the purchase of licenses, patents, technical services, hiring of knowledge-workers, etc.,

- purchase of knowledge embedded in goods, usually high-technology products

National policies on investment in knowledge differ. Some may invest heavily in R&D while others may choose to buy knowledge embedded in high-tech products. It is usually a question of the most efficient use of resources and the exploitation of particular national advantages

This paradigm leads to different set of indicators of international cooperation. They include:

- Investment in R&D
    - foreign direct investment in R&D
    - co-authorship of academic publications
    - cooperative research projects and strategic research alliances
    - R&D personnel exchanges
- Acquisition of Intellectual Property
    - trade in patents, licenses and services; the technological balance of payments
    - transfers, exchanges, immigration and emigration of highly-qualified personnel
    - student exchanges
- Trade in High-Technology Products
    - imports and exports of high-tech goods
    - revealed competitive advantage in high-tech trade; import penetration

In each case there are standard, internationally accepted, definitions for each measurement including the OECD Frascati Manual on the measurement of R&D, the OECD draft manual on the technological balance of payments, and the US Department of Commerce definition of advanced technology products.

What is not included are data at the firm level. Innovation takes place at the firm level. Thus national innovation surveys can serve as vehicles to gather comparable data on high-technology exports and imports, markets, personnel hiring and transfers. In several surveys of innovative firms in Canada, including a survey in BC, it has been found that innovative firms are more likely to be export-oriented.

But innovation also occurs in the public sector. Surveys of international agreements and their magnitude are needed at the organizational unit or institutional level, including universities, hospitals, libraries and state-run enterprises, as well as in government ministries.

## Conclusion

The last comment above, that of needing a list of international cooperation agreement brings the discussion back to the indicator used by the director of the Canadian ASEAN Centre, that of "deals". Some nations (for example, Australia) have gone to the trouble to catalogue the size, and partners of an of their governmental international S&T cooperation agreements. This gives policy makers a yardstick against which they can review Australia's performance.

A similar effort would be useful in the context of the Ibero-American S&T network. It would allow members to look at not only the magnitude of their international collaborative arrangements, but also the direction these arrangements. This would shed light on the "revealed' priorities of S&T program managers and how they choose to implement these priorities. Science and technology in South America, as a whole, would be the better for it.

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## Bibliography and References

Australian Bureau of Statistics, Australian Standard Research Classification, 1993, Catalogue 1297.0, Canberra, 1993

Holbrook, J.A.D. High Technology Trade Pattern Analysis: Its Use and Application for Industry Competitiveness Response and Government Policy Development, CPROST Report CP 95-11

Lipsett, M.S., Holbrook, J.A.D., and Lipsey, R.G., R&D and Innovation at the Firn1 Level: Improving the S&T Policy Information Base, Research Evaluation, in press, 1996

Organization for Economic Cooperation and Development, Frascati Manual: Proposed Standard practice for Surveys of Research and Experimental Development, 5th edition, Paris, 1993

Organization for Economic Cooperation and Development, Oslo Manual: Proposed Guidelines for Collecting and Interpreting Technological Innovation Data, Paris, 1992

Select Committee on S&T, Third Report, 1989/90, House of Lords, (Her Majesty's Stationery Office), London, 1990