Organisation de Coopération et de Développement Economiques
Organisation for Economic Co-operation and Development

OLIS : 16-Mar-1998
Dist. : 18-Mar-1998

Or. Eng.

DIRECTORATE FOR SCIENCE, TECHNOLOGY AND INDUSTRY
COMMITTEE FOR SCIENTIFIC AND TECHNOLOGICAL POLICY

Group of National Experts on Science and Technology Indicators

REPORT ON THE NSF/OECD WORKSHOP ON THE USE OF SCIENCE AND TECHNOLOGY INDICATORS FOR DECISION-MAKING AND PRIORITY SETTING

WASHINGTON, 8-10 SEPTEMBER, 1997

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REPORT ON THE NSF/OECD WORKSHOP ON THE USE OF SCIENCE AND TECHNOLOGY INDICATORS FOR DECISION-MAKING AND PRIORITY SETTING WASHINGTON 8-10 SEPTEMBER 1997

Aim

1. The aim of the Workshop was to improve understanding of the benefits and problems of using quantitative data for S&T decision-making/priority-setting with a view to identifying best practices for the users and the suppliers of the indicators concerned. The main emphasis was on government decision-making, but the workshop also included "best practice" in the use of S&T indicators for planning and assessment in industry and in the higher education sector.

Organisation and attendance

2. The workshop was organised jointly by the National Science Foundation and the Economic Analysis and Statistics Division of the OECD Directorate for Science and Technology and Industry under the auspices of the Group of National Experts on Science and Technology Indicators (NESTI) and was held at NSF headquarters in Arlington Virginia. The NSF gave high priority to the conference. Opening addresses were given by its Director Dr. Lane and by Claudia Mitchell-Kernan, Chairman of the Subcommittee on Science and Engineering Indicators, National Science Board (NSB), the closing address by Bennet Berthenthal, Assistant Director, Behavioural and Economic Sciences (NSF) and Joseph Stiglitz, Chief Economist at the World Bank and former chairman of the OECD Economic Policy Committee was the keynote speaker at a reception offered by the National Academy of Sciences. The practical arrangements were also extremely efficient.

3. The workshop was attended by about 80 members of the S&T indicators community at the national and international levels plus an audience from the NSF and other United States agencies. All major continents were represented: Europe, North America, South America, Asia and Africa. Experts were present from twenty Member countries as well as from Russia and the Slovak Republic (NESTI observers) and from Argentina, Brazil, China, Malaysia, South Africa and Chinese Taipei. On the international side the following were represented as well as OECD: DGXII of the European Commission, Eurostat, the World Bank, UNESCO, and RICYT (The Ibero-American S&T Indicators Network).

The programme

4. On the demand side, three panels (government, industry, higher education) presented their specific needs for R&D/S&T indicators for priority setting, decision-making and assessment of programmes and suggested how the existing indicators could be improved to meet these needs. A further panel reviewed how S&T indicators could be used in the public debate. As can be seen from Box 1 the level of contributors was very high. On the supply side two panels drawn from NESTI and one from non-Member countries explained how S&T indicators are made available to decision-makers and their staff,

how they are currently used in the planning and evaluation. (Participants also received the national responses to a special questionnaire on these topics). This led to a more general review of various ways of organising S&T indicator activities, their links to users and types of products and how service can be improved to meet the new needs and to profit from new means of delivery. The role of international organisations was also presented and discussed.

BOX 1 PANELS ON THE DEMAND FOR S&T INDICATORS

THE GOVERNMENT PERSPECTIVE

Peter Kreyenberg, Former Secretary General of the Science Council, Former Secretary of State, Ministry of Education, Science, Research and Culture, Schleswig Holstein, Germany

Graham Mitchell, Assistant Secretary for Technology Policy, Department of Commerce, United States

Giorgio Sirilli, National Research Council of Italy (CNR), Chair, NESTI

Natalia Gorodnikova, Centre for Science Research Statistics, Russia

THE INDUSTRY PERSPECTIVE

Peter Nicholson, Vice President of Bell Canada Enterprises, Canada

Jacques Bodelle, Vice President of R&D, Technology and Environment Representative for the USA, Elf Aquitaine, France

Erich Bloch, Senior Fellow, Council on Competitiveness, Former Director of National Science Foundation, United States

HIGHER EDUCATION AND RESEARCH INSTITUTIONS

Stephan Dupré, CEO, Canadian Institute of Advanced Research (CIAR), Canada

Karen Siune, Director, The Danish Institute for Studies in Research and Research Policy, Denmark

Claudia Mitchell-Kernan, Vice Chancellor, Academic Affairs and Dean, Graduate Division, University of California at Los Angeles (UCLA)
Chairman of the S&E Indicators Committee, National Science Board, United States

Shirley Malcom, President's Council of Advisors for Science and Technology, National Science Board, AAAS, United States

COMMUNICATING INFORMATION FOR THE PUBLIC DEBATE

R. Thomas Weimer, Staff Director, Subcommittee on Basic Research, Committee on Science, US House of Representatives

Will Lepkowski, Science writer, Chemical and Engineering News

Colin Macilwain, Senior US Correspondent, Nature

Al Teich, Director, Science and Policy Programme, AAAS

5. The chairs and rapporteurs for the sessions were drawn mainly from NESTI. Giorgio Sirilli, its chair was the general rapporteur and Bill Blanpied, chair of the Group on the Science System was rapporteur for the session on "International co-operation and the role of international organisations."

Developments in demand

6. Until recently S&T indicators were used by a relatively close-knit community of specialists in government science and technology ministries and agencies, science policy research and/or industrial technology institutes, industrial R&D associations and a few very large R&D intensive firms. They sought S&T indicators both to give them an up-to-date picture of the level and structure of national S&T efforts in their economic and social context and also to relate to their specific policy, economic or industrial preoccupations. These specialist users were generally well informed about the data available and their strengths and weaknesses.

7. A number of changes have occurred which have increased the number of potential users of S&T indicators and which have modified or added to the kinds of questions they are asking about S&T and thus for the type of indicator they seek. One of the main themes to emerge during the workshop was how to "mediate" between this new extensive network of potential users and the original specialist community (see below).

8. The main reason for the extension in potential demand for S&T indicators is that understanding of the importance of "knowledge" to improving economic performance has spread beyond its original constituency to other general and specific areas of policy and economic analysis. This new demand for quantitative information may refer precisely to S&T or to allied concepts such as "intangible investment". At the same time it has become evident that the links between science, technology, the economy and the social system are more complex than had originally been thought. In brief the "black box" has been unpacked to reveal the "National Innovation System" (NIS). In consequence S&T specialists find themselves having to explain a complicated conceptual framework to a wider audience of users. A NIS approach to policy making also calls for new types of indicators, especially those accounting for the economic impact of innovative activities as well as those describing flows of knowledge whether disembodied or embodied in people (Human resources for science and technology) or materials, machinery and equipment. The NIS approach also stresses the need for policy analysts to combine quantitative and qualitative information in order to take proper account of national specificities.

9. User's needs for S&T indicators have also developed to reflect changes in economic structures. Globalisation is probably the most important of these. Government policy makers need information on the share of national S&T efforts which are financed and/or carried out by multi-national corporations and by international organisations and about where the resulting innovation and production activities take place. The latter widens the range of countries which are of interest to Member governments. The multinational corporations represented at the workshop were clear that one of their specific needs for S&T indicators was to help them decide where to situate their R&D efforts. (These specific needs are listed in Box 2). This would require indicators of the general level and quality of national S&T efforts, information on the level and type of public support for industrial technology and on the costs of employing HRST and details of the mini "innovation systems" of possible sites within the countries concerned. This latter would mean assembling S&T indicators at sub-regional level.

10. Industrial structure has also changed with the growth of the services. Users need quantitative indicators of the level and nature of their R&D and innovation activities to replace the anecdotal evidence which otherwise forms part of the base for policy decisions in both the public and private sectors.

BOX 2 SEVEN GENERIC USES TO WHICH S&T INDICATORS ARE, OR MIGHT BE, PUT BY BUSINESSES

in approximate order of *increasing* specificity and probably *decreasing* order of familiarity.

1. The "macro" S&T indicators that are routinely collected by most statistical agencies provide individual businesses and advocacy groups with **hard data for policy debates**. The focus is typically on trends and *international* comparisons in the context of improving a particular nation's competitiveness. Business will often use these data to argue for more public sector support, perhaps through enhanced R&D tax credits; or increased funding for research; or calls for new emphases in school and university curricula.

2. S&T indicators are often used to **bolster corporate "public relations",** usually in the context of comparisons with competitor companies or particular industry sectors. For example, companies want to show investors that they are the leading edge, so they may cite ratios of R&D to sales or patents granted per employee, usually in comparison with some national or international benchmark. Alternatively, the message may be directed to governments and the general public when companies highlight, for example, their superior commitment to R&D or to the number of high tech jobs they are creating.

3. Moving into the realm of internal corporate objectives, S&T indicators may facilitate **benchmarking** the process by which managers compare their performance on certain standardised measures with a peer group of competitors. Unfortunately, most of the indicators published by national statistical agencies lack the fine grain resolution required for useful benchmarking exercises.

4. S&T indicators may also be useful in the early stages of the **investment decision process** in technology-intensive business. The first cut at a locational decision, for example, might involve scanning the world, or a particular nation, for locations with rich supplies of relevant S&T inputs. Here again, the problem is that today's public databases are often much too coarse-grained to be very useful. Deciding on the location of a significant investment inevitably requires detailed and highly customised assessment. However even sophisticated corporations may be ignorant as to the location of S&T "hot spots" around the world.. This suggests that national S&T statistics should at least have sufficient "granularity" to identify and adequately describe the key clusters. This information would, of course, flow naturally from a statistical description of a "national system of innovation".

5. **Personnel planning** is another critical area of corporate strategy that could, in principle, benefit from appropriate indicators of human capital -- both as to location, nature of specialisation, and rate of production. Better data in this regard are important to permit a tighter coupling between the demand side and the supply side of the market for technically-qualified people. The career choices of young people and the curriculum policies of learning institutions could benefit from more *objective* and *systematic* feedback from employers as to where opportunities are opening up or closing down. Appropriately designed indicator data would obviously facilitate the feedback and take it out of the realm of the anecdotal.

6. S&T indicators, perhaps surprisingly, may also play a role in **market planning**. For example, data relating to the penetration of personal computer ownership, or of Internet use will often be the starting point of a business plan for products or services relating to the information highway. Or data pointing to the relatively low penetration of certain advanced technologies in small and medium size enterprises -- say in Canada relative to the US -- may alert producers of technology in question to new geographical markets they may not have focused on. In these cases, the statistical indicators might have been collected for other purposes, but serendipitously could turn out to be a key indicator of a new market opportunity.

7. Finally, certain S&T indicators might be useful in **technology forecasting**. The type of indicators involved are usually not those that statistical agencies typically collect. For example, one of the most significant indicators in this category is the transistor packing density on a chip, the growth of which has doubled roughly every 18 months for the past 25 years, an empirical regularity known as Moore's Law. It lies at the foundation of technology forecasting in the computer and telecommunications industries. The discovery of empirical regularities like this -- and subsequent departures from them -- can be of enormous practical significance. To take another example -- the rate of production of graduate degrees in certain fields or the rate of growth of journal articles in particular sub-disciplines can be important leading indicators of structural change in the rate of progress in the affected fields. Similarly, citation analysis can produce insight as to the diffusion of key ideas from one discipline to another which, if properly interpreted, can be a good leading indicator of likely breakthrough areas.

Peter J. Nicholson

11. Governments are counting on SMEs to play an important role in growth in employment. As yet little is known about how they access and apply S&T except for the relatively few high-tech SMEs. It is clear that better S&T indicators are needed about SMEs, especially in the services, for economic and policy analysis. There was some discussion about how the data needs of SME's might be identified. (see below).

12. The end of the Cold war and the resulting decline in defence R&D and its effect on NISs were also cited as areas needing monitoring. This applies in selected OECD countries, such as the United States, the United Kingdom and France, but also, even more drastically in some others represented at the workshop, notably Russia and South Africa. The workshop also heard about the changes in the S&T indicator system in other countries in transition: Hungary and the Slovak Republic. In countries where the economy and S&T are changing very rapidly there may be no explicit demand for S&T indicators and individuals and producers may have to design and supply the indicators which can be of use to policy staff. For example during the period of rapid inflation quarterly R&D budget data were prepared in Russia.

13. The growing interest in the role of technology in economic performance should not imply that the societal applications and impacts of S&T should be ignored. This may be particularly important in developing countries but also applies in the OECD area, for example the interest of tracking the progress of women and minorities in the HRST component of the NIS.

14. Budget stringency in most countries means that governments are taking a more detailed interest in planning their S&T efforts, in deciding where they should be carried out and in evaluating them and assessing their impact. In industry this was described as going from "what you expect" to "what you inspect" and for government's view of R&D programmes and agencies from "Trust me" to "Show me". However, it is difficult to see whether one has had "value for money" without better "output" and "impact" indicators than are currently available.

Supplying S&T indicators: ways of mediating with users

15. The pattern of supply has also become more complex. As S&T indicators have become widely accepted and more linked to economic analysis, their collection, especially from industry, has been concentrated in national statistical offices with S&T agencies assembling S&T budget data and acting as initial "mediators" between the NSOs and the policy staff in their own ministries. There has also, as noted above, been an increase in the range of S&T indicators collected/compiled and used (R&D and innovation statistics, patents, TBP, bibliometrics, HRST stocks and flows, etc.).

16. There are now sufficient potential users of all these S&T data in many countries for it to be worthwhile putting them together and publishing them in a structured and attractive way in reports which "mediate" between the readers and the producers of the original data (and/or academic analysis). They draw their inspiration from the long-standing series of US science and engineering indicator reports, often modified by the "cascade" presentation of the more recent Japanese series published by NISTEP. The latest major addition is the European report, the second edition of which is in preparation. In some cases, notably Germany, the preparation of such a report (the Bufo) is also an important S&T policy process involving federal and provincial government and associated bodies. Here, as in Australia, a common and well-known classification helps to mediate between the indicators for different levels of government and sectors of the economy. In the United States the annual compilation of R&D data at various points in the budget process by the American Association for the Advancement of Science and the associated press conference are a process which attracts the attention and informs a wide range of persons and bodies who will be affected by the final outcome.

17. A recent development in countries including France, the Netherlands and Portugal is the establishment of independent "S&T observatories" financed by the S&T ministry and other sources and drawing on the best academic expertise in the country to prepare the national S&T indicators report, as well as other special studies. There was some discussion of the real "independence" of such observatories and also whether they played a significant role in "intermediation" or rather cut the producers off even further from the ultimate users.

18. Of course, the original producers of S&T data are not the NSOs. In the case of R&D or innovation they are the staff of firms, government departments, institutes and universities who fill in the questionnaires. These may well be the same firms, government departments, institutes and universities who have already been discussed as actual or potential users of the resulting S&T indicators.

BOX 3: PANELS ON THE SUPPLY AND GOVERNMENT USE OF S&T INDICATORS

OECD COUNTRIES

Netherlands: **Barend van der Meulen**, Centre for Studies of Science, Technology and Society, University of Twente

Germany: **Erika Rost**, Director, R&D Statistics, Federal Ministry for Education, Science Research and Technology (BMBF)

France: **Monique Méron**, Director of the Department of Research Statistics, Ministry of Higher Education Research and Technology

Australia: **Luciano (Lou) Lombardo**, Department of Industry, Science and Tourism

Japan: **Yu-ichi Maezawa**, NISTEP, Science and Technology Agency

Hungary: **Annamaria Inzelt**, Director, Innovation Research Centre, National Committee for Technological Development

Mexico: **Ruben Ventura Ramirez**, Deputy Director for S&T Policy, National Science and Technology Council (Conacyt)

NON OECD COUNTRIES

Russia: **Leonid Gokhberg**, Deputy Director, Centre for Science Research and Statistics, Moscow, Russia

South Africa: **Anastassios Pouris**, Science Consultancy Enterprises
Anthipi Pouris, Manager, S&T Information, S&T Policy Directorate, Foundation for Research and Development

Slovak Republic: **Frantisek Bernadic**, Institute of Informatics and Statistics, Slovak Statistical Office

The multiple effects of IT

19. The rise of IT has also had a complex effect on demand for S&T indicators and on current and potential improvements in supply. Understanding of the diffusion of IT (hardware and software) and its impact on innovation and productivity is essential for technology and industrial policy. The facilities offered by modern computers have increased the capacity to analyse and present numbers to users in a relevant and attractive format. It may help to explain a major change in users' attitudes in that many now seek detailed data which they can analyse themselves. In the past it was often said that policymakers could only remember one figure, but no-one at the workshop raised the interest of calculating such composite indicators. Lastly IT both allows the network of users and producers to grow (notably via the Web) and also allows more immediate and specialised contacts between them than had previously been possible.

20. The workshop discussed how reporting units could be encouraged by returning to them indicators calculated for their own unit together with an average for their industry/field of science, etc. which they could use as a benchmark. The need for other flexible indicators to meet specific users' needs was raised. This "customisation" generally requires more detailed data than was available for R&D or innovation.

21. The need for timeliness was stressed, especially by the users from the S&T press. Some improvements could be made by improving response and turnaround times. Reasonably accurate "nowcasting" to keep up-to-date was possible for government funding but was not ye possible for business funding. There was a call for "early warning" indicators which would signal emerging problems with S&T policy consequences, e.g. Aids.

The role of international organisations

22. The most useful roles for international organisations were to formalise best practice in standard methodologies, supply sets of timely internationally comparable data which could be used for simple benchmarking and to provide fora for the discussion of developments responding to the public and private evolving needs. Co-operation between them was progressing and OECD methodology was increasingly being adopted by other organisations and by a growing number of non-Member countries. The individual organisations also have their own special aims and areas of expertise, for example the European Commission has long experience with evaluating S&T programmes.

The lessons for NESTI

23. There was a useful exchange of views on how governments and university managers use S&T indicators. This was not entirely new territory for most of the NESTI members present and the main value-added was the opportunity to learn about how indicators might be used in industry and to discuss the improvements on the supply side to meet these needs. The ideas from the scientific press who brings S&T indicators to a much wider audience were also appreciated. The areas for development of new or improved indicators generally confirmed those suggested for economic analysis at the conference on S&T indicators for a knowledge based economy (KBE) in June 1996, which are being pursued in the activity on "new indicators for a KBE" with the addition of measures of social impacts of S&T. The discussion of 'mediation' between users and producers promoted reflection on how to improve service to those who prepare decisions about S&T and who assess the outcomes which should lead to improvements in indicators work in national capitals as well as in the Directorate for Science, Technology and Industry.

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